# DIFFERENCES AMONG ADHD PRESCHOOLERS WITH AND WITHOUT COMORBID ODD

by

CHAYA BRACHA GOPIN

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Jeffrey M. Halperin, Ph.D.

Date — Chair of Examining Committee

Maureen O'Connor, Ph.D.

Date — Executive Officer

Jeffrey M. Halperin, Ph.D.

Hilary Gomes, Ph.D.

Anil Chacko, Ph.D.
Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

*ABSTRACT*

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by

Chaya Bracha Gopin

Advisor: Dr. Jeffrey Halperin

The objective of this dissertation was to assess the distinctions between preschool children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD-), those diagnosed with ADHD and comorbid Oppositional Defiant Disorder (ODD; henceforth referred to as ADHD+), and typically developing (TD) children in an effort to evaluate the concurrent differential validity of these groups. Study 1, the first of a series of three studies, compared the neuropsychological functioning of these three groups on the domain and subtest levels. In addition, similar analyses were conducted after the sample was stratified based on overall intellectual functioning so that the contributions of IQ could be investigated. Study 2 assessed whether the groups differed in performance depending upon the degree of task engagement/reinforcement. Change in performance was assessed through comparing the groups' median reaction time (RT) and variability in RT during two conditions of a computerized task, which differed only in whether or not reinforcement was provided. Finally, Study 3 analyzed the differences in the parent-child relationship during video-taped tasks that differed in degree of parental involvement and task engagement. The results of Study 1 indicated that when the sample was not stratified based on IQ, preschool children diagnosed with ADHD were found to have global cognitive impairment, regardless of comorbid ODD status. Discrepancies in the performance of the two ADHD groups began to materialize only through secondary analyses, in which IQ was taken into account. The findings from Study 2 revealed that the ADHD+ group had a significantly greater reduction in reaction time variability relative to the other groups when the degree of engagement/reinforcement increased. The results of Study 3 revealed that the TD children were rated as exhibiting more positive behaviors than the ADHD children, regardless of comorbid ODD status; however, the ADHD+ children exhibited a differentially larger response to reinforcement relative to the ADHD- and TD preschoolers. Overall, these findings suggested that while ADHD- and ADHD+ children may *not* be distinguishable based on their neuropsychological profiles, the added ODD diagnosis confers an additional core deficit of an aberrant reward system. Given these findings, treatment implications are discussed, and directions for future research are suggested.

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*SPECIFIC AIMS*

More than a third of school-aged children diagnosed with Attention-Deficit/ Hyperactivity Disorder (ADHD) are also diagnosed with Oppositional Defiant Disorder (ODD; Biederman, Newcorn, & Sprich, 1991), which raises questions regarding the validity of labeling these as distinct diagnostic categories. Findings from studies conducted with elementary- and high-school children highlight the importance of considering "pure" ADHD and those with ADHD+ODD separately when investigating the correlates or trajectories of these subgroups of children (Waschbusch, 2002). Far less is known, though, regarding the differentiation of these subgroups during the preschool years, when symptoms first emerge. The overarching goal of this series of studies is to evaluate the distinctions between preschool children with ADHD, ADHD+ODD, and typically developing (TD) children. This dissertation will systematically evaluate the concurrent differential validity of these groups by examining group differences in cognitive/neuropsychological, behavioral and family functioning.

Neuropsychological functioning of individuals diagnosed with ADHD has received considerable attention in the literature. Yet, it remains unclear whether ADHD and/or ODD are associated with neurocognitive dysfunction in preschool children with ADHD, and if so, whether impairments are specific to executive functioning (EF) or are more global in nature. Given that older children with pure ADHD have been found to be more inattentive (Halperin et al., 1990b) and have more learning problems (Halperin et al., 1990a) than children with ADHD and conduct problems, one main hypothesis of Study 1 is that preschool children with ADHD, but not ODD, will perform more poorly than those in the ADHD+ODD and TD groups on measures of neuropsychological functioning. We have no specific hypotheses regarding the extent to which these deficiencies will be specific to executive functions or present across a wide array of cognitive domains.

A second factor that might distinguish preschoolers with ADHD+ODD from those with the sole diagnosis of ADHD is the child's response to reward or increased task engagement. Findings from numerous studies have revealed that individuals diagnosed with ADHD have a dysfunction in motivational and/or reinforcement systems (Johansen & Sagvolden, 2004; Castellanos & Tannock, 2002; Doyle et al, 2005; Sagvolden, Johansen, Aase, & Russell, 2005; Sonuga-Barke, 2002; Luman et al., 2007); however, this deficit does not appear to be specific to ADHD. Children with ODD also have a physiological response to reinforcement that is different than that of typically developing children (Luman, Oosterlaan, & Sergeant, 2005). When ADHD and ODD occur comorbidly, therefore, it is possible that the impact of the resultant aberrant reward system will be that much greater than it is in ADHD alone. The goal of Study 2 is to investigate this possibility. Specifically, it is hypothesized that task engagement/reinforcement will have a significantly greater impact on the performance (i.e., reaction time and reaction time standard deviation during a computerized task) of children in the ADHD+ODD group as compared to that of children with a diagnosis of ADHD alone and those in the TD group.

The third factor under investigation is the parent-child relationship. Family factors have been shown to be associated with ADHD symptomatology (Carlson et al., 1995; DuPaul, McGoey, Eckert, & VanBrankle, 2001; Johnston & Mash, 2001; Lindahl, 1998; Shelton, et al, 1998). Most research conducted with preschool children, however, does not categorize participants based on the children's high or low levels of oppositionality. To date, only two studies have conducted such an investigation. The results of one indicated that children with ADHD experienced more beneficial and encouraging interactions with their family members than did children with pure ODD or those diagnosed with both disorders (Lindalh, 1998); the other study did not reveal any differences between the two groups (Harvey et al., 2007). The aim of Study 3 is to further elucidate this matter. It is hypothesized that children in the ADHD+ODD group will display more behavioral difficulties during the parent-child interaction (PCI) than will children in the ADHD without ODD (i.e., ADHD-) and the TD groups. Further, children in the ADHD- group will be observed to display poorer behavior than the TD children. Similarly, parent and dyadic behavior will be the most problematic amongst participants in the comorbid group; a significant difference in parent and dyadic behavior amongst the TD and ADHD groups will be apparent, as well.

As part of Study 3, this dissertation will also investigate whether group differences are apparent depending upon the degree of task engagement and the extent of parental involvement in directing the task. Specifically, it is hypothesized that the degree of task engagement and parental involvement during the PCI will significantly impact the performance of children in the ADHD+ODD group to a greater extent than the other two groups.

*GENERAL INTRODUCTION*

**Attention-Deficit/Hyperactivity Disorder**

Symptoms of ADHD usually emerge during the preschool period (Campbell, 1995). To be diagnosed with ADHD, a person must display persistent symptoms of inattention and/or hyperactivity-impulsivity, which are more frequent and/or more severe than those typically observed in individuals of comparable age and developmental level. According to the *Diagnostic and Statistical Manual of Mental Disorders*, *4th Edition-Text Revision (DSM-IV-TR*; American Psychiatric Association, 2000), six out of nine possible inattentive behaviors must be present to meet the symptom threshold for a diagnosis of ADHD, primarily Inattentive Type. Similarly, six out of nine hyperactive-impulsive behaviors must be present for an individual to be diagnosed with ADHD, primarily Hyperactive/Impulsive Type. To meet diagnostic criteria for ADHD, Combined Type, an individual must display a minimum of six symptoms in each of these domains. At least some symptoms must be present before age 7-years, symptoms must be present and cause impairment in multiple settings, and they cannot be better accounted for by another disorder.

Currently, ADHD is the most commonly diagnosed behavioral disorder of childhood (Castellanos & Tannock, 2002), conservatively estimated to affect approximately 4-6% of the child population in the United States (American Psychiatric Association, 2000). In addition, ADHD is the most common diagnosis received by youngsters who are referred for mental health services (Egger & Angold, 2006; Gadow, Sprafkin, & Nolan, 2001; Keenan & Wakschlag, 2000; Wilens, Biederman, Brown, Monuteaux, Prince, & Spencer, 2002). Individuals diagnosed with ADHD are reported to be at increased risk for low academic achievement and impaired social skills, with evidence of such dysfunction already present during the preschool period (Wilens, Biederman, Brown, Tanguay, et al, 2002). As such, the cost ascribable to ADHD in the United States was recently estimated to exceed $42.5 billion annually (Pelham, Foster, & Robb, 2007).

Considerable research across various disciplines has examined potential risk factors for ADHD. While the specific cause of ADHD is currently unknown, findings suggest a multifactorial etiology (Faraone, 2000; Sprich-Buckminster, Biederman, Milberger, Faraone, & Lehman, 1993) comprised of complex interactions among multiple genes of small effect size and a host of environmental factors. Notably, ADHD is a highly heterogeneous disorder, and it is unlikely that all children diagnosed with ADHD have the same etiology or underlying pathophysiology (Doyle et al., 2005).

**Oppositional Defiant Disorder**

Another behavioral disorder that oftentimes begins to manifest during the preschool years is Oppositional Defiant Disorder (ODD; Lavigne, et al., 1996). This disorder is defined by the *DSM-IV-TR* (American Psychiatric Association, 2000) as a recurrent pattern of negative, hostile, disobedient, and defiant behaviors toward authority figures, which lasts for at least six months. Bullying, blaming others, defying authority, and refusing to comply with adult requests are some examples of ODD symptoms (American Psychiatric Association, 2000). The stipulations for the diagnosis of ODD are similar to those of ADHD in that the behaviors must be more frequent than is characteristically exhibited by one's same aged peers and must result in clinically significant levels of impairment in functioning, although not necessarily in multiple settings.

ODD is a common diagnosis amongst preschool children (Lavigne, et al., 1996). Estimates of the percentage of preschool children clinically referred for disruptive behavior who received a diagnosis of ODD range from 2-30% (for review, see Gadow & Nolan, 2002). It is not surprising that the prevalence rate of oppositional behaviors during this period is high. It is fairly common for preschool children, in general, to exhibit some symptoms of ODD, as the ability to emotionally and behaviorally self-regulate first starts to actualize when a child is approximately two years of age and continues to develop as a child matures from a toddler into a kindergartener (Keenan & Wakschlag, 2002). As a result, some investigators have expressed considerable concern about the ability to differentiate between normative, individual, temperamental differences and behaviors that are clinically significant during this particular period in development.

While such a perspective has merit, studies have indeed indicated that parental reports of oppositional behaviors remained relatively stable from the preschool to the kindergarten years and beyond (Pierce, Ewing, & Campbell, 1999). As a result, it is thought that ODD can be reliably diagnosed in preschool children (Lavigne, Cicchetti, Gibbons, Binns, Larsen, & DeVito, 2001). Keenan and Wakschlag (2002) suggested that the frequency, intensity, and obstinacy of the behaviors must be considered in order to differentiate typical from atypical forms of oppositionality. Doing so is currently the only way in which clinicians can distinguish children who are beginning to gain control over their feelings of anger and frustration and their reactions to aversive stimuli from those whose pattern of disruptive and defiant behaviors is likely to persist (Egger & Angold, 2006).

**Comorbid ADHD and ODD**

Although the diagnostic criteria for ADHD and ODD differ significantly, the frequent co-occurrence of the two disorders during childhood makes them difficult to discriminate from one another and raises questions about the validity of establishing two, truly distinct diagnostic categories (Newcorn & Halperin, 2000). Among school-aged children, 35% of those diagnosed with ADHD are estimated to also meet criteria for ODD (Biederman, Newcorn, & Sprich, 1991), a percentage that is far greater than would be expected based on chance alone. In addition, Speltz, McClellan, DeKlyen, and Jones (1999) found that amongst clinically referred preschoolers diagnosed with ODD, approximately half received a comorbid diagnosis of ADHD.

Studies conducted with older children have highlighted the importance of considering pure ADHD and comorbid groups separately (Waschbusch, 2002). In fact, according to the *International Statistical Classification of Diseases and Related Health Problems- 10th Revision* (ICD-10), an individual who presents with ADHD and Conduct Disorder (CD), a condition thought by many to be a more severe form of ODD, receives an entirely different diagnosis, known as hyperkinetic conduct disorder (WHO, 1993). While the *DSM-IV-TR* does not make such a subdivision, several researchers have argued for the implementation of a distinct diagnostic category for the comorbid condition in the next edition of the manual (Jensen, Martin, & Cantwell, 1997).

Findings based on research conducted with older children that highlight this distinction cannot be generalized to the early childhood period, as symptoms associated with CD (e.g., has broken into someone else's house, building or car; often stays out at night despite parental prohibitions; has forced someone into sexual activity, etc.), are seldom applicable to preschool children. Instead, preschoolers exhibiting disruptive behaviors are more frequently diagnosed with ODD, which is often thought of as a precursor to CD (For review, see Biederman et al, 1996). While it would not be surprising if ADHD preschoolers with and without ODD differed from one another, as do older ADHD children who present with and without CD, the subject has received far less attention.

The co-occurrence of ADHD and ODD symptoms is an important area of research, as the prognosis for children who exhibit both disorders is poorer than for those who display symptoms of only one of these disorders (Strayhorn & Weidman, 1989). Barkley (2006) concluded that comorbid ADHD and ODD is likely to result in a more severe form of ADHD. In addition, research has suggested that the comorbidity of these disorders during the preschool years places a child at increased risk for the future diagnosis of additional psychiatric disorders (Speltz, et al., 1999).

To date, there are no known biological or psychological mechanisms that can fully explain the high levels of comorbidity between ADHD and ODD (Harvey, et al., 2007). It has been suggested that the diagnosis of one externalizing disorder influences the perception of symptoms that comprise the other disorder (Jackson & King, 2004). To that extent, Abikoff, Courtney, Pelham, and Koplowicz (1993) reported that teacher ratings of ADHD, in particular, have been found to be influenced by oppositional behavior exhibited by boys. In a replication and extension of this study, Jackson and King found that teacher ratings of hyperactivity and inattentiveness impacted ODD teacher ratings of girls as well. Because ADHD and ODD diagnoses rely heavily upon observer reports, careful consideration must be given to this potential source of bias.

The aforementioned halo effect is not the only hypothesis that has been proposed to account for the high levels of comorbidity between ADHD and ODD diagnoses. Some researchers have suggested that ADHD and ODD do not represent separate entities. Rather, it has been posited that the seeming comorbidity is due to methodological problems, including referral bias, rater expectancy, and the current information-gathering strategies implemented (Angold, Costello, & Erkanli, 1999).

Other investigators do not think that the differences between the two disorders are merely artifacts. Some have argued that ADHD and ODD could be different phenotypic expressions of the same underlying genotype or distinct genetic variants of a single disorder with a heterogeneous presentation (for review, see Biederman, et al., 1991). If accurate, this conceptualization would demand a separate investigation of the causes and effects of ADHD and ADHD+ODD, as specific factors would underlie the different presentations.

An alternative perspective is that the presence or absence of ODD symptoms does not change the underlying ADHD symptomatology. For example, Biederman and colleagues (1991) stated that ADHD and ODD are entirely separate disorders that may share certain genetic and/or psychosocial vulnerabilities. It is also possible that the presence of ADHD increases the risk for the development of ODD, a concept referred to as multiformity (Rhee, Willcutt, Harman, Pennington, & DeFries, 2005). Indeed, the use of structural equation modeling procedures has revealed that hyperactive and impulsive symptoms predict later ODD symptoms even after controlling for the ODD factor's ability to predict its own presence over a two-year period (Burns & Walsh, 2002).

If ADHD and ADHD+ODD are indeed the byproduct of many of the same risk factors, similar etiological and protective profiles should be evidenced throughout investigations into both strands of the disorder. Alternatively, if the two conditions are distinct clinical entities, factors differentiating the two syndromes should be evident. The latter hypothesis will be tested in the following series of papers, investigating whether the neuropsychological profiles of children with ADHD, with and without comorbid ODD, are distinct from one another and whether environmental differences can be detected. Study 1 will focus on various domains of neuropsychological functioning, while Study 2 will focus specifically on motivation/reward sensitivity. Finally, in Study 3, the nature of parent-child interactions will be investigated. Participants for all three studies were derived from the baseline data of an ongoing longitudinal investigation (NIH grant # R01 MH68286; PI: J. Halperin) exploring the predictors of ADHD in preschool children. The samples differ slightly from one study to the next due to the fact that certain measures were added to the larger battery after some participants were already assessed, resulting in a reduced sample size for all analyses focusing on those particular tasks.

*Study 1: Neuropsychological Profiles of ADHD Preschoolers with and without ODD*

Attention-Deficit/Hyperactivity Disorder (ADHD) is a chronic, highly impairing, neurodevelopmental disorder that is characterized by developmentally inappropriate levels of inattention and/or hyperactivity/impulsivity (*DSM-IV*-TR; American Psychological Association, 2000), which become manifest during the preschool years for most afflicted individuals (Campbell, 1995). Since the emergence of ADHD as a diagnostic entity, investigators have formulated a variety of theoretical models to account for the heterogeneous array of cognitive and behavioral deficiencies that characterize individuals with ADHD. Within the past two decades, models of executive dysfunction have predominated and have posited that deficiencies in set-shifting (Müller et al., 2007), working memory (Mariani & Barkley, 1997; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005), and reinforcement processes (Sagvolden & Sergeant, 1998) not only parallel manifestations of ADHD, but are central to the pathophysiology of the disorder (see Seidman et al., 2006). Indeed, numerous investigators have found that children diagnosed with ADHD perform significantly more poorly than typically developing children on executive functioning (EF) tasks as early as the preschool period (Berlin, Hohlin, & Rydell, 2003; Hughes, Dunn, & White, 1998; Mariani & Barkley, 1997; Sonuga-Barke, Dalen, Daley, & Remington, 2002).

Yet, despite the abundance of data supporting the role of EF deficits in ADHD, a multitude of evidence has cast significant doubt as to whether executive dysfunction constitutes the *sine qua non* of ADHD. A recent meta-analysis (Willcutt, et al., 2005) called into question whether impairments in putative executive functions are either necessary or sufficient to account for the breadth of disturbances associated with the disorder, as many children who display symptoms of ADHD do not exhibit weaknesses in domains of executive functioning. This argument is further bolstered by several studies, which have demonstrated that preschoolers with ADHD do not differ from control children on EF measures after controlling for deficiencies in more rudimentary processes (Berwid, Curko Kera, Marks, Santra, Bender, & Halperin, 2005; Marks, Berwid, Santra, Kera, Cyrulnik, & Halperin, 2005). These findings in preschoolers are similar to those reported by Rommelse and colleagues (2007) in school-age children.

Adding to the rationale that EF deficits cannot fully explain the scope of deficiencies associated with ADHD are the findings that children diagnosed with ADHD also display deficits in non-executive domains including sustained attention (Heaton et al., 2001; Tsal et al., 2005; Willcutt, et al., 2005), orienting of attention (Brandeis et al., 1998), language (Barkley, DuPaul, & McMurray, 1990; Beitchman, Tuckett, & Batth, 1987; Beitchman, et al., 1996; Carte, Nigg, & Hinshaw, 1996; Redmond, 2004), learning and memory (Felton, Wood, Brown, Campbell, & Harter, 1987), perception (Garcia-Sanchez, Estevez-Gonzalez, Suarez- Romero, & Junque, 1997; Mangeot, et al., 2001), visuomotor integration (Raggio, 1999), motor functioning and coordination (Barkley, Murphy, & Kwasknik, 1996; Beyer, 1999; Blondis, 1999; Carte, Nigg, & Hinshaw, 1996; Kadesjo & Gillberg, 1998; Mariani & Barkley, 1997; Moffitt, 1990; Piek, Pitcher, & Hay, 1999; Sheppard, Bradshaw, Georgious, Bradshaw, & Lee, 2000; Steger, Imhof, Coutt, Gundelfinger, Steinhausen, & Brandeis, 2001), and academic achievement (Frazier, Demaree, & Yougstrom, 2004). When taken together, these findings suggest that, while EF deficits are indeed associated with ADHD, the resulting impairment may not be greater than that observed for other (i.e., non-executive) domains (Halperin, Marks, & Schulz, 2008).

An additional source of ambiguity relates to the fact that deficits in EF have also been linked with other psychological disorders [e.g., Autism (Geurts et al., 2004; Pennington & Ozonoff, 1996); Tourette’s Disorder (Bornstein, 1990); Obsessive Compulsive Disorder, Schizophrenia, and Depression (Moritz et al., 2002)]. Given that other disorders may present with analogous EF deficits, there has been a growing interest in examining the degree to which EF deficits among youth with ADHD may be at least partially accounted for by the presence of psychiatric comorbidity. In particular, attention has been focused on understanding the extent to which the association between ADHD and EF deficits may be accounted for by comorbid Oppositional Defiant Disorder (ODD), which frequently co-occurs with ADHD (Biederman, Newcorn, & Sprich, 1991). Although several studies have reported that poor performance on tasks of planning and working memory was associated with manifestations of ADHD irrespective of ODD status and was not evident in school-aged children and adolescents who were diagnosed with ODD alone (Banaschewski, et al., 2003; Kalff et al., 2002; Klorman et al., 1999; Oosterlaan, et al., 2005), additional investigations have suggested otherwise. Specifically, Séguin, Boulerice, Harden, Tremblay, and Pihl (1999) observed patterns of executive dysfunction in children who were physically aggressive even after controlling for ADHD symptoms and overall intellectual functioning. Others (e.g., Moffitt & Henry, 1989; Moffitt & Silva, 1988; Van der Meere, Marzocchi, & DeMeo 2005) identified EF deficits only in individuals who displayed symptoms of ADHD and ODD.

To date, efforts to link impairments in neuropsychological functioning to particular forms of psychopathology have largely been undertaken in school-aged children. While symptoms of ADHD and ODD typically have their onset during the preschool period (Lahey, Pelham, & Loney, 2004; Speltz, McClellan, DeKlye, & Jones, 1999), only a small number of investigations have examined neuropsychological profiles among preschoolers with ADHD as a function of ODD comorbidity. Results of these studies, which focused primarily on EF deficits, indicated that there is an association between executive dysfunction and high levels of ADHD symptoms irrespective of whether ODD symptoms were included as a covariate

(Thorell & Wåhlstedt, 2006; Brocki et al., 2007).

Yet, the only study that investigated multiple domains of neuropsychological functioning in ADHD preschoolers with and without ODD found otherwise (Youngwirth, Harvey, Gates, Hashim, and Friedman-Weieneth, 2006). These authors reported that, while children with ADHD and comorbid ODD performed significantly worse than control children on measures of language (i.e., NEPSY Comprehension of Instructions), memory (i.e., NEPSY Narrative Memory and NEPSY Sentence Repetition), and attention/executive functioning (i.e., NEPSY Statue), those who presented with only hyperactive symptoms did not differ from normal controls or from children in the comorbid group in their performance on any of the subtests from the neuropsychological battery administered.

Although these findings might appear to indicate that neuropsychological deficits are more strongly associated with comorbid hyperactivity and oppositionality than with ADHD alone, the authors acknowledged several weaknesses (Youngwirth, Harvey, Gates, Hashim, & Friedman-Weieneth, 2006). First, participants were classified based on elevated scores on indices that were specifically created for the study [i.e., hyperactivity and oppositional-defiance indexes were created using related scales from the Behavior Assessment System for Children (BASC), the Disruptive Behavior Rating Scale (DBRS), and the Diagnostic Interview Schedule for Children (DISC)] rather than through the assignment of categorical diagnoses. As a result, the generalizability of their findings to children diagnosed with ADHD and/or ODD is questionable. In addition, the sample sizes of their "diagnosed" groups were relatively small and unbalanced (Hyperactive Group, n = 28; Hyperactive/Oppositional Group, n = 29; Non-problem Group, n = 123).

An additional potential limitation of the aforementioned study is that the authors did not account for group differences in intellectual functioning in their analyses. Some researchers (e.g., Murphy et al. 2001) have included IQ as a covariate in their investigations of neuropsychological deficits associated with ADHD, asserting that such covariation is essential for determining whether unique deficiencies in EF are present. According to this perspective, executive functions are unique, or at least partially independent from intellectual abilities. Although performance on EF tasks is likely influenced by an individual's intellectual abilities, these investigators would argue that one can measure EF abilities above and beyond the contribution of IQ. However, other investigators (e.g., Faraone et al., 1993; Seidman et al., 1997) have contended that IQ and EF are inextricably linked. From this perspective, covariation for intellectual functioning is ill-conceived, as doing so may parcel out abilities common to both EF and IQ, and in the process, obfuscate/eradicate any EF differences that may in fact be present. As such, it is possible that the group differences seen in neuropsychological functioning may actually be due to differences in intellectual functioning. In fact, Miller and Chapman (2001) would maintain that the use of an analysis of covariance (ANCOVA) in conducting such investigations affects the representativeness of the groups being compared. As a result, the contributions of IQ to possible EF differences cannot be explored simply through the use of this statistical "correction" procedure alone; rather, Miller and Chapman recommend stratifying samples based on the variable in question whenever it is impossible to covary. Although this solution is not perfect, it enables researchers to glean a better understanding of what is truly occurring.

Ultimately, the jury remains out as to whether ADHD and/or ODD contribute to EF deficiencies in preschool children with ADHD, and if so, whether they occur in isolation or are embedded within a more global pattern of neurocognitive dysfunction. With such issues as a forethought, the current study was designed to compare the performance of preschool children who received formal diagnoses of ADHD+ODD (henceforth referred to as ADHD+), those who received a diagnosis of ADHD but not comorbid ODD (i.e., ADHD-), and typically developing (TD) controls on a comprehensive neuropsychological assessment battery (NEPSY: A Developmental Neuropsychological Assessment; Korkman et al., 1998). The analyses were first undertaken without controlling for general intellectual functioning. Then, to ascertain whether the impact of IQ is indeed distinct from the effects of ADHD, participants were stratified based on low, medium and high Full Scale IQ (FSIQ) scores, and the data were then reanalyzed.

## Methods

### Recruitment

Packets consisting of an explanatory cover letter, a consent form, and a behavior rating scale (ADHD-RS-IV-Home Version; DuPaul et al., 1998) were sent home to parents of 3- and 4-year-old children attending public and private preschools in New York City and Long Island, New York. Participants were also recruited through direct clinical referrals from school psychologists, social workers, pediatricians, and other health professionals, as well as responses to flyers and newspaper advertisements. Once parental consent and the completed rating scale were received, teachers were requested to complete an analogous rating scale (ADHD-RS-IV-School Version; DuPaul et al., 1998).

Participants were subsequently screened based on responses to parent and teacher ratings (see criteria below) and a brief telephone interview, designed to ascertain interest in the study and the presence of the following exclusionary criteria: (i) a chronic medical condition, (ii) continuous use of systemic medication, including psychopharmacological treatment for ADHD, (iii) a diagnosis of Autism or Pervasive Developmental Disorder, and (iv) non-English speaking parents and/or child. Children who met all of the pre-screening criteria then participated in a two-session, on-campus assessment (described below) and were excluded if they received a Full Scale IQ score of less than 80 on the Wechsler Preschool and Primary Scale of Intelligence-Third Edition (WPPSI-III; Wechsler, 2002). This study was approved by the Queens College Institutional Review Board. Parents were compensated $20 per hour to defray time and travel costs associated with participation in the on-campus evaluation. In addition, the children were given a small token gift at the conclusion of the assessment.

Participants' Characteristics

Participants were divided into three groups based upon Kiddie-SADs- Present and Lifetime Version (K-SADS; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996) diagnoses (see below). The ADHD- group consisted of children who received K-SADS diagnoses of ADHD Predominantly Hyperactive-Impulsive Type or Combined Type but not a diagnosis of ODD (n = 52). The ADHD+ group was comprised of children who received K-SADS diagnoses of ADHD, Predominantly Hyperactive-Impulsive or Combined Type, as well as a diagnosis of ODD (n = 44). The Typically-Developing Control (TD) group consisted of children who: (i) did not receive diagnoses of ADHD (any subtype) or ODD and (ii) received parent and teacher ADHD-RS ratings of fewer than three ADHD symptoms in either domain (n = 73). Children who exhibited a sub-threshold number of symptoms of either disorder, warranting diagnoses of ADHD, Not Otherwise Specified or Disruptive Behavior Disorder, Not Otherwise Specified were excluded from the analyses. In addition, for the purposes of this study, children who received a diagnosis of ADHD, Predominantly Inattentive Type were excluded, as previous findings have suggested that ADHD, with and without hyperactivity, may reflect two distinct developmental disorders rather than separate subtypes of a unitary syndrome (Barkley, DuPaul, McMurray, 1990). This decision was also made based on evidence suggesting that symptoms of hyperactivity/impulsivity, relative to inattention, are significantly more prevalent among preschool children (Gimpel & Holland, 2003). In fact, in our original sample, only 9 (4.2%) children met criteria for ADHD, Predominantly Inattentive Type.

The resultant sample consisted of 169 preschool children (boys = 122; girls = 47) with a mean (SD) age of 4.29 (.47) years. According to demographic data obtained from the parents, 38.5% of the sample was White, Non-Hispanic; 18.3% was White, Hispanic; 10.7% was Black, Non-Hispanic; 1.8% was Black, Hispanic; 12.4% was Asian; and 18.3% reported mixed or "other" ethnicity/race. Table 1 reports the participants' characteristics. The groups differed in socio-economic status (SES), which was measured using the Nakao-Treas Socioeconomic Prestige Index (Nakao & Treas, 1994). The typically developing children were from families with a higher SES [60.4(13.3)] than were the children in the ADHD+ group [51.1(15.7)], with neither group differing significantly in SES from the ADHD- group [54.1(15.4)]. The three groups did not differ significantly in age or gender; however, the FSIQ of children in the TD group was significantly higher than that of both the ADHD- and ADHD+ groups (F = 17.51 (2,166), $p < .001$); the ADHD- and ADHD+ groups did not differ significantly in FSIQ. Not surprisingly, the groups differed significantly in both teacher (F = 212.88 (2,165), $p < .001$) and parent (F = 127.66 (2,166), $p < .001$) ratings of ADHD symptoms. Post hoc analyses of teacher ratings indicated that the TD children were rated as displaying significantly less symptomatic behavior than both diagnosed groups. The teacher's ratings of the ADHD- and ADHD+ children did not differ from one another in the degree of hyperactivity/impulsivity or inattention. Parent ratings of ADHD symptoms, however, differentiated each of the three groups from one another; the TD group was rated as displaying the least amount of both hyperactive/impulsive and inattentive behaviors whereas the ADHD+ group was rated as displaying the most.

Table 1. Descriptive characteristics of TD, ADHD-, and ADHD+ groups

| **Group** | **TD (n= 73)** | **ADHD- (n=52)** | **ADHD+ (n=44)** | **Significance** |
|---|---|---|---|---|
| **Mean Age (SD)** | 4.22 (.47) | 4.33 (.50) | 4.37 (.42) | F = 1.74 (2,166), *p* = .18 |
| **% Males** | 66% | 77% | 77% | $\chi^2$ = 2.52, *p* = .28 |
| **FSIQ** | 112.79 (12.22) | 103.81 (13.17) | 99.19 (12.42) | F = 17.51 (2,166), *p* < .001* |
| **ADHD-RS total Hyperactive/ Impulsive score by teacher** | 2.41 (2.69) | 17.75 (6.33) | 19.57 (6.69) | F = 201.85 (2,165), *P* < .001* |
| **ADHD-RS total Inattentive score by teacher** | 2.30 (2.56) | 14.88 (6.37) | 16.14 (6.76) | F = 132.85 (2,165), *P* < .001* |
| **ADHD-RS overall score by teacher** | 4.71 (4.39) | 32.63 (11.33) | 35.70 (11.87) | F = 212.88 (2,165), *P* < .001* |
| **ADHD-RS total Hyperactive/ Impulsive score by parent** | 4.68 (2.59) | 15.21 (6.25) | 17.73 (5.22) | F = 132.17 (2,166), *p* < .001** |
| **ADHD-RS total Inattentive score by parent** | 4.10 (2.86) | 11.69 (5.57) | 14.20 (4.56) | F = 90.02 (2,166), *p* < .001** |
| **ADHD-RS overall score by parent** | 8.78 (4.87) | 26.90 (11.21) | 31.93 (9.05) | F = 127.66 (2,166), *p* < .001** |

* = TD group differed from ADHD- and ADHD+ groups, the latter did not differ significantly
** = all three groups differed significantly from one another

Measures

As part of their clinical evaluation, each participant was administered a comprehensive assessment battery consisting of parent, teacher, and clinician behavioral ratings, a semi-structured diagnostic interview conducted with the primary caretaker, an assessment of general intellectual functioning, and a detailed neuropsychological assessment.

*Behavioral Ratings*

i. Attention Deficit/Hyperactivity Disorder (ADHD) Rating Scale–IV (ADHD-RS-IV; DuPaul et al., 1998): This scale consists of the eighteen DSM-IV behavioral descriptors of ADHD rated on a 4-point scale (0 = never or rarely, 1 = sometimes, 2 = often, and 3 = very often) and can be completed by a child's parent and/or teacher. The psychometric properties of the ADHD-RS-IV have been well established for children above the age of 5-years (DuPaul et al., 1998), and recent data have indicated that the measure is also highly reliable and valid when used with preschool children (McGoey, DuPaul, Haley, & Shelton, 2007). Consistent with this finding, the reliability in our sample of 3- and 4-year-old children, as assessed by coefficient alpha, was found to be quite strong for both parent ($\alpha$ = .92) and teacher ($\alpha$ = .94) ratings. For the purposes of the current study, two groups of children were selected to advance from the screening to the clinical assessment phase of the project based on ADHD-RS-IV ratings: children whose parents *and/or* teacher endorsed 6 or more symptoms of inattention *and/or* hyperactivity-impulsivity, and children whose parents *and* teacher endorsed fewer than 3 symptoms in *both* domains. A symptom was considered to be present if it received a rating of 2 or 3.

ii. Children's Problems Checklist (CPC; Healey, Miller, Castelli, Marks, & Halperin, 2008): The CPC was developed to assess impairment caused by ADHD symptoms in preschoolers. Separate but similar items for parents and teachers were developed to evaluate areas that were considered to indicate impairment in preschoolers with ADHD (i.e., disruptiveness, difficulty with peer relationships, difficulties with relationships with adults, low self-esteem, trouble settling down to sleep, and having accidents). For both forms, the rater was asked whether or not each domain was a problem for the child, and if so, to rate the severity of the problem on a three-point scale (i.e., 1= mild, 2= moderate, 3= severe). Scoring for the scales was completed separately for parent and teacher reports.

iii. The Behavioral Assessment Scale for Children- 2nd edition (BASC-2; Reynolds & Kamphaus, 2002): The BASC-2 is a well-standardized instrument that measures both adaptive and clinical dimensions of behavior. Clinical scales include measures of

Aggression, Hyperactivity, Conduct Problems, Anxiety, Depression, Somatization, Attention Problems, Learning Problems, Atypicality, and Withdrawal. Adaptive scales provide an assessment of Adaptability and Social Skills. Both parent and teacher ratings were collected.

iv. Behavior Rating Inventory for Children (BRIC; Gopin, Healey, Castelli, Marks, & Halperin, 2010): This rating scale was designed for clinicians to quickly rate a child's global behavior during a structured assessment session. Hyperactivity, impulsivity, inattention, sociability and mood are rated on a five-point Likert Scale, and anchor points, which serve as examples of each item, are used to guide the clinician in reliably using the scale.

v. Kiddie-SADS - Present and Lifetime Version (K-SADS; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996): This semi-structured clinical interview was used to identify the presence of various psychological disorders. For the current study, the ADHD and ODD screeners and diagnostic modules were administered by Ph.D. level clinicians or trained graduate students; information from multiple sources (i.e., responses during the clinical interview; parent and teacher ADHD-RS, BASC-2, and CPC ratings; clinician BRIC ratings) was integrated to achieve a diagnostic consensus. Psychologists and Ph.D. level clinicians subsequently applied DSM-IV algorithms to determine the presence of the above disorders and/or diagnostic subtypes. Children who exhibited 6 or more ADHD symptoms in a given domain and had significant impairment were classified as meeting criteria for ADHD (although, as indicated above, only those with the Hyperactive/Impulsive and Combined subtypes were included in this study). As defined in DSM-IV (APA, 2000), children who exhibited four or more symptoms of ODD and evidenced impairment in social or academic functioning were determined to meet criteria for ODD.

*Cognitive Assessment*

i. Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III; Wechsler, 2002): This psychometrically sound measure of intellectual functioning yields separate verbal and nonverbal measures of cognitive functioning (Verbal and Performance IQ, respectively), as well as a global composite index (FSIQ). The WPPSI-III was used in this study to characterize the sample with respect to intellectual abilities and was used to stratify the sample for group-wise comparisons.

ii. NEPSY: A Developmental Neuropsychological Assessment - Core Subtests (Korkman, Kirk, & Kemp, 1997): The NEPSY is a comprehensive assessment battery designed to assess proficiency across five neurocognitive domains: (1) The Attention/Executive Functioning domain provides an index of selective and sustained attention (Visual Attention subtest) and executive control (e.g., inhibition, self-regulation, and planning; Statue subtest); (2) The Language domain includes measures of receptive language (Comprehension of Instructions subtest) and phonological processing (Phonological Processing subtest). (3) The Sensorimotor domain assesses fine motor skills (Imitating Hand Positions subtest) and graphomotor speed and accuracy (Visuomotor Precision subtest). (4) The Visuospatial domain measures the ability to integrate visual and spatial information to reproduce simple and complex geometric figures (Design Copying subtest), as well as visuoconstructional abilities (construction of three-dimensional designs from two and three-dimensional models; Block Construction subtest). (5) Finally, the Memory domain measures the ability to recall primarily short-term verbal information. Subtests require repetition of sentences of increasing length (Sentence Repetition subtest) and recall of details from a short story (Narrative Memory subtest).

The NEPSY scores were analyzed on both the domain and the subtest level. Although the findings are easier to comprehend when domain comparisons are presented, it currently remains unclear whether the NEPSY results should indeed be analyzed on the domain level. A review of the structure of the 3-4-year-old NEPSY battery (Stinnett, Oehler-Stinnett, Fuqua, and Palmer, 2002) found that the within-domain subtest correlations are very low. Furthermore, in the latest version of the NEPSY (NEPSY-II; Korkman, Kirk, & Kemp, 2007), the authors present normative data only on the subtest level, suggesting that they too felt that the creation of domain scores, as configured in the original battery, might have been problematic. As such, the NEPSY results were also analyzed and discussed on the subtest level.

## Procedure

Children who met the aforementioned pre-screening criteria were invited to the on-campus laboratory to participate in the neuropsychological assessment, which was completed over two sessions, each lasting two to three hours. Following a description of the study and completion of consent procedures, parents were administered the K-SADS interview while the children underwent the psychometric assessment in an adjacent room. Clinicians rated the children's behavior at the conclusion of each session.

## Data Analysis

Two sets of multivariate analysis of variance (MANOVAs) were used to examine differences between ADHD-, ADHD+, and TD groups; one examined group differences in the five NEPSY domains (Attention/Executive Functioning, Language, Memory, Sensorimotor, Visuospatial Processing), and the other in the eleven individual NEPSY subtests. For subsequent analyses, conducted to examine the influence of Full Scale IQ on group differences, the sample was divided into thirds, forming "lower", "middle" and "higher" IQ groups. MANOVAs were then conducted to ascertain whether, after matching participants on FSIQ, ADHD group status resulted in significant differences in NEPSY domain scores. Similar analyses were also run on the subtest level. Significant omnibus tests were followed by one-way Analyses of Variance (ANOVAs) using Bonferroni-Holm corrections to identify the specific dependent measures on which the groups differed, followed by post hoc analyses using the Tukey Honestly Significant Difference (HSD) procedure to determine specific group differences. In addition, Cohen's *d* effect size calculations were used to further determine the magnitude of the group differences.

## Results

### *Domain Analyses, Entire Sample*

A MANOVA examining whether the TD, ADHD-, and ADHD+ groups differed in Attention/Executive Functioning, Language, Memory, Sensorimotor, and Visuospatial Processing revealed significant overall differences (Wilks' Lambda = .724 (10,318), $p < .001$). Subsequent univariate ANOVAs revealed significant ($p < .01$) group differences for all five Domain scores (i.e., Attention/Executive Functioning, Language, Visuospatial Processing, Sensorimotor, and Memory). Post-hoc analyses indicated that children in the TD group performed significantly better than children in the ADHD- and ADHD+ groups in the Attention/Executive Functioning, Language, Sensorimotor and Visuospatial Processing domains (See Table 2). The ADHD+ and ADHD- groups did not differ significantly in any of these domains. The TD group also performed significantly better than the ADHD+ group in the Memory domain; however, neither the ADHD+ nor the TD group differed significantly from the ADHD- group.

Table 2. Mean (SD) Scores for TD, ADHD-, and ADHD+ Groups on the Five NEPSY Domains

| **Domain** | **Mean (SD)** | | | **Post Hoc Tests** | **Effect Sizes (*d*)** | | |
|---|---|---|---|---|---|---|---|
| | *TD* | *ADHD -* | *ADHD +* | | *TD & ADHD -* | *TD & ADHD +* | *ADHD - & +* |
| **A/E** | 106.90 (12.52) | 97.22 (12.27) | 92.98 (11.66) | TD > ADHD-§ TD > ADHD+§ | 0.78 | 1.15 | 0.35 |
| **L** | 105.84 (10.96) | 98.90 (12.67) | 98.02 (11.35) | TD > ADHD-* TD > ADHD+* | 0.59 | 0.70 | 0.07 |
| **S** | 98.03 (14.93) | 89.86 (12.70) | 89.74 (15.33) | TD > ADHD-* TD > ADHD+* | 0.59 | 0.55 | 0.01 |
| **V** | 111.59 (11.96) | 104.14 (12.75) | 102.16 (11.93) | TD > ADHD-* TD > ADHD+§ | 0.60 | 0.79 | 0.16 |
| **M** | 98.23 (13.88) | 92.55 (17.07) | 87.07 (13.53) | TD > ADHD+§ | 0.37 | 0.81 | 0.36 |

* $p < .01$; § $p < .001$
A/E = Attention/Executive, L = Language, S = Sensorimotor, V = Visuospatial,
M = Memory

*Subtest Analyses, Entire Sample*

Further analyses were conducted to ascertain which specific subtests significantly differentiated the groups. The MANOVA revealed an overall significant effect (Wilks' Lambda = .639 (22,308), $p < .001$), and the between-group effect was significant for seven out of the eleven subtests investigated (i.e., Design Copying, Comprehension of Instructions, Imitating Hand Positions, Narrative Memory, Block Construction, Sentence Repetition, and Statue). Post-hoc examination of differences revealed a pattern of subtest performance largely consistent with that of the domains such that the TD group performed significantly better than both ADHD groups, regardless of ODD status. Although the two diagnosed groups did not differ significantly from one another, effect size calculations revealed what Cohen (1988) defined as small to medium differences between the two diagnosed groups for the Statue and Narrative Memory subtests ($d$ = .36 and .48, respectively), such that the ADHD+ group performed more poorly. Means, standard deviations, and results of post hoc analyses are presented in Table 3.

Table 3. Mean (SD) scores of TD, ADHD-, and ADHD+ Participants on the 11 NEPSY subtests

| **Subtest** | **Mean (SD)** | | | **Post Hoc Tests** | **Effect Size (*d*)** | | |
|---|---|---|---|---|---|---|---|
| | *TD* | *ADHD -* | *ADHD +* | | *TD & ADHD-* | *TD & ADHD+* | *ADHD - & +* |
| BPN | 10.33 (3.09) | 9.33 (3.12) | 9.33 (3.30) | --- | 0.32 | 0.31 | 0.00 |
| DC | 12.35 (2.64) | 11.51 (2.31) | 11.00 (2.40) | TD > ADHD+* | 0.34 | 0.54 | 0.22 |
| PA | 10.25 (2.50) | 9.60 (2.42) | 9.40 (2.46) | --- | 0.26 | 0.34 | 0.08 |
| VA | 11.62 (2.35) | 11.08 (2.42) | 10.65 (2.30) | --- | 0.23 | 0.42 | 0.18 |
| CI | 11.97 (2.40) | 10.47 (2.59) | 10.19 (2.27) | TD > ADHD-‡, TD > ADHD+‡ | 0.60 | 0.76 | 0.11 |
| IHP | 9.57 (2.55) | 8.10 (2.44) | 8.35 (2.82) | TD > ADHD-‡, TD > ADHD+* | 0.59 | 0.45 | 0.09 |
| VP | 9.81 (3.26) | 8.61 (3.20) | 8.33 (3.24) | --- | 0.37 | 0.46 | 0.09 |
| NM | 9.22 (3.17) | 8.86 (3.37) | 7.40 (2.62) | TD > ADHD+‡ | 0.11 | 0.63 | 0.48 |
| BC | 11.52 (2.65) | 9.82 (2.91) | 9.63 (2.56) | TD > ADHD-‡, TD > ADHD+‡ | 0.61 | 0.73 | 0.07 |
| SR | 10.22 (2.13) | 8.80 (2.81) | 8.44 (2.33) | TD > ADHD-*, TD > ADHD+‡ | 0.57 | 0.80 | 0.14 |
| S | 10.44 (3.16) | 8.02 (2.50) | 7.14 (2.35) | TD > ADHD-§, TD > ADHD+§ | 0.85 | 1.19 | 0.36 |

* $p < .05$; ‡ $p < .01$; § $p < .001$
BP = Body Part Naming, DC = Design Copying, PP = Phonological Processing, VA = Visual Attention, CI = Comprehension of Instructions, I = Imitating Hand Positions, VM = Visuomotor Precision, NM = Narrative Memory, BC = Block Construction, SR = Sentence Repetition, and S = Statue.

*Domain Analyses, Stratified Sample*

To ascertain whether or not differences in FSIQ contributed to these findings, the entire sample was divided into thirds; the “lower” group was found to have FSIQ scores less than or equal to 99, the “middle” group had FSIQ scores between 100 and 112, and the “higher” group had FSIQ scores greater than or equal to 113. Within each of the IQ groups, there was no significant difference in FSIQ between the TD, ADHD-, and ADHD+ groups (F

= 1.34 (2,47), *p* = .27 for the "lower" IQ group; F = 2.80 (2,60), *p* = .07 for the "middle" IQ group; F = .25 (2,59), *p* = .78, for the "higher" IQ group). Of note, the difference in the proportion of TD, ADHD-, and ADHD+ participants in each FSIQ group was significant ($\chi^2$ = 25.56(4), *p* < .001; see Table 4).

Table 4. IQ group ("lower", "middle", and "higher") by ADHD group (TD, ADHD-, and ADHD+)

| | | ADHD group status | | | Total |
|---|---|---|---|---|---|
| | | **TD** | **ADHD-** | **ADHD+** | |
| **IQ group status** | **"lower"** | 10 (13.7%) | 18 (34.6%) | 20 (45.5%) | 48 (28.4%) |
| | **"middle"** | 23 (31.5%) | 21 (40.4%) | 17 (38.6%) | 61 (36.1%) |
| | **"higher"** | 40 (54.8%) | 13 (25%) | 7 (15.9%) | 60 (35.5%) |
| **Total** | | 73 | 52 | 44 | 169 |

$\chi^2$ = 25.6(4), *p* < .001

Because the sample was further subdivided into the three IQ groups, the sample sizes became considerably smaller, which meant that the analyses likely lacked the power necessary to detect group differences. As such, the decision was made to focus on effect sizes (Cohen's *d*) rather than significance values. Effect sizes greater than or equal to 0.5, as defined by Cohen (1988), were considered to be clinically significant. Careful examination of the means and standard deviations of each group uncovered considerable diagnostic group differences in the "lower", "middle", and "higher" IQ groups.

<u>*Lower IQ Group*</u>. Within the "lower" IQ group, the effect sizes calculated to assess the differences in performance between the TD and ADHD- participants were in the medium to large range for each of the domains. Differences in the performance of the TD and ADHD+ groups were fairly similar to those of the TD and ADHD- group; however, there was no difference in their Language functioning. The two ADHD groups evidenced fairly similar profiles, but there was a medium effect size for the differences in both the Language

and Memory domains (*d* = .51 and .43, respectively; See Table 5 for specific effect sizes), such that the ADHD+ group performed better than the ADHD- group.

Table 5. Mean scores (Standard Deviations) for the TD, ADHD-, and ADHD+ groups within the "lower" IQ group on the 5 NEPSY domains and results of post-hoc analyses

| **Domain** | **Mean (SD)** | | | **Effect Size (*d*)** | | |
|---|---|---|---|---|---|---|
| | *TD* | *ADHD-* | *ADHD+* | *TD & ADHD-* | *TD & ADHD+* | *ADHD- & ADHD+* |
| **Attention/Executive** | 99.78 (17.50) | 89.24 (11.96) | 91.75 (11.26) | 0.70 | 0.55 | 0.22 |
| **Language** | 94.00 (7.11) | 88.06 (12.04) | 93.80 (10.65) | 0.60 | 0.02 | 0.51 |
| **Sensorimotor** | 96.33 (18.02) | 85.41 (13.90) | 84.35 (12.77) | 0.68 | 0.77 | 0.08 |
| **Visuospatial** | 108.22 (9.08) | 98.00 (12.37) | 98.45 (12.54) | 0.94 | 0.89 | 0.04 |
| **Memory** | 89.33 (6.69) | 78.82 (13.93) | 84.95 (14.37) | 0.96 | 0.39 | 0.43 |

*Middle IQ Group*. Within the "middle" IQ group, the performance of the TD and ADHD- participants was more similar than it was for those individuals in the "lower" IQ group. However, there was a large difference between the performance of the TD and ADHD+ children in the Attention/Executive Functioning domain (*d* = 1.28); participants in the TD group performed better than those in the ADHD+ group. In addition, there was a medium difference in performance within the Language domain, and the effect sizes for the other three domains of functioning (i.e., Sensorimotor, Visuospatial, and Memory) were small. Across domains, the ADHD+ group performed more poorly than the TD group. There was also a large difference in the performance of the ADHD- and ADHD+ participants within the Attention/Executive Functioning domain, as well as a medium difference in the Language and Memory domains (See Table 6). The ADHD- participants outperformed the ADHD+ participants in each of these domains.

Table 6. Mean scores (Standard Deviations) for the TD, ADHD-, and ADHD+ groups within the “middle” IQ group on the 5 NEPSY domains and results of post-hoc analyses

| **Domain** | **Mean (SD)** | | | **Effect Size (*d*)** | | |
|---|---|---|---|---|---|---|
| | *TD* | *ADHD-* | *ADHD+* | *TD & ADHD-* | *TD & ADHD+* | *ADHD- & ADHD+* |
| **Attention/ Executive** | 106.04 (10.32) | 102.14 (9.87) | 92.71 (10.53) | 0.39 | 1.28 | 0.92 |
| **Language** | 102.87 (10.92) | 101.00 (8.68) | 97.29 (6.51) | 0.19 | 0.62 | 0.48 |
| **Sensorimotor** | 96.17 (15.78) | 91.67 (12.99) | 91.59 (14.74) | 0.31 | 0.30 | 0.01 |
| **Visuospatial** | 105.70 (9.82) | 103.71 (12.20) | 101.94 (10.46) | 0.18 | 0.37 | 0.16 |
| **Memory** | 92.61 (15.45) | 94.19 (13.47) | 88.18 (9.56) | 0.11 | 0.34 | 0.51 |

*Higher IQ Group*. Effect size calculations conducted to assess the difference in performance of the TD, ADHD-, and ADHD+ participants in the “higher” IQ group revealed considerable differences within the Attention/Executive Functioning, Sensorimotor, and Memory domains. Specifically, there was a large difference in the performance of the TD group and both ADHD groups in the Attention/Executive Functioning domain such that the TD group outperformed both ADHD groups; the difference in the performance of the two ADHD groups was small. The ADHD- children performed more poorly than the TD and ADHD+ children on tasks within the Sensorimotor domain, resulting in a medium effect size. Finally, within the Memory domain, the ADHD- children outperformed the TD participants, who performed better than the ADHD+ children. The resulting effect size comparing the performance of the TD and ADHD- children was small, that of the TD and ADHD+ participants was medium, and that of the two ADHD groups was large (See Table 7).

Table 7. Mean scores (Standard Deviations) for the TD, ADHD-, and ADHD+ groups within the "higher" IQ group on the 5 NEPSY domains and results of post-hoc analyses

| **Domain** | **Mean (SD)** | | | **Effect Size (*d*)** | | |
|---|---|---|---|---|---|---|
| | *TD* | *ADHD-* | *ADHD+* | *TD & ADHD-* | *TD & ADHD+* | *ADHD- & ADHD+* |
| **Attention/ Executive** | 109.18 (11.82) | 99.69 (11.61) | 96.00 (15.78) | 0.81 | 0.95 | 0.27 |
| **Language** | 110.39 (8.95) | 109.54 (7.11) | 111.43 (13.01) | 0.11 | 0.09 | 0.18 |
| **Sensorimotor** | 99.41 (13.68) | 93.23 (9.68) | 100.29 (17.69) | 0.52 | 0.06 | 0.50 |
| **Visuospatial** | 115.51 (12.22) | 112.85 (9.42) | 111.86 (9.44) | 0.24 | 0.33 | 0.10 |
| **Memory** | 103.67 (11.61) | 107.62 (11.52) | 91.57 (18.86) | 0.34 | 0.77 | 1.03 |

*Subtest Analyses, Stratified Sample*

Similar analyses were then run on the subtest level. Within the "lower" IQ group, the performance of the ADHD- and ADHD+ participants was fairly similar. However, on the Sentence Repetition subtest, the mean score of the ADHD- group was considerably lower than that of the ADHD+ children (See Figure 1a). Additionally, both diagnosed groups differed from the TD group on the Imitating Hand Position, Visuomotor Precision, Block Construction, and Statue subtests.

Within the "middle" IQ group, the two diagnosed groups differed in their performance on the Visual Attention, Narrative Memory, and Statue subtests. On each of the measures, the ADHD+ group's mean score was lower than that of the ADHD- group (See Figure 1b). Furthermore, analysis of the means and standard deviations resulting from the groups' performances on the Statue subtest revealed a medium-sized difference in the performance of the TD group relative to that of the ADHD- group ($d$ = .56) but a large difference between the TD and ADHD+ group ($d$ = 1.3). In both cases, the TD group outperformed the respective ADHD group.

Finally, in the “higher” IQ group, seven out of the eleven subtests (i.e., Body Part Naming, Design Copy, Visual Attention, Narrative Memory, Block Construction, Sentence Repetition, and Statue) yielded clinically significant differences in performance across all three groups (See Figure 1c). There was considerable variability in the pattern of relative performance of the TD, ADHD-, and ADHD+ groups. Means, standard deviations, and effect sizes are specified in Table 8.

Figure 1a.

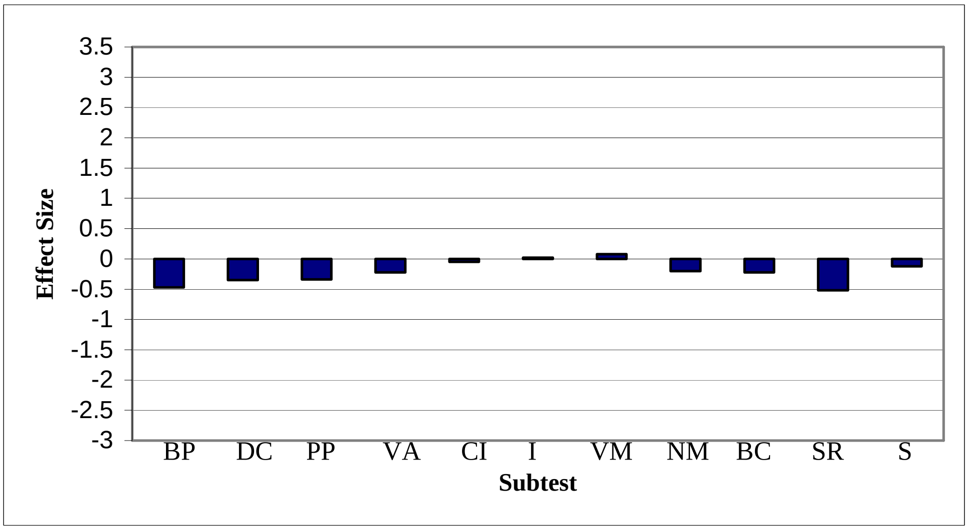



Figure 1b.

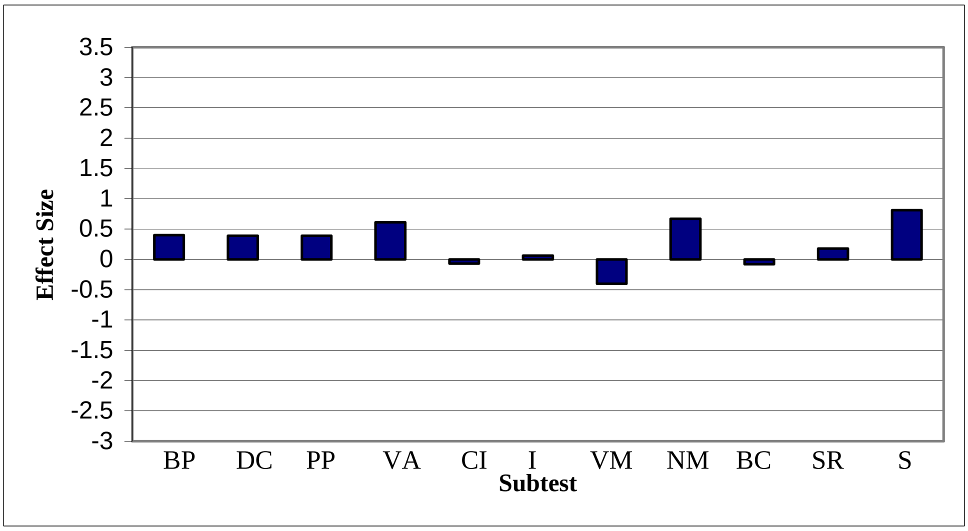


Figure 1c.

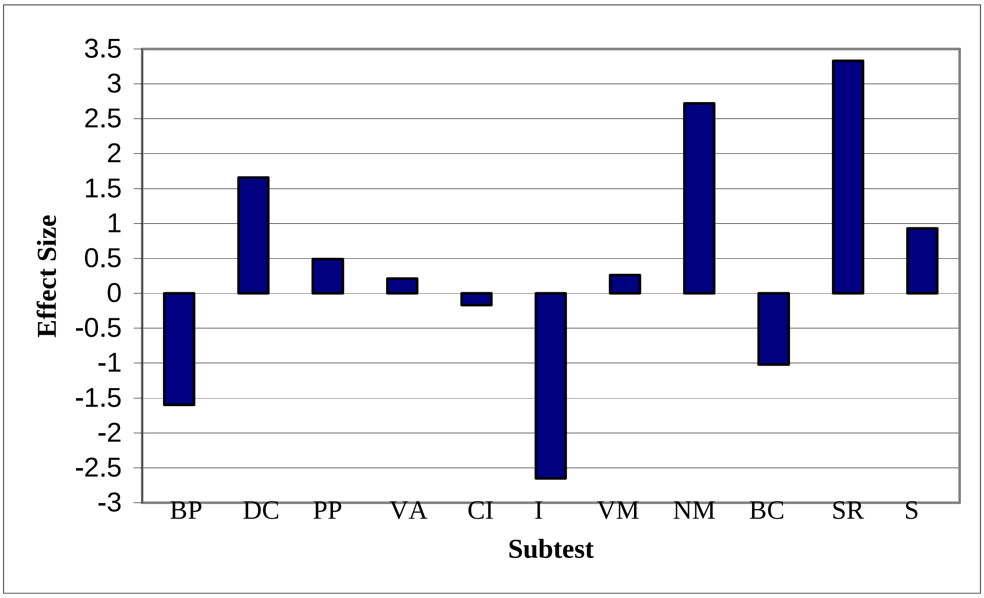



*Figure 1*. Effect sizes (Cohen's *d*) assessing the differences between the ADHD- and ADHD+ participants, within the (a) "lower", (b) "middle", and (c) "higher" IQ groups, on the 11 NEPSY subtests. A positive effect size indicates that the mean score of the ADHD- group was greater than that of the ADHD+ group, whereas a negative effect size reveals that the ADHD+ group outperformed the ADHD- group. (a) Depicts that only one subtest had an effect size that was considered to be clinically significant (i.e., $d \geq 0.5$). (b) The effect sizes for the VA, NM, and S subtests were considered to be clinically significant (i.e., $d \geq 0.5$). (c) The effect sizes for all but four subtests (i.e., PP, VA, CI, and VM) were considered to be clinically significant (i.e., $d \geq 0.5$). BP = Body Part Naming, DC = Design Copying, PP = Phonological Processing, VA = Visual Attention, CI = Comprehension of Instructions, I = Imitating Hand Positions, VM = Visuomotor Precision, NM = Narrative Memory, BC = Block Construction, SR = Sentence Repetition, and S = Statue.

Table 8. Mean scores (Standard Deviations) for the TD, ADHD-, and ADHD+ groups within the “higher” IQ group on the 11 NEPSY subtests and results of post-hoc analyses

| **Subtest** | **Mean (SD)** | | | **Effect Size (*d*)** | | |
|---|---|---|---|---|---|---|
| | *TD* | *ADHD-* | *ADHD+* | *TD & ADHD-* | *TD & ADHD+* | *ADHD- & ADHD+* |
| Body Part Naming | 11.74 (.40) | 11.39 (.69) | 12.71 (.94) | 0.62 | 1.34 | 1.60 |
| Design Copying | 12.90 (.38) | 13.31 (.66) | 12.00 (.90) | 0.76 | 1.30 | 1.66 |
| Phonological Awareness | 10.54 (.39) | 10.69 (.68) | 10.29 (.92) | 0.27 | 0.35 | 0.49 |
| Visual Attention | 12.13 (.33) | 11.85 (.56) | 11.71 (.77) | 0.61 | 0.71 | 0.21 |
| Comprehension of Instructions | 12.69 (.32) | 12.46 (.55) | 12.57 (.75) | 0.51 | 0.21 | 0.17 |
| Imitating Hand Positions | 9.56 (.44) | 8.46 (.76) | 10.86 (1.03) | 1.77 | 1.64 | 2.65 |
| Visuomotor Precision | 10.21 (.47) | 9.39 (.82) | 9.14 (1.11) | 1.23 | 1.26 | 0.26 |
| Narrative Memory | 10.23 (.53) | 11.54 (.91) | 8.57 (1.25) | 1.76 | 1.73 | 2.72 |
| Block Construction | 12.46 (.44) | 11.08 (.76) | 12.00 (1.03) | 2.22 | 0.58 | 1.02 |
| Sentence Repetition | 10.02 (.31) | 11.00 (.54) | 8.86 (.73) | 2.23 | 2.07 | 3.33 |
| Statue | 10.77 (.45) | 8.00 (.77) | 7.14 (1.05) | 4.39 | 4.49 | 0.93 |

## Discussion

The present study was designed to assess the neuropsychological functioning of preschool children who received formal diagnoses of ADHD+ODD, those who received a diagnosis of ADHD but not comorbid ODD, and typically developing controls on a variety of tasks, spanning five major neuropsychological domains (i.e., Attention/Executive Functioning, Language, Memory, Sensorimotor, and Visuospatial Processing). This was undertaken in an effort to ascertain whether youngsters with ADHD exhibit specific deficiencies in executive function, or whether such impairments are merely components of a more global pattern of dysfunction. The study further aimed to investigate whether comorbid ODD can account for the EF deficits that are frequently attributed to ADHD. An additional goal of the study was to ascertain the extent to which EF deficits, if present, might be at least partially accounted for by differences in intellectual functioning.

The findings consistently indicated that, when not accounting for differences in IQ, children in the TD group could be distinguished from *both* ADHD groups based on differences in neuropsychological functioning; that is, the presence of ODD symptoms did not seem to confer greater neuropsychological risk above and beyond ADHD in isolation. Both the ADHD- and ADHD+ groups exhibited a broad array of cognitive difficulties, and there were few differences between the performances of the two diagnosed groups. Results of the current study further indicated that, even though parents rated children in the comorbid group as having greater ADHD symptom severity than those who do not have an ODD diagnosis, such differences did not translate into substantive variations in neuropsychological functioning.

In contrast, the previous work of Youngwirth et al. (2006) revealed that children with symptoms of ADHD+ODD differed from controls on several measures of neuropsychological functioning but neither group differed from children with symptoms of ADHD alone. The differences in the results of these two studies are likely due to differences in group selection criteria. In the Youngwirth et al. (2006) study, the authors included participants who displayed symptoms of hyperactivity and oppositionality/defiance; however, it remains unclear whether those children would have indeed met diagnostic criteria for ADHD and/or ODD. In contrast, in the present study, we used information gleaned from parent and teacher ratings of symptoms and impairment, a semi-structured parent interview, and clinician observation to arrive at categorical diagnoses, possibly resulting in a more symptomatic and/or impaired sample. The fact that, in the current study, children in the ADHD groups performed more poorly than typically developing children on even more tasks than were reported in the study conducted by Youngwirth and colleagues (2006) seems to suggest that our sample was indeed more impaired.

Additional preliminary analyses conducted as part of the current study further revealed that, upon stratifying the sample so that groups were more closely matched in intellectual functioning, interesting patterns of performance start to emerge. Within the “lower” IQ group, both ADHD- and ADHD+ participants exhibited weaknesses in sensorimotor abilities and visuospatial skills relative to those of typically developing children. Analysis of children in the “higher” IQ group’s performance on tasks within those two domains, however, differentiated the two diagnostic groups from one another. Namely, a visuospatial deficit was exhibited solely by those diagnosed with ADHD+, while a specific deficit in sensorimotor abilities emerged only within the ADHD- group. In addition, ADHD- participants within the “lower” IQ group demonstrated a relative impairment in language functioning. Finally, “lower” and “higher” IQ children diagnosed with ADHD, regardless of whether or not they also displayed symptoms of ODD, exhibited deficits in attention/executive functioning. Amongst those in the “middle” IQ group, though, such attention/executive functioning difficulties were specific to the ADHD+ children.

It is possible that, in taking a more fine-grained look at the neuropsychological profiles of the participants, specific deficits associated with each diagnostic group can be identified. Based on the current results, ADHD- seems to be primarily associated with weaknesses in basic sensorimotor and linguistic abilities. If this is indeed the case, it is feasible that the deficits demonstrated in the executive functioning domain are actually secondary to such difficulties and not the principal source of the dysfunction evident in ADHD-.

ADHD+, on the other hand, was not found to be associated with early motor and language difficulties. Rather, the ADHD+ pattern of performance highlighted weaknesses in attention/executive functioning and memory. It is possible that in this form of the disorder, children actually do exhibit primary impairment in higher-level cognitive control abilities, the same systems discussed as the underlying mechanism in the development of disorders such as substance abuse. Difficulties that emerged in aspects of memory may then be explained as a reflection of the underlying impairment in the attention/executive function domain.

Caution must be taken when interpreting these data as dividing the children into the three IQ groups reduced the sample size considerably, yielding inadequate power to detect statistically significant group differences for most contrasts. The results of these analyses are tentative at best and require replication with a larger sample before definitive conclusions can be drawn. Nevertheless, the substantial diagnostic group differences in performance that were revealed through the effect size calculations suggest that future investigations may indeed find that ADHD- and ADHD+ exhibit distinct neuropsychological profiles, if their level of general intelligence is considered.

Regardless of whether or not one controls for IQ, one can readily conclude that ADHD is not purely a disorder of attention/executive functioning. Although this domain continually emerged as an area of difficulty for the diagnostic groups, other non-specific weaknesses were also evident. As such, these findings are consistent with the assertion that an executive dysfunction model of ADHD cannot fully explain the wide array of deficits that are associated with this disorder (Halperin, Marks, & Schulz, 2008). Further, the current results suggest that the inconsistencies in the literature regarding the neuropsychological impairment associated with ADHD are due to discrepancies in the samples under investigation, as consideration of general intelligence and comorbid oppositional defiant disorder revealed variability in the neuropsychological profile of ADHD preschoolers.

In sum, for the most part, children with ADHD with and without comorbid ODD perform similarly on measures of neuropsychological functioning. When the level of general intellectual functioning is not accounted for, the performance of both diagnosed groups is poorer than that of typically developing control children across neuropsychological domains. However, in taking IQ into account, differences in the neuropsychological profiles of ADHD- and ADHD+ preschoolers begin to emerge. Future analyses that extend those of the current study may indeed discover that the two groups should be considered as two distinct diagnostic entities, at least from a neuropsychological perspective. Taken at face value, though, the similarities in the neuropsychological profiles of ADHD- and ADHD+ preschoolers, when general intelligence is not taken into account, seem to suggest that the two groups can, for the most part, be considered one diagnostic entity from a neuropsychological perspective.

*Study 2: ADHD Preschoolers with and without ODD: Do They Act Differently Depending Upon Degree of Task Engagement/Reward?*

As reviewed in Study 1, executive dysfunction has received considerable attention within the ADHD literature. Recent meta-analyses (Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Willcutt et al., 2005), however, have called into question whether impairments in putative executive functions are either necessary or sufficient to account for the breadth of disturbances associated with the disorder, as many children who display symptoms of ADHD do not exhibit weaknesses in any area of executive functioning. In light of the fact that: (i) individuals with ADHD may not present with EF deficiencies, (ii) those without ADHD (e.g., individuals with other psychiatric disorders) may exhibit impoverished EF skills (Geurts et al., 2004; Pennington & Ozonoff, 1996; Bornstein, 1990; Moritz et al., 2002), and (iii) impairments in non-executive domains have comparable if not greater discriminative capability (Jakobson & Kikas, 2007; Bruce et al., 2006; Dewey et al., 2002; Dewey et al., 2007; Piek et al., 1999; Smith & Bryson, 1994), it has become increasingly clear that measures of executive functioning may lack adequate specificity to be considered the sole, defining feature of the disorder.

It is most likely, therefore, that a dual- or multiple-pathway model must be employed to understand the causal/associative features of the disorder. One model that has received considerable attention within the literature posits that individuals diagnosed with ADHD have a dysfunction in motivational and/or reinforcement systems (Sonuga-Barke, Taylor, Sembi, & Smith, 1992; Tripp & Alsop, 2001; Castellanos & Tannock, 2002; Sonuga-Barke, 2002; Doyle et al, 2005; Johansen & Sagvolden, 2004; Sagvolden, Johansen, Aase, & Russell, 2005; Luman et al., 2007). Several theoretical models have been proposed to explain this deficiency. Some investigators have emphasized that fronto-limbic, dopaminergic abnormalities result in an inability to accurately process stimuli associated with reward (Sagvolden et al., 2005; Sonuga-Barke-2002). Others have proposed that children with ADHD have an elevated reward threshold and therefore require additional reward in order to optimize their performance (Haenlein & Caul, 1987). A third conceptualization is that individuals with ADHD are not able to use intrinsic motivation to optimize performance (Douglas, 1989; Sergeant, Oosterlann, & Van der Meere, 1999; Luman et al., 2007). It has also been suggested that the problem is not related to reward per se; rather, it is associated with decreased sensitivity to conditions of non-reward and punishment (Quay, 1988a, 1988b, 1988c, 1997).

Regardless of the underlying mechanism, the ADHD-associated abnormal response to reinforcement potentially poses additional problems when a comorbid disruptive behavior disorder is present because it increases the likelihood that the maladaptive behaviors will be maintained (Sagvolden et al., 2005). Based on Patterson’s (1982) model, Sagvolden and colleagues explain that disruptive, or as they entitle it, “coercive behaviors”, are the outgrowth of inappropriate/ineffective parenting, such that a child’s nagging or misbehavior is reinforced when parents succumb to the child’s request. This then causes the child to temporarily terminate those behaviors, thereby reinforcing the parent’s willingness to give in to future misbehavior. This cycle, in general, becomes difficult to extinguish because of its mutually rewarding nature. With an ADHD child, who has less efficient reinforcement processing abilities, however, this cycle takes longer to terminate despite conscious attempts to refrain from reinforcing the bad behavior (Sagvolden et al., 2005). The attempt to eliminate the previously reinforced responses of children diagnosed with ADHD initially results in excessive responding (Sagvolden, Aase, Zeiner, & Berger, 1998), which will likely increase the probability that parents will become frustrated with the extinction process and return to rewarding the child so as to reap the immediate benefits.

A diagnosis of ODD also seems to be associated with a response to reinforcement that is different than that of typically developing children (Luman, Oosterlaan, & Sergeant, 2005). Studies that compare task performance of children with ADHD to that of children with ODD during different reinforcement conditions do not reveal differences between the groups. Nevertheless, results of the studies do indicate that the performance of children with ODD, without comorbid ADHD, is less optimal than that of age-matched typically-developing controls, regardless of the reinforcement contingency (Oosterlaan & Sergeant, 1998; Scheres, Oosterlaan, & Sergeant, 2001). It is possible, therefore, that when ADHD and ODD occur comorbidly, the impact of the resultant aberrant reward system will be that much greater in magnitude than it is in ADHD alone.

In fact, Quay (1988a, 1988b, 1988c, 1997) argues that while both ADHD and ODD populations respond to reinforcement in a manner that is different from that of typically-developing children, this is the result of different mechanisms. Quay bases his model on Gray's (1982, 1987) theory of learning and emotion, in which three systems are hypothesized to collaborate in modulating behavior: the behavioral inhibition system (BIS), the behavioral activation system (BAS), and the nonspecific arousal system (NAS). According to Quay, the BIS, which involves the septo-hippocampal system and is normally activated by non-reward/punishment conditions, is under-activated in children with ADHD. ODD, on the other hand, is thought to be associated with an overactive BAS, meaning that the nucleus accumbens, ventral striatum, and dopaminergic pathway, which are normally activated under conditions of reward, are overly active. It would follow, therefore, that a child who is diagnosed with both disorders would present with even more atypical responses to reinforcement than would a child with a sole diagnosis of ADHD or ODD.

Many of the investigations cited to bolster the hypothesis that ADHD is associated with an abnormal response to reinforcement actually report that diagnoses of both ADHD and ODD were present in the populations that they studied (Sonuga-Barke, Taylor, Sembi, & Smith, 1992; Oosterlaan & Sergeant, 1998; Tripp & Alsop, 2001; Luman, et al., 2007). Some of those investigations discuss the fact that this comorbidity is a possible confounder of the dependent variables under investigation. Nevertheless, the impact of ODD on the relationship between ADHD and a deficient reinforcement system has not been investigated (Luman, Oosterlaan, & Sergeant, 2005).

Thus, the main objective of the present study was to examine the effects of task engagement/reinforcement on reaction time (RT) and RT standard deviation (RTSD) in typically developing (TD) children, those with a diagnosis of ADHD, and those with diagnoses of both ADHD and ODD. It was hypothesized that task engagement/reinforcement will have a significantly greater impact on the performance of children in the ADHD+ODD group as compared to that of children with a diagnosis of ADHD without comorbid ODD and to those in the TD group.

## Methods

<u>Participant Characteristics</u>

The children who participated in this study were a sub-sample of those described above (see Study 1). The Preschool Balloon Popping task (described below) was added to the assessment battery after many of the children in were already evaluated. As such, only a portion of the larger sample was administered this measure. The resulting sample consisted of 73 preschool children (boys = 52; girls = 21) with a mean (SD) age of 4.39 (.41) years. The ADHD- group consisted of children who received K-SADS diagnoses of ADHD, predominantly Hyperactive or Combined Type but not ODD (n = 20). The ADHD+ group was comprised of children who received K-SADS diagnoses of ADHD, predominantly Hyperactive or Combined Type, and ODD (n = 17), and the typically-developing (TD) group consisted of children who did not receive a diagnosis of ADHD or ODD and who received parent and teacher ADHD-RS ratings of fewer than three ADHD symptoms in both domains (n = 36). Any child who exhibited numerous, sub-threshold symptoms of either disorder, warranting a diagnosis of ADHD-NOS or ODD-NOS was excluded from the analyses.

The groups did not differ significantly in gender or age ($\chi^2 = 2.05$ (2), $p > .05$; F = .35 (2,70), $p > .05$, respectively). The sample was ethnically diverse, and consisted of 41.1% Caucasian non-Hispanic, 15.1% Caucasian of Hispanic decent, 6.8% African-American non-Hispanic, 4.1% African-American of Hispanic decent, and 15.1% Asian individuals; 17.8% were of mixed ancestry. The groups differed in socio-economic status (SES), which was measured using the Nakao-Treas Socioeconomic Prestige Index (Nakao & Treas, 1994). The typically developing children were from families with higher SES [61.6(12.6)] than were the children in the ADHD+ group [50.2(15.3)], with neither group differing significantly in SES from the ADHD- group [53.4(17.4)]. As is to be expected, the two ADHD groups differed significantly from the typically developing children on ratings of ADHD behaviors (ADHD-RS, see below) by both parent (F = 79.37 (2,67), $p < .001$) and teacher (F = 74.94 (2,67), $p < .001$). The ADHD+ and ADHD- groups did not differ significantly in parent or teacher ratings of ADHD behaviors, which indicated that the two groups were equivalent in symptom severity. In addition, the groups differed significantly in Full Scale IQ (F = 3.24 (2,70), $p < .05$), such that the children in the ADHD+ODD group had a significantly lower IQ than did the typically developing children. Neither group's IQ differed significantly from that of the ADHD- group. Table 9 reports the participants' characteristics.

Table 9. Descriptive characteristics of the TD, ADHD-, and ADHD+ participants in Study 2

| **Group** | **TD (n= 36)** | **ADHD- (n=20)** | **ADHD+ (n=17)** | **Significance** |
|---|---|---|---|---|
| **Mean Age (SD)** | 4.36 (.41) | 4.45 (.50) | 4.35 (.32) | F = 0.35 (2,70), *p* = .71 |
| **% Males** | 78% | 70% | 59% | $\chi^2$ = 2.05 (2), *p* = .36 |
| **FSIQ** | 111.86 (14.56) | 107.80 (14.27) | 101.65 (10.70) | F = 3.24 (2,70), *p* < .05* |
| **ADHD-RS total Hyperactive/Impulsive score by parent** | 3.97 (2.51) | 16.10 (6.26) | 18.53 (5.08) | F = 78.31 (2,67), *p* < .001** |
| **ADHD-RS total Inattentive score by parent** | 3.14 (2.48) | 12.55 (5.96) | 14.93 (4.70) | F = 54.85 (2,67) (2,165), *p* < .001** |
| **ADHD-RS overall score by parent** | 7.11 (4.39) | 28.65 (11.28) | 33.47 (8.97) | F = 79.37 (2,67), *p* < .001** |
| **ADHD-RS total Hyperactive/Impulsive score by teacher** | 2.20 (2.83) | 17.85 (7.41) | 19.53 (6.63) | F = 81.84 (2,67), *p* < .001** |
| **ADHD-RS total Inattentive score by teacher** | 2.00 (2.46) | 13.70 (6.59) | 15.07 (7.93) | F = 46.53 (2,67), *p* < .001** |
| **ADHD-RS overall score by teacher** | 4.20 (4.52) | 31.55 (13.06) | 34.60 (13.43) | F = 74.94 (2,67), *p* < .001** |

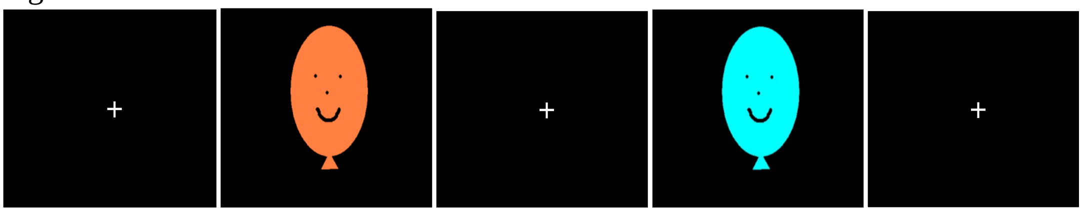
* = TD differed significantly from the ADHD + group only
** = TD differed significantly from ADHD- and ADHD+ groups

<u>Measures</u>

As part of their clinical evaluation, each participant was administered the comprehensive assessment battery described above (see Study 1). In addition, the children who participated in this investigation were administered

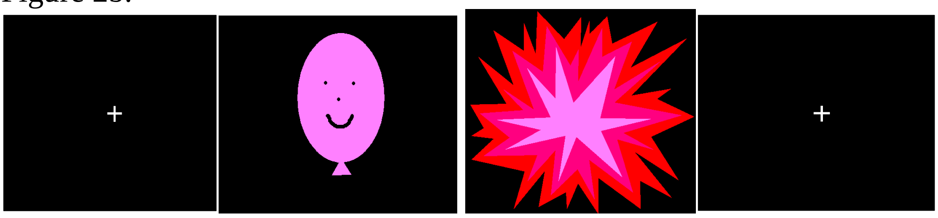
*The Preschool Balloon Popping Task*. This child-friendly computerized task consists of two reaction time (RT) task conditions: simple RT (SRT) and reinforced SRT (SRTr). The target stimuli, in each of the conditions, were bitmap images of brightly colored, smiley-faced balloons that appeared on a black background (See Figure 2). The balloons, which were created in Microsoft Paint, were approximately 14 cm high and 9 cm wide. During each condition, 20 balloons were presented in two different colors (e.g., 10 pink and 10 green) in random order. Children were told to press a mouse button to make the balloon go away. The mouse-press responses terminated the stimuli; if the child did not press the mouse button, the stimulus would remain on the computer screen for a maximum of 5 seconds. There were four inter-target intervals (ITI), which varied randomly but in equal frequency (i.e., 1800 ms, 2800 ms, 3800 ms, 4800 ms).

Figure 2a.



1800-1400ms    < 5000 ms

Figure 2b.



1500-4500 ms    < 5000 ms    300 ms    1500-4500 ms

*Figure 2*. Stimuli used in the (a) SRT and (b) SRTr conditions

The response device was a two-button stationary mouse. It was placed on a table at midline, equidistant between the child and the computer screen, which was situated approximately 1 foot in front of the child. The buttons on the mouse were large enough to accommodate the difficulties with fine motor coordination that periodically occur in young children. Additionally, the mouse buttons were clearly separated, with one on each side of the device, so that the children could easily press the button that corresponded to their dominant hand. For each SRT and SRTr trial, children were instructed to press the mouse button with their dominant index finger *as fast as possible* as soon as the stimulus appeared, regardless of the color of the stimulus. During the SRTr condition, though, the target balloon stimulus was followed by an engaging colorful visual and auditory "pop" feedback if the child responded within 1 second of the stimulus presentation.

## Procedure

Children who met the above-mentioned pre-screening exclusionary criteria were invited to the on-campus laboratory to participate in the assessment, which was completed over two sessions, each lasting two to three hours. Following a description of the study and completion of consent procedures, parents were administered the K-SADS interview while children underwent the psychometric assessment in an adjacent room. The Balloon Popping task was administered on the second day of the assessment.

To minimize distraction, children were tested in a small room that measured approximately 60 square feet in size; the door remained closed throughout the assessment. The session was highly structured by the examiner to maximize the extent to which the children remained properly engaged in the task. All examiners were well trained in administering tasks to preschool children, which ensured smooth and quick transitions between all tasks to minimize opportunities for off-task behavior. To guarantee that the RTs of these young children were truly the fastest responses that they could make, task administrators issued frequent reminders, as necessary, to respond as quickly as possible to each of the stimuli. Children were also redirected by the administrator during off-task behavior (e.g., talking, turning the head away from the screen) or incorrect responding (e.g., missing the stimulus, using the incorrect finger or hand to respond, pressing the mouse button more than once to respond).

Data Analysis

Across task conditions, responses that had RTs of less than 100ms were excluded, as they were likely to have been initiated prior to the onset of the stimulus and thus were not a measure of RT. All other responses were included in the analyses, as it was thought that the exclusion of very slow responses would mask the findings. However, because the very late responses were included, the median, as opposed to the mean RTs were used in the analyses to ensure that the results reflected the typical response pattern rather than the outliers.

A series of repeated measures ANOVAs were used to examine whether reinforcement would differentially impact the median RT and RTSD of the ADHD-, ADHD+, and TD groups. Task condition (i.e., SRT vs. SRTr) served as the within subjects variable; group and the order of task administration served as between subjects variables. To determine which groups, in particular, differed from one another during the SRT and SRTr conditions, significant interaction effects were followed-up by a one-way ANOVA in which the difference between the two conditions served as the dependent variable. Additionally, Cohen's *d* effect size calculations were used to further determine the magnitude of the group differences.

## Results

A repeated measures ANOVA was conducted to analyze group differences in response accuracy during the SRT and SRTr conditions. The main effect for condition was significant ($F = 4.89$ (1,67), $p < .05$), such that all children responded more accurately during the SRTr condition (93.7% correct) than they did during the SRT condition (88.4% correct). However, neither the main effect for group nor the main effect for order was significant ($F = .65$ (2, 67), $p = .52$ and $F = .27$ (1, 67), $p = .61$, respectively), and none of the interaction effects were significant. See Table 10 and Figure 3 for group comparisons.

Table 10. Accuracy, RT, and RTSD of the participants in the TD, ADHD-, and ADHD+ groups during the SRT and SRTr conditions

| **Group** | **TD (n= 36)** | **ADHD- (n=20)** | **ADHD+ (n=17)** | **Significance** |
|---|---|---|---|---|
| SRT Accuracy | 18.14 (2.91) | 16.85 (4.04) | 18.06 (1.68) | F = 1.25 (2,70), *p* = .29 |
| SRTr Accuracy | 18.72 (2.89) | 18.45 (2.35) | 19.06 (1.92) | F = .26 (2,70), *P* = .77 |
| SRT Median RT | 919.68 (334.28) | 966.28 (298.78) | 897.97 (262.90) | F = .19 (2,70), *P* = .83 |
| SRTr Median RT | 762.74 (233.42) | 866.03 (277.14) | 644.62 (163.35) | F = 1.76 (2,70), *P* = .18 |
| SRT RTSD | 593.22 (354.42) | 706.08 (306.35) | 818.51 (333.16) | F = 2.68 (2,70), *P* = .08 |
| SRTr RTSD | 427.31 (313.02) | 387.53 (277.56) | 362.38 (251.25) | F = .32 (2,70), *P* = .73 |

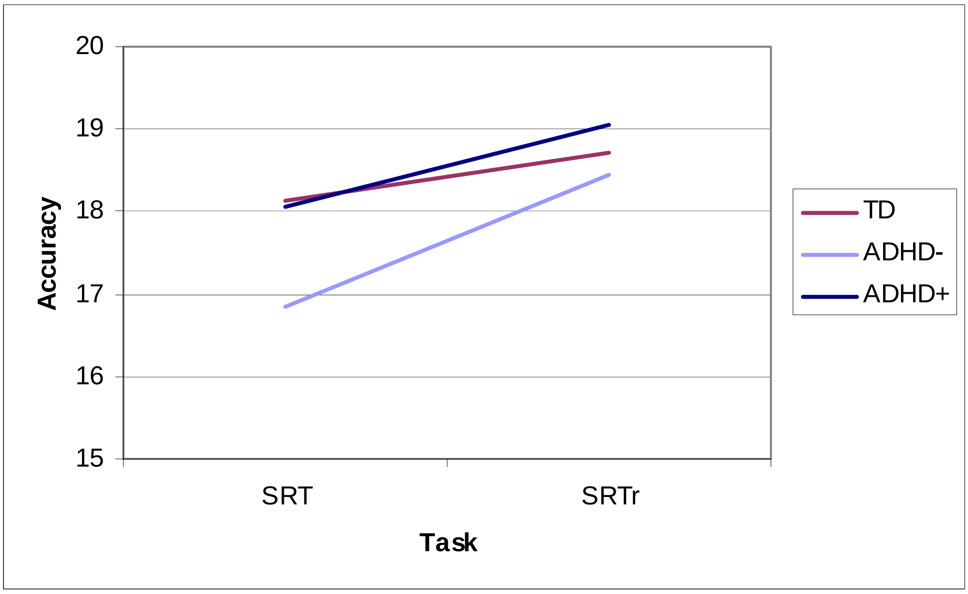



Figure 3. Response accuracy of the three groups (TD, ADHD-, and ADHD+) during the SRT and SRTr conditions. All children responded more accurately during the SRTr condition than the SRT condition ($p < .05$), but neither the main effect for group nor the group x reinforcement interaction was significant.

The repeated measures ANOVA analyzing the impact of reinforcement on the median RT of responding across the ADHD-, ADHD+, and TD groups revealed an overall main effect for reinforcement (F = 25.81 (1,67), $p < .001$), such that the median RT of all groups was faster during the SRTr than during the SRT condition. In addition, the main effect for order of task administration was significant (F = 4.44 (1,67), $p < .05$); when the SRT task was administered prior to the SRTr task, the median reaction time of all participants was faster that it was when the SRTr task was presented first (RT = 770.84 ms versus 895.84 ms). Once again, the main effect for group was not significant ($F$ = 1.74 (2,70), $p$ = .18). Similarly, there was no significant group x condition interaction (F = .85 (2,67), $p$ = .43), condition x order interaction (F = .12 (1, 67), $p$ = .73), or condition x group x order interaction (F = 1.15 (2,67), $p$ = .32; See Table 10 and Figure 4).

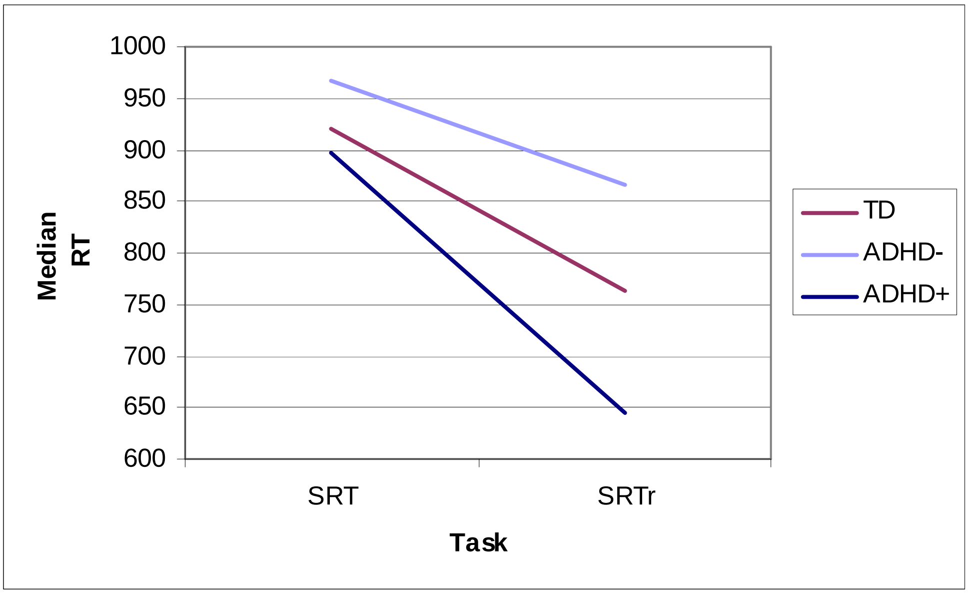



Figure 4. Median RT of the TD, ADHD-, and ADHD+ groups during the SRT and SRTr conditions. Although the main effect for reinforcement was significant ($p < .001$), neither the main effect for group nor the group x reinforcement interaction was significant.

When a similar repeated measures ANOVA was conducted with RTSD as the dependent variable, the main effect for reinforcement was again significant (F = 41.33 (1,67) $p < .001$). The RTSD of all participants was significantly less variable during the SRTr condition than it was during the SRT condition. The main effect for order approached significance (F = 3.08 (1,67), $p$ = .08), but the main effect for group was not significant (F = .58 (2,67), $p$ = .56). Although the condition x order and the three way interaction were not significant (F = .13 (1,67), $p$ = .73 and F = 2.41 (2,67), $p$ = .10), there was a significant group x reinforcement interaction (F= 3.38 (2,67), $p < .05$). To determine the nature of this interaction, the difference in RTSD between the two conditions was calculated and served as the dependent variable in a follow-up one-way ANOVA. The subsequent analysis revealed that the TD and ADHD+ groups differed significantly in their responses to the reinforcement manipulation, such that the difference in the ADHD+ group's RTSD across the two conditions [mean = 456.13 (333.38)] was significantly greater than that of the TD group [mean = 165.90 (442.87)]. The ADHD- group's RTSD change across the two conditions [mean = 318.55 (329.82)] did not differ significantly from the TD or the ADHD+ group (See Figure 5).

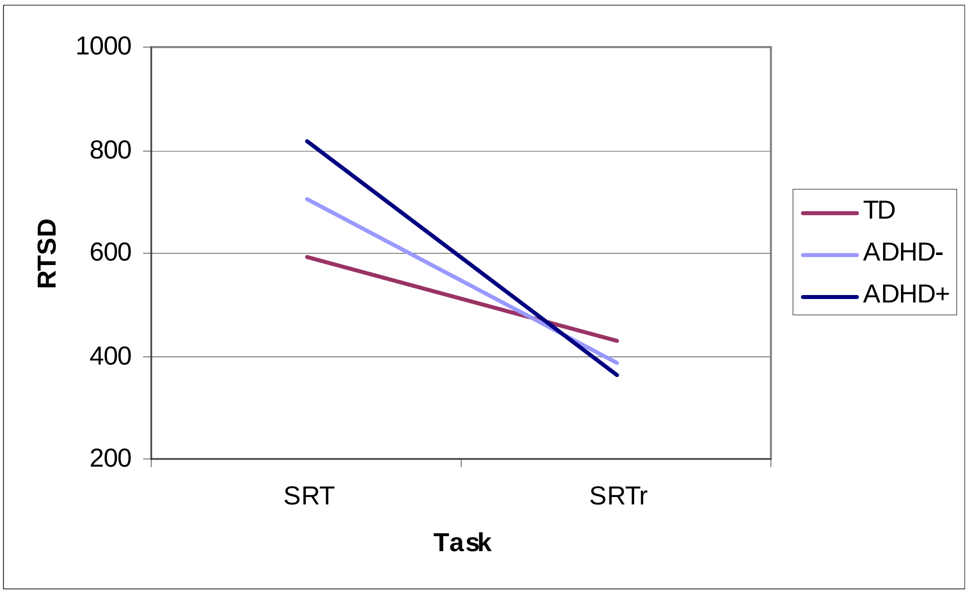



Figure 5. Group x reinforcement interaction with RTSD serving as the dependent variable. The main effect for group was not significant, but the main effect for reinforcement was significant ($p < .001$). In addition, there was a significant group x reinforcement interaction ($p < .05$), such that the TD and ADHD+ group differed significantly in RTSD but only during the SRT condition.

Effect size calculations for the RTSD change across the two conditions revealed moderately large differences ($d = 0.74$) between the TD and ADHD+ groups. The differences between each of those two groups and the ADHD- group were found to be in the small to medium range (*d* = 0.39 and *d* = 0.41, respectively) as defined by Cohen (1988). Through looking at the means and effect sizes of the three groups, it is clear that the performance of the ADHD- group fell in between that of the TD and ADHD+ group, suggesting that this group had a smaller response to the reinforcement manipulation than the ADHD+ children did but a greater reaction than the TD children.

## Discussion

The aim of this study was to investigate whether children who received diagnoses of ADHD+ODD, those who received a diagnosis of ADHD but not comorbid ODD, and typically developing preschool children differed in their response to reward/increased task engagement. Preliminary analyses did not reveal group differences in response accuracy. The ability of all preschool children to respond fairly accurately to the targets indicated that use of such a task in the preschool population is indeed valid. In addition, this finding made the remainder of the results interpretable, as the validity of any group differences in reaction times would otherwise have been subject to debate.

The groups also did not differ in median reaction time during the reinforced (SRTr) and non-reinforced (SRT) conditions, indicating that the processing speed abilities of all three groups of participants were similar during each condition. However, group differences were apparent when the variability in response reaction time (RTSD) was compared across tasks. Given that RTSD is the most sensitive of the measures used in detecting attentional lapses (for review, see Spencer et al., 2009), it is not surprising that significant findings were revealed through this particular set of analyses.

Regardless of whether the improvement in performance during the SRTr was due to the rewarding nature of the task or to its novelty, the fact that such robust effects are evident indicates that the task was indeed reinforcing. The results suggest that, while every preschool child benefits from reinforcement, children who have a propensity to be both hyperactive and oppositional are the most responsive to such feedback. When given reinforcement, the performance of ADHD+ODD children not only improves but is fully inline with that of typically developing children. As such, it appears that these children exhibit a deficient response to non-rewarding conditions; however, it remains uncertain whether they demonstrate an intact or a slightly exacerbated response to reward.

Based on these results, one can hypothesize that there is a disturbance in the frontostriatal dopamine circuitry, such that the reward system associated with ADHD+ODD is deficient relative to typically developing children. In contrast, the reward system in ADHD- appears fairly age-appropriate or, at the very most, is aberrant to a much smaller degree than it is in ADHD+. If one considers the hypothesis that these children display both a hypoactive behavioral inhibition system (BIS) and a hyperactive behavioral activation system (BAS; Quay, 1997), it is not surprising that the difference in their performance during a task that requires intrinsic motivation and one that involves extrinsic reward is particularly great. It is to be expected that the underactive nature of their BIS would result in a lack of motivation to respond consistently and efficiently during conditions of non-reward, while the overactive BAS would make them particularly sensitive to the reward condition.

This model implicates the septo-hippocampal system as well as the nucleus accumbens, ventral striatum, and dopaminergic pathways in the development of aberrant reward response seen in ADHD+ODD. Given that the nucleus accumbens is also the neural substrate of reward that has been implicated in the substance abuse literature (for review, see Deadwyler, Hayashizaki, Cheer, & Hampson, 2004), it is not surprising that ADHD+ODD children are at greater risk for future substance use and abuse (Looby, 2008). It is extremely important, therefore, that children with ADHD+ODD, in particular, receive early intervention to address their deficient motivational system.

Given their deficits, it would be expected that ADHD+ODD children would have the most robust response to behavioral interventions in which parents are taught techniques to motivate their children and modify their behaviors. Although parent training programs, in which parents are taught to positively attend to their children and to provide them with contingent rewards and/or punishments (Verduin, Abikoff, & Kurtz, 2008), have proven to be effective in the treatment of ADHD symptoms (Pelham & Fabiano, 2008; Eyeberg et al., 2001; Nixon, 2001), these programs were initially developed to mitigate symptoms of childhood conduct disorder (Forehand & McMahon, 1981; Webster-Stratton, 1982). In fact, some investigators have even posited that such an approach is often successful in improving the behavior of preschool children with ADHD only because the training is successful in addressing the high rate of comorbid oppositional and aggressive behaviors in this population (Webster-Stratton, Reid, & Hammond, 2004; Johnston & Mash, 2001). While some researchers have recently concluded that oppositional/aggressive behavior disorders do not moderate the outcome of parent training with ADHD children (Pelham & Fabiano, 2008), it is likely that ADHD+ children's response to such treatments is just as robust as it is for ADHD- children, if not better. Future studies should continue to investigate the relative effectiveness of parent training on the core symptoms of both of these disorders.

In addition, further investigations are necessary to ascertain whether inattentive children with and without ODD differ in their performance on the SRT and SRTr tasks. This could not be done in the present study, as children with a diagnosis of ADHD, Predominantly Inattentive Type were excluded from participation. This decision was based on findings from previous studies, which suggested that ADHD, with and without hyperactivity, might reflect two distinct developmental disorders (Barkley, DuPaul, McMurray, 1990). Additionally, symptoms of inattention are far less prevalent among preschool children, relative to symptoms of hyperactivity/impulsivity (Gimpel & Holland, 2003). However, given that results of previous studies have suggested that consideration of the particular ADHD subtype is important in predicting future alcohol and drug use (for review, see Looby, 2008), it would be interesting to investigate whether performance on these reinforcement tasks differs based on ADHD subtype.

Another limitation of the current study is that a group of children with a sole diagnosis of ODD was not recruited for participation. Although this study aimed to ascertain whether oppositionality/defiance, above and beyond a diagnosis of ADHD, impacted the motivation/sensitivity to reward of preschool children, the addition of an ODD comparison group would have provided additional information about the contribution of each of the disorders. In addition, the inclusion of such a group would have enabled the investigators to conclude whether it is the presence of ODD or the combination of the two disorders that results in the children’s aberrant responding during the SRT condition.

Lastly, it remains to be determined whether these results will generalize to the environment outside of the laboratory. The use of computerized measures to investigate this matter enabled the elimination of numerous, potential confounding factors. Nevertheless, it is possible that ADHD+ODD children will not display the same impairment in motivation/reward sensitivity in their daily lives. As such, Study 3 will investigate whether this behavioral pattern is also manifest in a setting that more closely simulates the children’s typical, daily experiences.

*Study 3: Differences amongst ADHD Preschoolers, with and without ODD,*

*During Recorded Parent-Child Interactions*

The developmental psychopathology framework of ADHD suggests that children with the disorder are born with a complex interaction of heritable and environmentally acquired predispositions or vulnerabilities for the disorder. The family environment in which one is reared becomes one of many possible factors if not in the genesis, in the maintenance of at least some forms of the disorder. Indeed, parents of preschool children diagnosed with ADHD have been reported to implement poorer parenting practices, to display more negative behaviors toward their children, and to be more rejecting and demanding than parents of non-problem children (DuPaul, McGoey, Eckert, & VanBrankle, 2001; Lindahl, 1998; Shelton, et al, 1998).

Johnston and Mash (2001) posit that family dysfunction may exacerbate and maintain a child's inattentive, impulsive, and hyperactive behaviors. This hypothesis is consistent with DuPaul and colleagues' (2001) suggestion that preschool-aged children with ADHD seemed to exhibit noncompliant and inappropriate behaviors in order to evade parent-directed tasks. In addition, it is bolstered by the finding that a chaotic family environment intensifies a child's ADHD symptoms such that they reach clinical significance (Carlson et al., 1995).

The notion that the home environment plays a significant role in the development and maintenance of ADHD symptomatology is fairly similar to the widely held model regarding the etiology of clinically significant oppositional/defiant behaviors. A child's predisposition to develop certain behavioral traits is typically thought to interact with family risk factors, resulting in a refusal to follow rules, poor social skills, verbal and physical aggression, and arguments with adults that persist and often escalate over time (Lahey & Loeber, 1994; Lahey & Waldman, 2003; Moffitt, 1993; Patterson, 1992). These behaviors frequently result in parental usage of punishment. Patterson (1982) argues that the relationship between behavioral problems and poor parenting is a bidirectional, dynamic process. According to Patterson's model, children's defiant behaviors often trigger the use of inconsistent or harsh parenting strategies, which negatively reinforce the misbehavior. The process is thought to continually escalate, potentially resulting in chronic antisocial behavior (Goldstein, Harvey, Friedman-Weieneth, Pierce, et al., 2007).

Data suggest that this dynamic process can be thwarted by a robust reduction in negative and ineffective parenting practices. Indeed, parent training sessions, through which parents learn to have fun with and properly instruct their children, have been shown to result in a decrease of oppositional symptoms in children, regardless of ADHD status (Strayhorn & Weidman, 1989). Although several studies report that parent training mitigates symptoms of ADHD (see Pelham & Fabiano, 2008; Sonuga-Barke, Daley, Thompson, Laver-Bradbury, & Weeks, 2001), it is possible that the family environment in general, and parenting factors in particular, are actually impacting upon the development and maintenance of oppositional behaviors rather than on inattentive, impulsive, and hyperactive behaviors (Webster-Stratton, Reid, & Hammond, 2004; Johnston & Mash, 2001).

Although family factors have been shown to be associated with ADHD symptomatology in general, the aforementioned research does not categorize participants based on the children's high or low levels of oppositionality. As a result, positive findings may have been mistakenly attributed to the presence of ADHD symptoms. The results of several studies (for review, see Johnston, 1996), which make such a distinction, seem to indicate that the extent of a child's oppositional behaviors moderates the relationship of hyperactive and impulsive behaviors to family factors.

Discriminant analyses reveal that while participants in both ADHD only and ADHD+ODD groups experience more family conflict during recorded interactions than do the members of a normal control group, the two clinical groups can be distinguished based on positive family interactions alone (Lindhal, 1998). Namely, children with ADHD experience more beneficial and encouraging interactions with their family members than do children with pure ODD or those diagnosed with both disorders. The families of children in the comorbid group are also found to be less cohesive than are the families of the children with ADHD only.

In their model of ADHD development, Harvey and colleagues (2007) take this argument one step further and portray parenting as a critical determinant in the development of comorbid ADHD+ODD but not in the genesis of ADHD without ODD symptomatology. Although this theory is supported by data from several investigations (see Johnston, 1996; Goldstein, Harvey, and Friedman-Weieneth, 2007), the authors' subsequent study of preschoolers and their parents does not reveal any significant differences between the groups. Global ratings of parental warmth, maternal negative affect, and laxness, obtained based on behaviors during videotaped mother-child interaction tasks, differentiated parents of controls from parents of hyperactive/oppositional children and hyperactive only children, but the youngsters in the hyperactive only group were not significantly different from those in the comorbid group.

Additional investigations, focusing on this critical period in development, are clearly warranted to further elucidate whether, and if yes how, parenting is associated with ADHD with and without ODD in preschool children. Thus, the goal of the current study was to examine differences in various aspects of child, parent, and dyadic behavior, during a recorded parent-child interaction, amongst ADHD children, with and without ODD, and typically developing children. Given the results of Study 2, the authors also aimed to investigate whether group differences would be apparent depending upon the degree of task engagement. In addition, the manifestation of behavioral differences, based upon the extent of parental involvement in directing the task, was also assessed.

## Methods

### Participants

Children who participated in this investigation were a sub-sample of those who took part in Study 1 (see above). The Duplo Task (described below) was added to the Parent-Child Interaction (PCI) after some of the children in the larger sample were already evaluated. As a result, the data from their PCI were subsequently considered to be incomplete and therefore not included in these analyses. For the purposes of the current study, children were included if they entered into the larger study as Typically Developing (TD) children and did not receive Kiddie-SADS diagnoses (see below) of ADHD or ODD (n = 57), were diagnosed with ADHD, primarily Hyperactive type or Combined type without ODD (ADHD-; n = 38), or received a diagnosis of ODD in addition to one of the aforementioned subtypes of ADHD (ADHD+; n = 32). The groups did not differ significantly in gender ($\chi^2 = 1.95$, $p = .38$) or age (F = 0.22, $p = .80$).

According to demographic data obtained from the parents, 41.7% of the sample was White, Non-Hispanic; 15.9% was White, Hispanic; 10.6% was Black, Non-Hispanic; 1.5% was Black, Hispanic; 11.4% was Asian; and 18.9% reported mixed or "other" ethnicity/race. The groups differed in socio-economic status (SES), which was measured using the Nakao-Treas Socioeconomic Prestige Index (Nakao & Treas, 1994). The typically developing children were from families with a higher SES [60.6(14.1)] than were the children in the ADHD+ group [50.1(14.8)], with neither group differing significantly in SES from the ADHD- group [55.0(14.8)]. Because the correlation between SES and each of the dependent variables was weak (all below $r = .22$), SES was not included as a covariate in subsequent analyses.

Measures

As part of their clinical evaluation, children were administered the comprehensive assessment battery described above (see Study 1). In addition, the children and their mothers participated in a video-recorded parent child interaction (PCI).

The *Coding System for Mother-Child Interactions* (CSMCI; Healey, Gopin, Grossman, Campbell, & Halperin, 2010) was used to rate the behaviors observed during the PCI. This coding system was designed to assess individual child characteristics, the quality of dyadic parent-child interactions, and parent characteristics as displayed during a laboratory interaction task (see below). The coding system was primarily based on the one used in the NICHD Study of Early Child Care [NICHD Early Child Care Research Network (ECCRN), 1999; 2003; 2006] and was augmented with codes used by Campbell, Pierce, March, Ewing, and Szumowski (1994) and Eyberg, Bessmer, Newcomb, Edwards, and Robinson (1994). These coding systems have been used extensively in research on parent-child interactions and found to be valid and reliable measures of both individual and dyadic behaviors. Codes from these systems were combined in order to assess a wider array of characteristics.

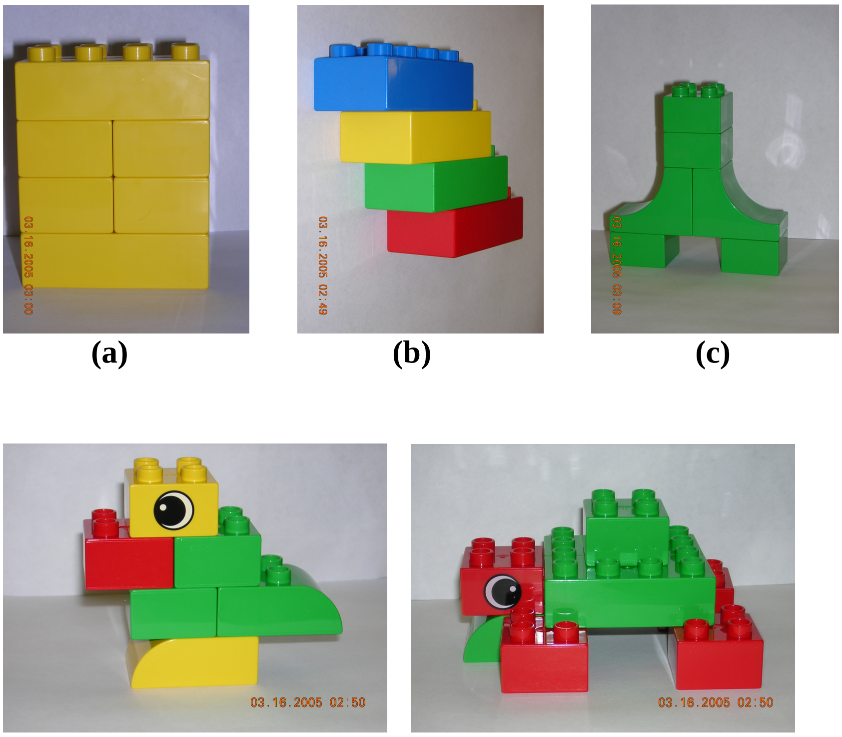
The CSMCI child codes consist of: (a) *Enthusiasm*, an assessment of whether the child approached the task with energy and excitement; (b) *Negativity and Hostility*, a measure of whether the child forcefully rejects the parent's ideas or is unreasonably demanding; and (c) *Cooperation-Compliance,* which measures whether the child obeys suggestions and commands quickly/cheerfully. The CSMCI dyadic codes include: (a) *Affective Mutuality/Felt Security*, which assesses whether the parent and child respond appropriately to each other's emotions; (b) *Mutual Enjoyment*, which measures whether, as a pair, the participants engage positively with the situation and with each other; and (c) *Reciprocal Interactions*, a measure of whether behavioral or verbal responses are characterized by turn-taking. The CSMCI parental codes include: (a) *Emotionally Supportive Presence*, a measure of the parent's positive regard, warmth, praise and emotional support to the child; (b) *Respect for Child's Autonomy*, which assesses whether the parent respects the child's individuality, motives, and perspectives in the session; (c) *Negative Affect*, which measures parental expressions of anger or rejection of the child; and (d) *Quality of Assistance*, which measures whether the parent provides sufficient structure and instruction. Three composite scores (child, parent, and dyad) were calculated through averaging the scores that were assigned for the respective items.

Coders rated each item on an anchored, 5-point Likert scale. Three coders received extensive training and supervision prior to independently coding all of the interactions to ensure that there was a minimum inter-rater reliability of .70 (Aspland & Gardner, 2003). The correlation between the coders' scoring, after receiving the initial training, was .835. The raters, blind to symptom ratings and impairment status of the child, were randomly assigned to code certain videos. Regular group supervision sessions helped to ensure that their scoring remained comparable to one another and did not drift over time. Coders overlapped on 15% of the cases to ensure that the inter-rater reliability remained stable ($r$ = .848).

<u>Procedures</u>

During the laboratory visit, information about the child's development, family history, and overall functioning were obtained through parent interviews. Child evaluators administered a comprehensive assessment battery to the child consisting of measures of cognitive and neuropsychological functioning, and families participated in a 16-minute mother-child interaction, comprised of three tasks.

The first segment of the playroom interaction consisted of a Free Play Task (FPT), in which the parent and child were instructed to play with the available toys (e.g., puzzles, puppets, bowling, basketball, action figures, cars, coloring books) as they normally would at home. At the conclusion of this five-minute segment, the parents were asked to have their child clean up the toys that were used during the FPT (1 min.), but the coders did not score this latter segment. During the next five-minute segment, the Paper and Pencil Task (PPT), parents were given a series of age-appropriate worksheets that contained instructions at the bottom of each page and were told to assist their children in completing as many of the worksheets as possible. The final segment was comprised of a Duplo Task (DT). Parents and children were provided a booklet containing pictures of various designs that were created using Duplos (See Figure 6); the designs progressively increased in complexity. The dyads were instructed to assemble as many of the depicted buildings, in the order that they appeared in the booklet. The DT and PPT differed from the FPT in that parents structured these tasks for the child; however, the DT and PPT differed from one another primarily in the degree of task engagement (e.g., DT was considered to be the more engaging task).




(a) (b) (c)

(d) (e)

Figure 6. Examples of the Duplo Task designs that the parent-child dyad was presented with and asked to recreate.

The coders watched the videotaped FPT, paused the video, and completed the CSMCI, rating the parent, child, and dyadic behavior during that portion of the videotaped interaction. They then followed the same protocol for the videotaped PPT and DT.  As such, the coder completed the CSMCI three times for each video.

<u>Data Analysis</u>

For each task, composite child, dyadic, and parent behavior scores were created by averaging the respective items (for details of the procedure, see Healey, Gopin, Grossman, Campbell, & Halperin, 2010).  A series of mixed ANOVAs was conducted to analyze group (i.e., TD, ADHD-, ADHD+) differences in child, dyadic, and parent behaviors across the three tasks (i.e., FPT, PPT, DT).  Follow-up ANOVAs were then conducted to assess the nature of any significant interactions.  Finally, Cohen's *d* effect size calculations were used to further determine the magnitude of the group differences.

# Results

## *Child Composite Analyses*

To examine the effect of diagnosis (i.e., ADHD+, ADHD-, TD) and type of task (i.e., FPT, PPT, and DT) on child behaviors, as well as the interaction between these two factors, a mixed two-way ANOVA was conducted. Results revealed a significant main effect for task (F = 48.52 (2,123), $p < .001$), such that all children behaved more poorly during the PPT than during the FPT and DT, with no significant difference between behaviors exhibited during the FPT and the DT. In addition, there was a significant main effect for group (F = 5.65, $p < .01$), such that children in the TD group behaved significantly better than those in the ADHD- and ADHD+ groups, with the latter not differing significantly. The group x task interaction was also significant [F = 6.77 (4, 246), $p < .001$; See Table 11].

Table 11. Means (Standard Deviations) of the Child behavior ratings during the three tasks of the PCI (e.g., FPT, PPT, DT)

| **Task** | **Mean (SD)** | | | **Significance** |
|---|---|---|---|---|
| | **TD** | **ADHD-** | **ADHD+** | |
| **FPT** | 4.58 (.47) | 4.39 (.51) | 4.56 (.43) | F = 1.99 (2, 126), $p = .14$ |
| **PPT** | 4.14 (.63) | 3.86 (.84) | 3.31 (1.02) | F = 10.91 (2, 126), $p < .001$* |
| **DT** | 4.33 (.67) | 4.00 (.69) | 4.19 (.72) | F = 2.59 (2, 126), $p = .08$ |

* ADHD+ differed significantly from the TD and ADHD- groups

Post hoc analyses revealed that children in the ADHD+ group displayed more behavioral dysregulation during the PPT than did the TD and ADHD- groups (whose behavior did not differ significantly). However, there were no group differences in child behavior during the other two tasks (See Figure 7). These analyses indicated that, while all children behaved more poorly on the less engaging (PPT) task, the lack of positive engagement differentially impacted upon those with ADHD + ODD, but not those in the ADHD only group.

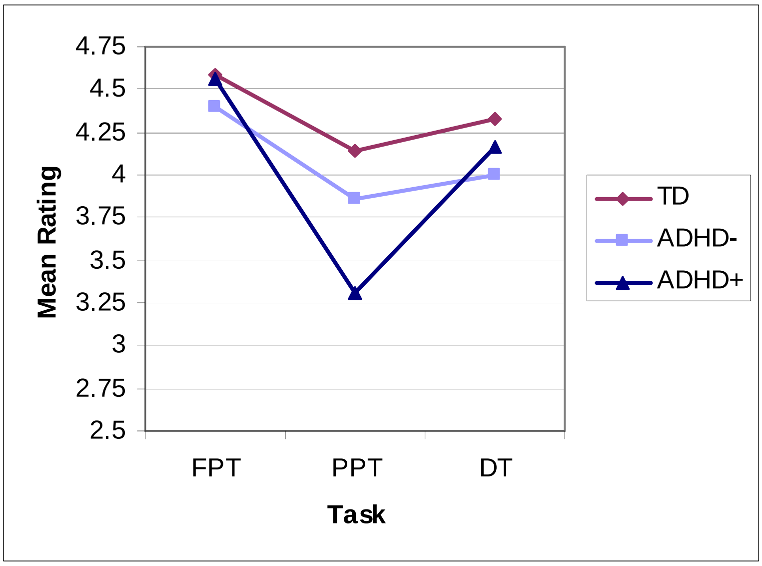



Figure 7. Differences in TD, ADHD-, and ADHD+ Child behavior ratings across PCI tasks. The group x task interaction was significant (*p* < .001), such that the ADHD+ group displayed more behavioral dysregulation during the PPT than did the TD and ADHD- groups (whose behavior did not differ significantly). There were no group differences in child behavior during the other two tasks.

*Parent Composite Analyses*

The ANOVA conducted to assess group differences in parent behaviors across tasks also yielded a significant main effect for task (F = 21.81 (2, 123), *p* < .001), such that all parents were rated as displaying more negative behaviors during the PPT than during the other tasks. Additionally, there was a significant main effect for group (F = 3.74 (2), *p* < .05), such that parents of children in the ADHD+ group were rated as displaying more negative behaviors than parents of children in the other two groups; however, the group x task interaction was not significant (See Table 12 and Figure 8).

Table 12. Means (Standard Deviations) of the Parent behavior ratings during the three tasks of the PCI (e.g., FPT, PPT, DT)

| Task | Mean (SD) | | | Significance |
|---|---|---|---|---|
| | **TD** | **ADHD-** | **ADHD+** | |
| **FPT** | 4.28 (.49) | 4.26 (.50) | 4.13 (.58) | F = .94 (2, 126), *p* = .39 |
| **PPT** | 4.10 (.54) | 4.02 (.59) | 3.71 (.65) | F = 4.62 (2, 126), *p* < .05* |
| **DT** | 4.28 (.45) | 4.21 (.50) | 4.01 (.61) | F = 2.99 (2, 126), *p* = .054* |

* ADHD+ differed significantly from the TD group only

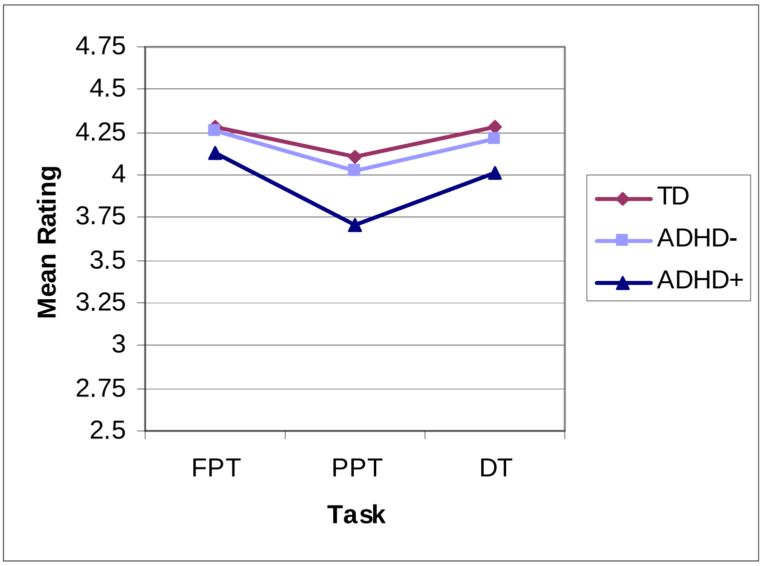



Figure 8. Differences in TD, ADHD-, and ADHD+ Parent behavior ratings across PCI tasks. There was a significant main effect for task ($p < .001$), such that all parents were rated as displaying more negative behaviors during the PPT than during the other tasks. The main effect for group was also significant ($p < .05$); parents of children in the ADHD+ group were rated as displaying more negative behaviors than parents of children in the other two groups. The group x task interaction was not significant.

*Dyadic Composite Analyses*

When the Dyadic behaviors were entered into a mixed ANOVA, there was again a significant main effect for task (F = 49.15 (2,123), $p < .001$), such that the dyad was rated as having more negative interactions during the PPT as compared to both the FPT and DT; the main effect for group was not significant (See Table 13). In addition, there was a significant group x task interaction (F = 5.13 (4,246), $p < .01$). Post hoc analyses indicated that, during the PPT, the ADHD+ dyads interacted in a more negative manner than did those in the TD group; with the difference between ADHD+ and ADHD- group behaviors approaching significance ($p = .052$). None of the groups differed significantly during the FPT and DT tasks (See Figure 9).

Table 13. Means (Standard Deviations) of the Dyad behavior ratings during the three tasks of the PCI (e.g., FPT, PPT, DT)

| Task | Mean (SD) | | | Significance |
|---|---|---|---|---|
| | TD | ADHD- | ADHD+ | |
| **FPT** | 3.91 (.71) | 3.96 (.70) | 3.82 (.67) | F = .37 (2, 126), *p* = .69 |
| **PPT** | 3.57 (.76) | 3.37 (.93) | 2.90 (.84) | F = 6.66 (2, 126), *p* < .01* |
| **DT** | 3.90 (.73) | 3.61 (.79) | 3.65 (.79) | F = 2.01 (2, 126), *p* = .14 |

* ADHD+ differed significantly from the TD group only

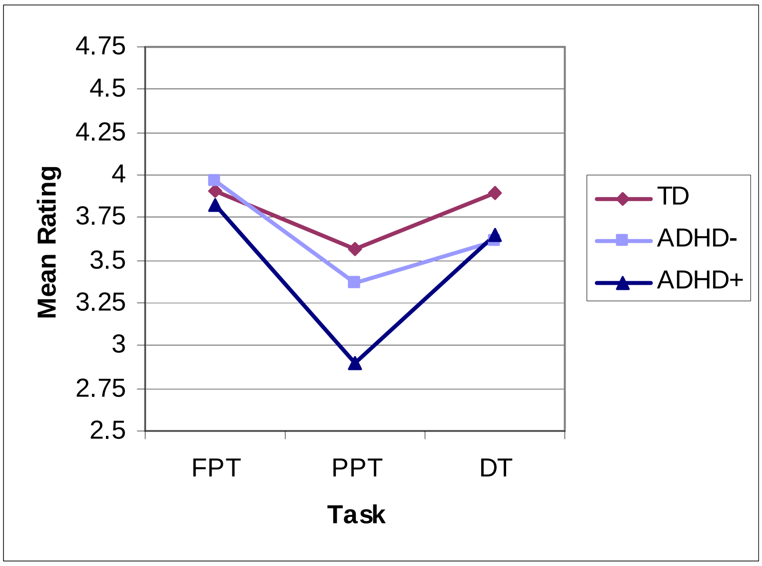



Figure 9. Differences in TD, ADHD-, and ADHD+ Dyad behavior ratings across PCI tasks. Although the main effect for group was not significant, there was a significant main effect for task (*p* < .001), such that the dyad was rated as having more negative interactions during the PPT as compared to both the FPT and DT. There was also a significant group x task interaction (*p* < .01); during the PPT, the ADHD+ dyads interacted more negatively than did those in the TD group. The difference in behavior between the ADHD+ and ADHD- groups approached significance (*p* = .052).

*Effect Size Calculations*

Overall, effect size calculations for the PPT consistently revealed medium to large differences between the ADHD+ and the TD groups. Medium differences were found between the ADHD- and ADHD+ groups, and small differences were found between the ADHD- and TD groups. Child, parent, and dyad differences during the FPT were generally found to be small. Similarly, group differences during the DT tended to be small (see Table 14).

Table 14. Effect sizes (*d*) for all components of the parent-child interaction task

| **Task** | **Person Rated** | **Effect Size (*d*)** | | |
|---|---|---|---|---|
| | | **TD & ADHD-** | **TD & ADHD+** | **ADHD- & ADHD+** |
| **FPT** | Child | 0.39 | 0.04 | 0.36 |
| | Parent | 0.04 | 0.28 | 0.24 |
| | Dyad | 0.07 | 0.13 | 0.20 |
| **PPT** | Child | 0.38 | 0.98 | 0.59 |
| | Parent | 0.14 | 0.65 | 0.50 |
| | Dyad | 0.24 | 0.84 | 0.53 |
| **DT** | Child | 0.49 | 0.20 | 0.27 |
| | Parent | 0.15 | 0.50 | 0.36 |
| | Dyad | 0.38 | 0.33 | 0.05 |

*Secondary Analyses*

To determine whether the group differences in child or parent behavior during the PPT was driving the differences in dyadic behavior, we conducted an analysis of covariance assessing group differences in dyadic behavior during the PPT while controlling for child behavior. Group differences in dyadic behavior were no longer significant after controlling for child behavior (F = .38 (2,186), $p = .69$). Nevertheless, similar analyses controlling for parent behaviors during the PPT were indeed significant (F = 3.084 (2,186), $p < .05$).

## Discussion

The family environment in which one is reared has been implicated as having a causal and/or maintenance role in the development of both Attention-Deficit/Hyperactivity Disorder and Oppositional Defiant Disorder. Despite numerous investigations into the nature of parent-child interactions in families of preschool-aged children with ADHD, it currently remains unclear whether, and if yes how, parenting is differentially associated with ADHD, with and without comorbid ODD. As such, the current study examined differences in various aspects of child, parent, and dyadic behavior during a recorded parent-child interaction, amongst ADHD children, with and without ODD, and typically developing children. It was hypothesized that the type of task performed would likely impact the nature of the interaction; therefore, the dyads participated in three different tasks, which differed in the degree of task engagement and parental involvement.

Overall, children with ADHD, irrespective of the presence of ODD, behaved more poorly than controls across task conditions. These data suggest that ADHD is associated with an underlying deficit that results in less enthusiastic, more negative/hostile, and less cooperative/compliant behaviors compared to typically developing preschool children. Moreover, this deficit is apparent across situations, regardless of whether reinforcement is provided.

However, above and beyond this deficit, preschoolers with ADHD+ODD seem to demonstrate an additional weakness, such that during tasks that are relatively boring, they exhibit even more negative behaviors. The finding that the comorbid condition is associated with situational variability, such that the introduction of a reward markedly improves performance, is consistent with Quay's (1997) model of ODD. Quay suggests that the diagnosis is associated with an overactive behavioral activation system (BAS), and as such, children with the disorder are particularly sensitive to conditions of reward. However, the ADHD- and TD groups performed similarly to one another, even upon the introduction of reinforcement. This finding negates the hypothesis that children with ADHD are less sensitive to reinforcement than TD children and thus require a greater level of reinforcement to produce comparable improvement in behavior (Haenlein & Caul, 1987). The findings do not completely negate the possibility that ADHD children display deficits in reinforcement processing, though. Because the present study did not assess differences in performance over task duration, it remains plausible that children with ADHD do indeed have an impaired capacity to delay reinforcement (Douglas & Parry, 1983; Sagvolden et al., 1998; Barkley, 2006).

Regardless of whether or not ADHD- children display such a weakness, their parents did not behave differently than the parents of typically developing children; this finding is not task dependent. In contrast, parents of children with comorbid diagnoses of ADHD and ODD displayed increased negative behaviors across parent-child interaction tasks as compared to parents of children in the other two groups (ADHD only and typically developing children). These findings support Patterson's (1982) bidirectional model of childhood defiance. The results indicate that the additional ODD component is associated with more negative parenting practices regardless of task and degree of parental involvement. Because the child's behavior, and not the parent's behavior, was found to account for the poor conduct displayed during the dyadic interactions, it is likely that the child's behavior is indeed instigating the implementation of harsh parenting strategies and not vice versa.

However, these findings are not consistent with DuPaul, McGoey, Eckert, and VanBrankle's (2001) hypothesis that preschoolers diagnosed with ADHD exhibit noncompliant and inappropriate behaviors in order to evade parent-directed tasks. Children in the ADHD- group behaved in a comparable manner during the two engaging tasks that differed in the degree of parental structure (FPT and DT). Rather, the data from the present study suggest that the manipulation of task engagement has an impact on child behavior but only amongst those with the dual ADHD+ODD diagnosis. As such, these findings bolster Lindhal's (1998) argument that children who have been diagnosed with ADHD can be differentiated from those diagnosed with ADHD and ODD on the basis of their behavior during a parent-child interaction. However, the current findings build upon Lindhal's theory and stipulate that, in order to do so, the task used in such an interaction must be one that is not particularly engaging.

There are several limitations to this study that restrict the generalizability of the findings. Unfortunately, parent-child interaction data on children with a diagnosis of ODD alone were not collected. As such, we cannot draw any conclusion regarding the contribution of ODD relative to that of ADHD. We can simply conclude that when the two diagnoses present simultaneously, the combination results in a behavioral change during non-engaging tasks relative to that of typically developing preschoolers and those with a diagnosis of ADHD without ODD.

In addition, degree of task engagement was determined based on face validity. The distinction was later bolstered by informal discussions with the children after the parent-child interaction. However, future studies should provide the children with questionnaires, subsequent to each task, to ascertain whether the two highly structured tasks did indeed differ in task engagement to the expected extent. Such rating would also provide a means of assessing that the two engaging tasks were indeed similar in that respect.

A further limitation is that the three tasks were always administered in the same order: first the FPT, then the PPT, and finally the DT. Because the DT was added to the PCI after numerous participants from the larger sample were already assessed, it was decided to add the new task to the end of the battery so as not to change the protocol that had been used for the previous participants. It is possible, therefore, that the results are reflective of order effects; however, the improvement observed in child, parent, and dyadic behavior during the DT relative to the PPT would suggest otherwise. Nevertheless, the conditions should be counterbalanced in future investigations.

In summary, digitally recorded parent-child interactions that involve tasks that are not engaging can be used to differentiate children with ADHD+ODD from children with ADHD only and typically developing children. The relatively poor behaviors that the ADHD+ODD children display in such an environment appear to then instigate the implementation of poor parenting practices. These finding suggest that parents of children with ADHD+ODD will likely benefit from parent training in which they can learn how to make mundane tasks seem more engaging (e.g., allow children to pick the color of the pencil that is to be used, have them color in the stimuli, point out items that are humorous etc.). Furthermore, sessions focusing on providing additional structure for these children will likely prove to be futile, as manipulation of parental involvement in the tasks did not seem to impact upon the parent-child interaction.

## *General Discussion*

This series of studies was undertaken to assess the distinctions between preschool children with ADHD, ADHD+ODD, and typically developing controls in an effort to evaluate the concurrent differential validity of these groups. The findings indicated that the presentation of the two ADHD groups is indeed similar in some respects but quite different in others. Specifically, the neuropsychological functioning of the diagnosed groups was fairly comparable when IQ was not taken into account; however, the ADHD- and ADHD+ODD groups differed in their response to reward/increased task engagement.

The hypothesis of Study 1 was that preschool children with ADHD, but not ODD, would perform more poorly than those in the ADHD+ODD and TD groups on measures of neuropsychological functioning. This was not found to be the case. When the sample was not stratified based on IQ, the patterns of performance revealed that the ADHD- and ADHD+ children exhibited similar neuropsychological profiles. Specifically, preschool children diagnosed with ADHD were found to have global cognitive impairment, regardless of comorbid ODD status. Additionally, these children demonstrated difficulty with self-regulation, above and beyond the cognitive difficulties that they exhibited. It is only through the consideration of secondary analyses, in which effect size analyses yielded medium to larger differences, that discrepancies in the patterns of performance of the two ADHD groups begin to materialize.

Our hypothesis for Study 2 was that task engagement/reinforcement would have a significantly greater impact on the performance (i.e., median reaction time and reaction time standard deviation during a computerized task) of children in the ADHD+ODD group as compared to that of children with a diagnosis of ADHD alone and those in the TD group. This hypothesis was proven to be partially correct. Processing speed, as measured by reaction time, increased to a similar degree with reinforcement across groups. However, with increased engagement/reinforcement, the ADHD+ODD had a significantly greater reduction in reaction time variability. The findings suggest that, while all children respond well to additional, extrinsic motivation, those with comorbid ADHD and ODD diagnoses are particularly sensitive to reward manipulations.

Finally, the hypotheses of Study 3 were (i) children in the ADHD+ODD group would display more behavioral difficulties during the parent-child interaction (PCI) than would children in the ADHD- and the TD groups, (ii) children in the ADHD- group would be observed to display poorer behavior than the TD children, (iii) parent and dyadic behavior would be the poorest amongst participants in the comorbid group, (iv) a significant difference in parent and dyadic behavior amongst the TD and ADHD groups would be apparent, and (v) group differences would be apparent depending upon the degree of task engagement. Again, these hypotheses were proven to be partially correct. Findings revealed that, overall, TD children were rated as exhibiting more positive behaviors than the ADHD- and ADHD+ children; however, the ADHD+ group was rated as behaving significantly worse during the PPT than were the children in the other two groups. These findings demonstrated that the ADHD+ODD preschool children exhibit a differentially larger response to reinforcement relative to ADHD- and TD children. Additionally, parents of ADHD+ children display more negative behaviors than the parents of the other children, regardless of the type of task and degree of parental involvement.

The amalgamation of these findings seems to suggest that while children with ADHD+ODD and children with ADHD but not ODD may *not* be distinguishable based on their neuropsychological profiles, there are clear differences between the two groups in their response to task reinforcement/engagement. The hyperactive/impulsive and combined subtypes of ADHD appear to be associated with global cognitive impairment, as has been reported time and time again in the ADHD literature (e.g., Halperin & Gittleman, 1982; Hinshaw, 1992; Sonuga-Barke, Lamparelli, Stevenson, Thompson, & Henry, 1994). In addition, the current findings revealed an association between ADHD and self-regulatory abilities, which may underlie the poor behavior that these children demonstrate when interacting with their parents. This is consistent with Barkley's (1997, 2006) model of ADHD, in which a deficit in behavioral inhibition is the characteristic feature of the disorder and is associated with a disruption in the ability to self-regulate.

The additional ODD diagnosis, however, confers the supplementary core deficit of an aberrant reward system. As a result, children with ADHD+ODD demonstrate situational variability, such that their behavior and performance is markedly poor under conditions that lack engagement/reward. It is specifically these children who seem to demonstrate an under-active septo-hippocampal system or what Quay (1997) terms a hypoactive behavioral inhibition system (BIS). In addition, the findings are consistent with Quay's theory that an overactive behavioral activation system (BAS) is central to the pathophysiology of ODD, as the introduction of reinforcement/increase in task engagement significantly enhanced the performance of this subgroup of children with ADHD. As such, although the findings are largely consistent with Quay's theories, they do not support his distinction between ADHD and ODD; rather, the data suggest that both the BIS and BAS abnormalities are specific to ADHD+ODD. Similarly, the results of Studies 2 and 3 appear to indicate that Sagvolden and Sergeant's (1998) reinforcement processing framework of ADHD is applicable only to ADHD+ODD children, at least during the preschool years.

In summary, given these results, one could argue that ADHD with and without ODD are actually two distinct disorders. According to such a model, ADHD- would best be described as a disorder of global cognitive impairment and self-regulation, which differentiates children in this group from TD children. ADHD+, on the other hand, would have the additional deficit in reinforcement processing, evident when conditions are not rewarding. In the latter population, poor parenting behaviors would ultimately develop in response to the child's behavioral dysregulation. Among preschoolers with ADHD-, though, there may be considerable variability in presentation, given the range of cognitive functioning, genetic factors, and parent personalities/approaches to child rearing (Doyle et al., 2005). As such, some ADHD- children may appear to behave in a manner that mimics the presentation of an ADHD+ child; however, the underlying deficits evident in the two populations would remain distinct (See Figure 10).

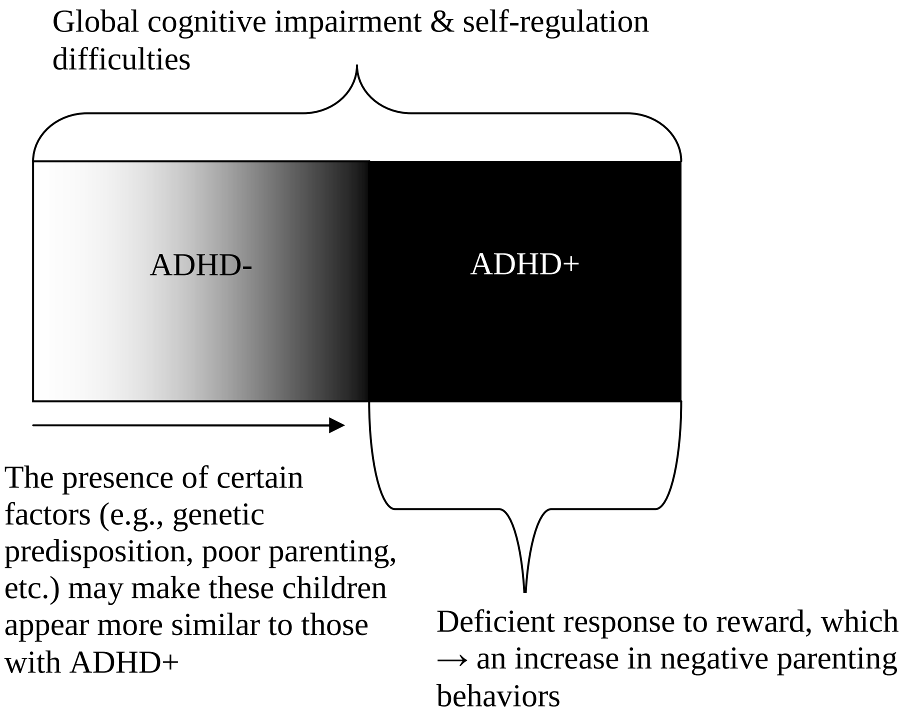



Figure 10. Model of ADHD- and ADHD+ posited based on the collective findings of this series of studies.

Therefore, the two diagnosed entities should be thought of as distinct from one another when considering treatment options. This suggestion is fully consistent with Waschbusch's (2002) assertion that the presence of comorbid ODD must be considered when assessing the correlates and trajectories of ADHD in elementary and high school children. Although the implementation of reward systems and other behavior modification strategies will probably benefit all children, regardless of ODD status, those with ADHD+ODD will likely experience the greatest improvement when those techniques are implemented, as evidenced by the ADHD+ group's dramatic improvement in behavior when provided with a reward. Consequently, despite the fact that parents, educators, and medical professionals all report that those children are the most difficult to engage and to work with, their underlying motivational deficit also provides an avenue through which these youngsters can be treated and hopefully protected from future behavioral, social, and emotional decline.

Based on the current data alone, one cannot definitively conclude that ADHD+ODD represents a true comorbidity of distinct disorders, with ADHD contributing primarily neurocognitive difficulties and ODD resulting in deficient reward/reinforcement processing. To validate such a hypothesis, future studies would need to include an additional ODD group to ascertain the particular deficits that are specific to that disorder. This is an especially challenging task, as approximately half of the preschoolers who present with symptoms of ODD also exhibit the hyperactive/impulsive behaviors seen in ADHD (Speltz, McClellan, Deklyen, & Jones, 1999), making it difficult to recruit such a sample. Nevertheless, it is necessary to amass such information if any definitive conclusions are to be reached. In the interim, the results of the current dissertation highlight the similarities and differences in the cognitive/ neuropsychological, behavioral, and family functioning profiles of these two groups and suggest that comorbidity status must be carefully considered prior to treatment planning.

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