Neuropsychological Test Performance and Other Predictors of Adult Outcome in a Prospective Follow-Up Study of Children with ADHD

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ABSTRACT

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The present research is a prospective follow-up study which investigates the neuropsychological test performance of children with Attention Deficit/Hyperactivity Disorder (ADHD) and examines whether test performance and severity of childhood disruptive behaviors predict adult psychiatric status and functioning in major domains (educational, social, and occupational). Participants were 100 middle-class, White boys (mean age = 9) of average intelligence diagnosed with ADHD without comorbid conduct disorder (CD) diagnoses. Childhood predictors were teacher behavioral ratings and performance on a variety of neuropsychological tests. Participants were later assessed at mean age 25 by clinicians blind to childhood status. Linear and logistic regression analyses were used to determine the impact of childhood predictor variables on adult outcome. Results showed no significant impairment on measures of neuropsychological functioning, nor was neuropsychological test performance generally correlated with severity of disruptive behaviors. ADHD boys with low ratings of conduct disorder behaviors (*not at all, just a little*) demonstrated lower verbal ability than those without CD behaviors. Severity of childhood CD behaviors emerged as the most consistent predictor of adult functioning and prevalence of psychiatric disorders. Measures of working memory and attention (Working Memory Index and Freedom from Distractibility Factor of the WISC-R) inconsistently predicted functioning in some areas, although this may reflect the well-known relationship between childhood IQ and later adult functioning. Taken together, the findings suggest that in boys with

ADHD who are of average intelligence and have intact neuropsychological functioning, even low levels of CD behaviors are associated with poor prognosis in adulthood.

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Dedication

To my parents, Ellen and Alain Roizen, who have provided me with unparalleled support, encouragement, and love. They continue to provide an extraordinary example of the way in which human beings can promote one another's growth through open and genuine dialogue of who and what we want to be. And, to Sal, who takes every opportunity to demonstrate his commitment to my personal and professional development. I thank him for his unrelenting dedication to mentorship and friendship.

Introduction

The primary aims of this study are to investigate the neuropsychological test performance of children with Attention Deficit/Hyperactivity Disorder (ADHD) and to examine whether test performance and childhood disruptive behaviors predict adult outcome in psychiatric status and major functional domains.

Numerous empirical and theoretical papers have investigated the cognitive deficits associated with ADHD. Despite this extensive literature, the core neuropsychological impairments in ADHD and their ecological validity continue to be debated. Clarification of these deficits has considerable implications for diagnostic criteria, assessment, and treatment. This is particularly significant given that the symptoms of ADHD are ubiquitous in psychiatry (Nigg, 2005). Inattention and its various behavioral manifestations (poor concentration, short attention span, distractibility, etc.), for example, is a common symptom of mood, anxiety, and psychotic disorders. In addition, clarification of deficits may facilitate guidelines for the clinical assessment of ADHD, which varies from unstructured interviews with the child and parent to comprehensive evaluations including cognitive and neuropsychological testing, standardized teacher rating scales, structured diagnostic interviews, and systematic classroom and home behavioral observations. Furthermore, an understanding of these deficits has implications for treatment, specifically refining target areas for intervention that likely affect functioning in multiple domains.

Over the past three decades, several studies have implicated a frontal lobe dysfunction in ADHD since frontal lesions in experimental animals and human patients often produce hyperactivity, distractibility, or impulsivity (Doyle, 2006; Pennington & Ozonoff, 1996). Consistent with this hypothesis, research on the neuropsychological impairments in ADHD has focused primarily on executive functions (EFs) presumed to measure frontal lobe dysfunction. There are at least 33 definitions of EF (Sergeant, Geurts, & Oosterlaan, 2002). Within the context of this literature, executive functioning refers to higher-order neurocognitive processes that underlie self-regulation and goal-directed behavior, including working memory, response inhibition, set shifting, abstraction, planning, organization, fluency, and certain aspects of attention (Doyle, 2006; Pennington & Ozonoff, 1996; Sergeant et al., 2002).

The current study is distinctive in its ability to investigate whether childhood neuropsychological test performance and other behavioral ratings predict adult outcome in psychiatric status and major functional domains. There are few prediction studies of children with ADHD that share the following features: (1) clinic sample of children with ADHD; (2) long-term follow-up interval into young adulthood; (3) multiple childhood predictor variables, including neuropsychological test performance; (4) and a number of adult outcome variables across several domains. Furthermore, certain methodological limitations (e.g., high attrition, short follow-up intervals, etc.), failures to replicate, and meager explained variances have prevented definitive conclusions. Given that ADHD is a highly prevalent disorder and poses a public health concern due to these children’s increased risk for involvement in criminal activities and drug abuse, it is important to search vigorously for sturdy predictors of outcome. Ultimately, the information gained from these prediction analyses may benefit clinicians in designing prevention programs that focus on childhood factors most strongly associated with poor adult prognoses.

The following section will review the major theoretical models of neuropsychological deficits in ADHD. Next, the empirical evidence for these purported deficits will be evaluated, addressing whether there are neuropsychological deficits that are specific to ADHD. This discussion will be followed by a look at the heterogeneity within ADHD and potential moderators of this heterogeneity. The final sections will cover both childhood neuropsychological and non-neuropsychological predictors of later outcome.

Theoretical Models of a Core Neurological Deficit in ADHD

The most prominent theoretical models of ADHD have argued that abnormalities of certain aspects of EFs represent the core deficit in the disorder. Most recently, the majority of these models have focused on inhibitory control (e.g., Barkley, 1997; Quay 1997; Schachar, Tannock, & Logan, 1993). Notably, most of these models apply to ADHD Combined type and Hyperactive-Impulsive type. They generally do not refer to the subgroup whose primary complaint is inattention alone (e.g., Barkley, 1997; Quay, 1997).

Behavioral inhibition deficits. Quay's (1997) model expands upon Gray's neurological model of anxiety to explain the poor inhibition seen in ADHD. Quay (1997) asserts that this deficit in inhibition reflects the underactivity of Gray's Behavioral Inhibition System (BIS), a brain system located in the septo-hippocampal system with connections to the frontal cortex. According to Quay (1997), this system responds to conditioned stimuli for punishment and nonreward to produce response inhibition. The model predicts that children with ADHD are less sensitive to these stimuli and therefore have difficulty inhibiting their responses. Quay (1997) explained, "It is not that children with ADHD do not respond to punishment but it is that they are less responsive to conditioned stimuli – cues and signals – that punishment or nonreward is likely to be contingent upon their making a particular response" (p. 8).

Barkley (1997) also proposes a model in which the core impairment in ADHD is a deficit in behavioral inhibition. He posits that this deficit leads to secondary impairments in four executive neuropsychological functions that are critical for self-regulation and goal-directed persistence: (a) working memory, (b) self-regulation of affect-motivation-arousal, (c) internalization of speech, and (d) reconstitution. These functions are dependent on inhibition because a delay in the decision to respond is the basis for further self-directed, executive actions. Barkley (1997) explains, “This is not to say that behavioral inhibition directly causes these executive or self-directed actions to occur. However, it does set the occasion for their performance by providing the delay necessary for them to occur” (p. 68). This model also predicts impairments in the motor system, given that the behavioral inhibition system and each of the four executive functions directly affect motor control.

Information processing deficits. The previous two models suggest that ADHD is the result of a failure to delay responding associated with inhibitory deficits. Sergeant (2000) advocates an alternative position using a model of information processing. In contrast to the previous models, this model: (1) emphasizes dysfunction of the subcortical and brain stem loci rather than the frontal cortex (Sergeant, Geurts, Huijbregts, Scheres, & Oosterlaan, 2003), and (2) contends that the process underlying ADHD’s inhibitory difficulties reflects an energetic dysfunction. Sergeant’s (2000) cognitive-energetic model (CEM) of ADHD contains three distinct levels: (1) a lower set of cognitive processes (encoding, search, decision, and motor organization), (2) a second level of energetic pools (arousal, activation, effort), and (3) a management or executive function level. According to Sergeant (2000, 2005), the overall efficiency of information processing is determined by the interplay between all three of these levels. This model predicts that the impulsivity seen in ADHD is associated with deficits in motor organization (not encoding or search) and deficiencies in two of the energetic pools, activation and effort. Activation is associated with the readiness to respond and is affected by task variables such as preparation, alertness, time of day, and time on task. Effort is defined as the energy necessary to meet task demands, and encompasses motivation and response to contingencies. Research has demonstrated that these two pools have a considerable effect on motor output (Sergeant, 2000, 2005).

Dual Pathway Models of Neurological Deficits in ADHD

In contrast to Barkley (1997) and Quay (1997), Sonuga-Barke initially posited that the failure to delay responding in ADHD children was a result of delay aversion rather than deficits in inhibition. He more recently altered his position and endorsed a dual pathway model (Sonuga-Barke, 2003). This dual pathway model addresses contradictory and inconsistent neuropsychological findings by combining the cognitive and motivational models of ADHD within a common framework. Sonuga-Barke (2003) asserts that both executive dysfunction (the cognitive model) and delay aversion (the motivational model) make distinctive contributions to the development of the disorder. This hypothesis builds upon the idea that alterations within the executive circuit modulated by mesocortical dopamine and the reward circuit modulated by mesolimbic dopamine constitute the processes leading to inhibitory deficits and delay aversion, respectively. This model predicts that Combined-type ADHD is the common clinical outcome of these distinct developmental processes (Sonuga-Barke, 2003, 2005).

Nigg, Goldsmith, and Sachek (2004) recently proposed an alternative multiple pathway model that also attempts to address the etiological heterogeneity in ADHD. These researchers argue that while most children with ADHD have deficits in executive functioning, the remaining cases may have other causal pathways associated with nonexecutive processes (Nigg et al., 2004). Based on temperament theory, Nigg and colleagues (2004) suggests that these other pathways are characterized by positive or negative approach problems which are associated with two key temperament traits: reactivity and effortful control. Nigg, Wilcutt, Doyle, and Sonuga-

Barke (2005) later pointed out other causal pathways, including a delay aversion pathway, a marital conflict pathway, and a genetic subtype (i.e., with or without long-repeat allele of the dopamine D4 receptor gene).

Deficits in Executive Function in ADHD

Many empirical studies investigating neuropsychological deficits are often cited as evidence for the aforementioned models of ADHD. Pennington and Ozonoff (1996) reviewed 18 studies that explicitly tested the frontal hypothesis of ADHD using commonly accepted EF measures. This review demonstrated that 15 of 18 studies found a significant difference between ADHD subjects and controls on one or more EF measures. The average effect sizes for these measures ranged from 0.27 to 1.08. Within the EF domain, ADHD subjects fairly consistently exhibited significantly poorer performance on measures of vigilance (e.g., Gordon Diagnostic System), perceptual speed (e.g., Coding and Symbol Search), planning (i.e., Tower of Hanoi), inhibition (e.g., Matching Familiar Figures Test, Stroop test, Go No-Go, etc.), and set shifting (i.e., Trails B). In contrast, ADHD groups tended to perform normally on a variety of other measures (e.g., verbal memory tasks). Given that even studies with the best control groups find EF deficits, these researchers concluded that this finding is not a confound of age, sex, intelligence quotient (IQ), socioeconomic status (SES), ethnicity, or comorbid reading disorder (RD) or conduct disorder (CD).

Ten years later, Willcutt, Doyle, Nigg, Faraone, and Pennington (2005) performed a meta-analysis to evaluate the EF theory of ADHD. Rather than include all previous neuropsychological studies of ADHD or all possible EF tasks, this review identified 13 measures that are frequently administered or represent domains of interest in theoretical models of ADHD. A total of 83 studies were included. The meta-analysis found significant differences between groups with and without ADHD on all 13 EF tasks with effect sizes in the medium range (.46 to .69). The strongest and most consistent results were obtained on measures of response inhibition, vigilance, working memory, and planning. Weaknesses in EF were significant in both clinic-referred and community samples and were not fully explained by group differences in intelligence, academic achievement, or symptoms of other disorders. Overall, these results replicated the findings of Pennington and Ozonoff's (1996) previous review. These researchers, however, emphasized that effect sizes were moderate and much smaller than differences in symptoms between groups with and without ADHD. They also cited a recent study, which found that fewer than half of children with ADHD exhibit significant impairment on any specific EF task. Based on these and a number of other findings, Willcutt and colleagues (2005) concluded that EF weaknesses are likely one of several important components in a multifactorial neuropsychologic model of ADHD. This conclusion is in line with the multiple pathway models discussed earlier.

Willcutt and colleagues (2005) also referred to the significant but small correlations (r = +.15 to +.35) between ADHD symptoms and scores on EF tasks as evidence that EF deficits are not the single necessary and sufficient pathway to ADHD. More recently, Jonsdottir, Bouma, Sergeant, and Scherder (2006) found that EFs (i.e., planning, vigilance, and working memory) were not significantly related to parent or teacher ratings of ADHD symptoms. In fact, only comorbid symptoms of depression and autistic symptomatology were significantly related to EFs. Similarly, Naglieri, Goldstein, Delaunder, and Schweback (2005) found no significant correlations between Conners Continuous Performance Test (CPT) and Conners Behavior Rating Scales. Naglieri and colleagues (2005) explained that the correlations between variable pairs such as Attentiveness on the CPT and Cognitive Problems/Inattention on Conners Rating Scale showed little to no correlation ($r = .01$). This finding warrants further investigation.

Are there Specific Neuropsychological Deficits in ADHD?

Many researchers have compared children with ADHD to children with other disorders (e.g., autistic spectrum disorders; ASD, bipolar disorder; BP, oppositional defiant disorder; ODD, and conduct disorder; CD) to determine whether there are differences in EF deficits (e.g., Dickstein et al., 2005; Happé, Booth, Charlton, & Hughes, 2006; Oosterlaan, Scheres, & Sergeant, 2005).

ADHD vs. ASD. Multiple studies have compared executive functioning in children with ADHD and ASD. The majority of studies have identified differences between ADHD and ASD in several EF domains, particularly related to planning, cognitive flexibility, and response inhibition (Bramham et al., 2009). Children with ASD tend to demonstrate cognitive deficits in flexibility and planning across studies, whereas children with ADHD tend to demonstrate deficits in response inhibition (Bramham et al., 2009). Happé and colleagues (2006) examined age-related changes in the EF profiles of boys with ADHD and ASD. They concluded that the profiles were distinct. The ADHD group showed greater inhibitory problems on a Go-no-Go task, while the ASD group was significantly worse on response selection/monitoring in a cognitive estimates task. Results also demonstrated that older children with ASD outperformed younger participants on several EF tasks, whereas the ADHD group showed no such age-related improvement in performance. This suggests that, in addition to different EF profiles, ASD and ADHD may show different developmental trajectories, with greater gains in ASD over time (Happé et al., 2006).

ADHD vs. BP. To better understand pathophysiological differences, Dickstein and colleagues (2005) evaluated ADHD, BP, and normal children on a measure of motor function. Notably, their study is one of the few studies in which ADHD and BP children are compared on the same behavioral measure (Dickstein et al., 2005). Controlling for age and gender, these researchers found a differential pattern by diagnosis: ADHD children were impaired on repetitive task reaction time (e.g., finger tapping 20 times), whereas BP children, both with and without comorbid ADHD, were impaired on sequential task reaction time (e.g., oppose one's thumb to each of the four other digits on the same hand five times). These results seem to provide support for previous research in this area. Since repetitive task reaction time requires rapid inhibition of irrelevant movements, this deficit is consistent with the behavioral and neuroimaging literature and suggests that ADHD involves a core deficit of fronto-striato-basal ganglia neurocircuity (Dickstein et al., 2005).

ADHD vs. ODD/CD. Many investigators have questioned whether EF deficits are specific to ADHD or whether such deficits are also associated with other disruptive behavior disorders (i.e., ODD and CD). ADHD and ODD/CD have been found to co-occur frequently, however, the majority of studies investigating EF impairments in these children have not controlled for comorbidity (Oosterlaan, Scheres, & Sergeant, 2005). The limited amount of research attempting to differentiate EF deficits in ADHD and ODD/CD has produced conflicting results. Several studies support the hypothesis that only ADHD (not ODD/CD) is associated with deficits in EF, others support the hypothesis that only ODD/CD (not ADHD) is related to such deficits, and some maintain that both ADHD and ODD/CD are associated with these impairments (Oosterlaan et al., 2005; Pennington & Ozonoff, 1996).

Oosterlaan et al.'s (2005) study was designed to address three relevant issues: (1) whether ADHD is associated with EF deficits while controlling for ODD/CD, (2) whether ODD/CD is associated with EF deficits while controlling for ADHD, and (3) whether comorbid ADHD and ODD/CD is associated with EF deficits. The EF domains investigated in this study were verbal fluency, working memory, and planning. These researchers found that ADHD, independent of ODD/CD, was associated with deficits in planning and working memory, while no EF deficits were associated with ODD/CD. They concluded that EF deficits in ADHD are independent of the presence or absence of ODD/CD (Oosterlaan et al., 2005).

Heterogeneity Within ADHD

As previously alluded to, despite the well-replicated EF weaknesses in children with ADHD, several meta-analyses have demonstrated substantial variability across studies (Doyle, 2006; Frazier, Demaree, & Youngstrom, 2004; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005). Even the finding that children with ADHD exhibit poor response inhibition has not been universal. For example, Crosbie and Schachar (2001) found that at least 30% of their sample exhibited good inhibition on the stop signal paradigm. The ADHD children in the good inhibition group had a level of inhibitory control similar to that of children of the same age in the general population. Interestingly, these children did not differ from ADHD children with poor inhibition in IQ, impairment, ADHD subtype, or comorbid diagnoses (Crosbie & Schachar, 2001). Nigg and colleagues (2005) also found that only half of the ADHD Combined type subjects assessed at multiple research centers exhibited scores on the stop signal paradigm that surpassed the 90^{th} percentile of controls. No other neurocognitive measure in this analysis was impaired in more than 50% of ADHD subjects.

Potential Moderators of Heterogeneity

Researchers have cited various potential moderators of neurological heterogeneity, including family history, comorbidity, and subtypes in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM–IV*; American Psychiatric Association [APA], 1994).

There is some evidence that ADHD children with a family history of ADHD perform more poorly on EF tasks than those children without a family history of the disorder (Doyle, 1996).

The presence of comorbid disorders, particularly learning disorders and anxiety disorders, has been shown to either exacerbate or modify neuropsychological deficits (Doyle, 2006). With surprisingly few exceptions, studies of clinical samples of children with ADHD often have not controlled for CD when examining neuropsychological deficits (Nigg, Hinshaw, Carte & Treuting, 1998). Nigg and colleagues (1998) investigated whether, in a referred ADHD sample, key neuropsychological impairments were accounted for by comorbid symptoms of ODD, CD, or RD. Boys (*N* = 171) ages 6-12 years were recruited from clinics, schools, physicians, and self-help groups and were administered the same set of neuropsychological measures by a blind clinician. These measures included tasks requiring both language output and nonlinguistic motor output and reflected the understanding that children with ADHD have difficulty in the regulation of response organization and motor output. Forty-two boys were diagnosed with pure ADHD (i.e., no comorbid ODD or CD), 37 boys diagnosed with ADHD and ODD, 21 with ADHD and CD, and 71 comparison boys who did not meet criteria for ADHD. The pure-ADHD group was found to be impaired relative to the comparison group on the neuropsychological measures. This difficulty on effortful neuropsychological tasks was maintained after controlling for comorbid ODD, CD, or RD. Only one significant neuropsychological difference was detected among the three ADHD groups (i.e., pure ADHD, ADHD plus ODD, and ADHD plus CD) – ADHD children with comorbid CD exhibited verbal deficits (lower Verbal IQ) not found in the pure-ADHD group (Nigg et al., 1998). This finding is consistent with population-based studies and suggests that children with ADHD and comorbid CD may have additional cognitive impairments. This study's failure to identify other neuropsychological impairments in the comorbid ADHD plus CD group compared with the noncomorbid group runs counter to major findings from some population-based studies in Dunedin and elsewhere (Nigg et al., 1998). Similarly, a meta-analysis of 8 studies found that response inhibition deficits did not distinguish children with ADHD from children with CD, nor from children with comorbid ADHD and CD (Oosterlaan, Logan, & Sergeant, 1998).

Although it has been hypothesized that different patterns of EF weaknesses would distinguish between DSM-IV subtypes (i.e., ADHD Inattentive and Combined subtypes), the existing meta-analyses do not provide clear support for this contention. Given conflicting findings, further investigation is warranted (Doyle, 2006).

Ecological Validity of Executive Functioning Deficits

Little is known about the clinical implications of executive functioning deficits in children with ADHD. Although impairments on neuropsychological tests are assumed to relate to deficits in multiple domains of functioning, the ecological validity has yet to be determined. Biederman and colleagues (2004) examined the association between EF deficits and academic and psychosocial impairments among children and adolescents with ADHD. They evaluated 259 clinically referred participants with ADHD and 225 control participants between the ages of 6 and 17 at the time of ascertainment. Their neuropsychological battery assessed: (a) vigilance and distractibility, (b) planning and organization, (c) response inhibition, (d) set shifting and categorization, (e) selective attention, (f) visual scanning, and (g) verbal learning. Although the researchers acknowledge that there is no standard battery of EF measures in the field, the tests were chosen based on the empirical and clinical literatures on attention, ADHD, and EFs at the time. These tests included the Rey-Osterrieth Complex Figure, Auditory Continuous Performance Test, Wisconsin Cart Sorting Test, Wide Range Achievement of Memory and Language Test, Stroop test, and Freedom From Distractibility Index. They found that EF deficits were significantly more common in participants with ADHD relative to control participants. Among participants with ADHD, EF deficits were associated with impairments in academic functioning. The deficits increased the risk for grade retention, learning disability, and lower academic achievement. Poor EF was particularly impairing at high levels of ADHD. Contrary to their prediction, EF deficits were not associated with psychiatric comorbidity nor social dysfunction, regardless of ADHD status (Biederman et al., 2004).

Neuropsychological Predictors of Later Outcome

Berlin, Bohlin, and Rydell (2003) studied a community-based sample and found that inhibitory control in preschoolers was related to symptoms of hyperactivity and inattention in school age children. Studies investigating a broader spectrum of behavioral adjustment also implicate neuropsychological dysfunction in the development of behavioral problems two years later (Nigg, Quamma, Greenberg, & Kusche, 1999; Riggs, Blair, & Greenberg, 2003).

Diamantopoulou, Rydell, Thorell, and Bohlin (2007) demonstrated similar results in a community based sample of 112 Swedish children. Using a short-term longitudinal design, the researchers examined whether high levels of ADHD symptoms and poor EF at age 8 years would predict social and academic outcomes one year later. These researchers measured EF with four tasks based on Barkley's (1997) previously described model of ADHD. These tasks included a

Stroop-like task (inhibitory control), a non-verbal working memory task, the Digit Span subtest of the Swedish version of the Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III) (verbal working memory), and the Controlled Oral Word Association Test (reconstitution/verbal fluency task). They found that high levels of teacher and parent ratings of ADHD symptoms and poor EF at age 8 were associated with poor social functioning and poor teachers' ratings at age 9. Similar to Biederman et al.'s (2004) findings, these researchers found that EF alone did not predict social functioning (Diamantopoulou et al., 2007).

Wahlstedt, Thorell, and Bohlin (2008) conducted a similar short-term longitudinal study with a greater number of outcome measures. These researchers investigated ADHD symptoms and EF impairments as predictors of later ADHD symptoms (i.e., hyperactivity/impulsivity and inattention), EF functioning, and the broader scope of socioemotional problems, such as dysfunctional emotional regulation, internalizing problems, symptoms of ODD, and difficulties with social competence. Participants in this 2-year follow-up study were 206 children between the ages of 4 and 6 years old who were randomly selected from preschools in Sweden. EF was measured using four different tasks loading on inhibition and working memory. Results demonstrated that early ADHD symptoms and EF impairments predict continuing problems within each domain. In other words, ADHD symptoms and EF impairments showed stability across the 2-year interval. Only ADHD symptoms, however, predicted aspects of socioemotional functioning, such as problems with emotional regulation and lower levels of social competence.

Studies investigating longitudinal relations between EF in early childhood and behavioral outcomes later in life are rare (Riggs, Blair, & Greenberg, 2003). Although several longitudinal studies have found childhood behavioral predictors of later outcome (e.g., Barkley, Fischer, Smallish, & Fletcher, 2004; Biederman, et al., 1996; Chronis, et al., 2007; Fischer, Barkley, Fletcher, & Smallish, 1993; Hechtman, Weiss, Perlman, & Amsel, 1984; Kessler et al., 2005; Loney, Whaley-Klahn, Kosier, & Conboy, 1983; Mannuzza, Klein, Konig, & Giampino, 1990; Molina & Pelham, 2003; Molina, Pelham, Gnagy, Thompson, & Marshal, 2007; Satterfield & Schell, 1997), few have considered the long-term impact of childhood neuropsychological deficits in ADHD samples. In fact, it appears that the longest follow-up interval in this area of study is approximately 3 years (Berlin et al., 2003). This is regrettable given that longitudinal studies are essential to the construction of developmental models of the role of early neurocognition in future functioning.

Follow-up Studies of Children with ADHD Into Adulthood

Numerous follow-up studies have reported on the fate of ADHD children in adolescence. These studies have fairly consistently demonstrated that ADHD children, compared to controls, exhibit impaired academic and social functioning, perform more poorly on cognitive tasks, and are characterized by low self-esteem at 13 to 15 years of age. ADHD symptoms also remain problematic in two thirds to three quarters of these children, and antisocial behaviors are common (Mannuzza & Klein, 2000). Several of the same follow-up studies have demonstrated that these children continue to exhibit disruptions in many of the same areas in their mid-twenties. Compared with controls, adults diagnosed with childhood ADHD tend to complete less schooling, hold less prestigious jobs, and continue to suffer from poor self-esteem and social skills deficits. In addition, significantly more of these adults are diagnosed with antisocial personality disorder (APD) and, often, a substance use disorder (Mannuzza & Klein, 2000). However, despite these relative deficits, two-thirds of these adults show no evidence of any mental disorder and nearly all are gainfully employed. In their review article of long-term outcome of children with ADHD, Mannuzza and Klein (2000) conclude, “Although ADHD children, as a group, fare poorly compared with their non-ADHD counterparts, the childhood syndrome does not preclude attaining high educational and vocational goals, and most children no longer exhibit clinically significant emotional or behavioral problems once they reach their mid-twenties" (p. 723).

Non-Neuropsychological Predictors of Later Outcome

The following will review prediction studies of children with ADHD that meet the following criteria: (1) prospective follow-up in late adolescence, young adulthood, or adulthood, and; (2) investigation of the relationship between a number of childhood predictors and outcome variables.

Loney and colleagues (1983) evaluated 65 boys with ADHD at age 21 to 23 years. While predictors included individual, ecological, and familial factors, outcome variables primarily focused on antisocial behaviors and associated diagnoses. The 14 predictor and 39 outcome variables were analyzed using multiple regression analyses. Among the strongest predictors were (a) IQ, which was negatively associated with the diagnoses of APD and alcoholism; (b) childhood aggression, which predicted weapon use, police contacts, objections to drinking, and hallucinogen use; (c) parental mental disorder, which was associated with alcohol problems, inhalant use, and employment instability (job changes, unemployment); (d) urban residence, which predicted breaking and entering, violence when drinking, and opiate, sedative, and stimulant use; and (e) number of children, which was related to APD, fighting, drunkenness, and inhalant use. Other significant predictors included childhood hyperactivity (predicted shoplifting and breaking and entering), early age at referral (predicted weapon use, underage driving, and job changes), low SES (predicted suspended driving license and stimulant use), and family instability (predicted underage driving and fire-setting). Excessive parent control was also significantly associated with several outcome variables, however, the direction of the relationship was inconsistent (i.e., negatively associated with job changes vagrancy, and drunkenness, while positively associated with weapon use and multiple substances used). Regarding two major outcome variables, APD and alcoholism, it is disconcerting that the proportion of variance accounted for by the predictors was less than 10%. Furthermore, the clinical relevance of certain outcome measures in this study is difficult to interpret. For example, although several predictors were significantly associated with the use ("Ever tried") of drugs, the extent to which ever having used a drug impacts outcome is unclear.

Hechtman and colleagues (1984) identified many of the same predictors. In their 10-year prospective follow-up of children with ADHD, these researchers evaluated 76 (73% of their original sample) subjects at mean age 19. Several outcome measures were studied, including emotional adjustment (psychiatric symptoms, personality traits, peer relationships), school performance, police involvement (number and severity of offenses), car accidents (number, severity, and cost of damage), and substance use. Predictor variables (measured at age 6-12 years) included personal characteristics (IQ, hyperactivity, aggressivity, emotional stability, frustration tolerance), social-academic parameters (school performance, peer and adult relations, antisocial behavior), and family parameters (SES, family psychiatric history, family climate, child-rearing practices, family rating). Univariate and multivariate regression analyses demonstrated numerous significant associations. Among the more important predictors (in terms of the number of outcomes significantly predicted) were childhood hyperactivity (predicted emotional adjustment, school performance, work record, police involvement, and substance use/abuse), childhood aggressivity (predicted school performance, work record, and substance use/abuse), childhood antisocial behavior (predicted school performance, work record, and substance use/abuse), IQ (predicted emotional adjustment, school performance, work record, police involvement, and substance use/abuse), parent mental disorder (predicted emotional adjustment, school performance police involvement, auto accidents, and substance use/abuse), emotional climate of the home (predicted emotional adjustment, school performance, police involvement, auto accidents, and substance use/abuse), and SES (predicted school performance, work record, and police involvement). It should be noted, however, that certain analyses represented as little as 50% of the childhood cohort due to attrition and missing data.

Fischer and colleagues (1993) prospectively followed 123 hyperactive children (78% of the original sample) 8 years after initial assessment at mean age 14.9 years. Similar to the above studies, predictor variables included childhood characteristics and parent/family factors. Multiple linear and logistic regression equations were used to relate these childhood predictors to adolescent academic, psychiatric, social, and emotional adjustment. DSM-III-R (APA, 1987) oppositional defiant disorder in adolescence was strongly predicted by the combination of greater childhood impulsivity-hyperactivity, paternal antisocial behavior, and family instability. No measures, in contrast, were able to predict a diagnosis of ADHD at adolescent outcome and only more mental health therapy predicted a diagnosis of CD. More mental health therapy also significantly predicted self-rated social maladjustment and, in combination with fewer birth complications, a higher likelihood of being suspended/expelled from school. Family instability also predicted teacher rated social maladjustment and academic failure (being retained in grade), while family adversity was the only variable that significantly predicted a greater number of suspensions/expulsions from school. Other significant predictors included IQ, which was associated with adolescent academic achievement, and childhood defiance, which predicted number and type of arrests.

Fischer, Barkley, Smallish, and Fletcher (2002) conducted a later follow-up of this sample at mean age 20-21 years. As part of this study, these researchers examined the association between childhood conduct problems and adult psychiatric disorders. After controlling for severity of childhood ADHD, higher levels of childhood conduct problems significantly increased the odds of having passive-aggressive, borderline, and antisocial personality disorders. Childhood conduct problems, however, did not significantly affect the risk for major depression or histrionic personality disorders in adulthood.

These researchers later extended their findings by examining childhood predictors of young adult antisocial activities and drug use (Barkley et al., 2004). Severity of both childhood ADHD and conduct problems predicted drug-related crime, but not later drug use.

In another prospective follow-up study, Molina and Pelham (2003) interviewed adolescents (13-18 years old) who were diagnosed with ADHD 5 years earlier. Notably, only 56% of the original sample agreed to participate in the adolescent follow-up. Bivariate and multiple regression analyses were used to test prediction of adolescent substance use from the childhood predictors of inattention, impulsivity-hyperactivity, and ODD/CD symptoms. Childhood inattention predicted age of first illicit drug use, illicit drug use within the past 6 months, frequency of intoxication in the past 6 months, alcohol problems, frequency of marijuana use in the past 6 months, marijuana problems, and quantity of cigarettes in the past 6 months. Childhood impulsivity-hyperactivity predicted age of first cigarette and illicit drug use, while ODD/CD symptoms predicted age of first cigarette use and illicit drug use within the past 6 months. In the multivariate analyses, inattention remained statistically significant after controlling for impulsivity-hyperactivity and ODD/CD symptoms with the exception of illicit drug use within the past 6 months. Childhood impulsivity-hyperactivity did not predict substance use after the effects of childhood inattention and ODD/CD symptoms were controlled.

Using the same sample, these researchers also investigated whether childhood aggression predicted peer functioning in adolescence (Bagwell, Molina, Pelham, & Hoza, 2001). Childhood aggression significantly predicted lower self-perceived peer acceptance in adolescence and less competence in their ability to establish close adolescent friendships at the level of a trend.

Similar to Molina and Pelham (2003), Wilens and colleagues (2011) investigated childhood characteristics that predict future development of substance use disorder (SUD). Subjects were children and adolescents (mean age = 10.9 years) with ADHD followed prospectively over a 10-year follow-up period. Cox models were used to assess the SUD risk associated with predictors within ADHD adjusting for SES and parental history of SUD. Comorbid ODD and CD were found to be significant predictors of SUD in young adulthood.

Satterfield and Schell (1997) conducted prospective adolescent (12-13 years old) and adult (18-23 years old) follow-up studies of hyperactive children initially diagnosed between the ages of 6 and 12. Like many of the previous studies, no attempt was made to exclude children with CD at initial assessment. These investigators estimate that about three-quarters of their sample would have met criteria for CD (Satterfield et al., 2007). Childhood predictor variables included four conduct problems items (i.e., fights, lies, steals from other children, and steals from family members) and two factor scores from both teacher and parent ratings (i.e., the antisocial and hyperactive factor) on the Satterfield Teacher and Parent Rating Scale. Outcome variables included adolescent and adult criminality. Subjects rated high by parents on lies, steals from other children, and steals from family members were significantly more likely to become juvenile recidivists and have higher adult arrest rates. Subjects rated high by parents on the antisocial factor were also more likely to become juvenile recidivists and have higher adult arrest rates. None of the teacher ratings or factor scores was predictive of juvenile recidivism or adult arrests. In addition, other childhood attributes, including Full Scale IQ, Verbal IQ, social class, and family type, did not predict these outcomes.

The same cohort of subjects was followed up in mid-adulthood between the ages of 32 and 42 years old (Satterfield et al., 2007). Satterfield and colleagues (2007) examined the same set of six predictors referred to above for adult felony recidivism over a longer period of time. Results remained consistent. High parent ratings of childhood conduct problems and antisocial factor scores predicted adult recidivism. Interestingly, the majority (92%) of the adult felony recidivists had at least one childhood conduct problem. In contrast to their previous findings, subjects' IQ and SES were significantly related to felony offender rates in mid-adulthood.

Langberg and colleagues (2011) also conducted a prospective adolescent follow-up (mean age = 16.8 years) of a large sample of children who met diagnostic criteria for ADHD-Combined type in early childhood (mean age = 8.5 years; N = 579). Outcome variables focused on two different types of academic outcomes – academic achievement, measured by standardized test scores, and academic performance, measured by grades in school. Predictors and outcomes were analyzed using multivariate regression models. Organization skills (+), classroom performance (+), and parental education (+) best predicted grades across all subject areas and overall GPA. None of the ADHD or ODD symptom variables was significant in any of the multivariate grades models. Intelligence (+), family income (+), classroom performance (+), and special education services (-) significantly predicted all scores on the Wechsler Individual Achievement Test (WIAT). Symptoms of inattention (-) were significant in the models predicting Math and Spelling achievement scores.

Biederman and colleagues (1996) conducted an investigation of predictors of persistence and remission of ADHD in a short-term (4-year) prospective study of 128 6- to 17-year-old boys with ADHD. Eighty-five percent of the sample had persistent (i.e., ongoing) ADHD at follow-up. Significant predictors of persistent ADHD included paternal psychopathology, family conflict, inattentive symptoms at baseline, family history of ADHD, and comorbid conduct, bipolar, and anxiety disorders. Given that subjects with persistent ADHD were only 14 years old at follow-up, it is unknown whether these factors will continue to predict outcome when remission occurs in a larger proportion of the sample.

Kessler and colleagues (2005) conducted a retrospective study to investigate the predictors of ADHD persistence into adulthood. A retrospective assessment battery of childhood ADHD, childhood risk factors, and a screen for adult ADHD was administered to a sample of 3197 18-44 years old respondents in the National Comorbidity Study Replication. Logistic regression was used to study childhood predictors of persistence. Respondents with greater childhood ADHD symptom severity (i.e., threshold attention-concentration symptoms *and* impulsive-hyperactive symptoms) and childhood treatment significantly predicted persistence. Neither comorbid DSM-IV disorders nor childhood adversities predicted adult persistence either individually or overall.

Mannuzza and colleagues (1990) used the current sample to investigate childhood predictors of adolescent mental status. Ninety-eight percent of the 103 boys with ADHD were assessed 9 years after they were seen in childhood. Predictor variables included measures of clinical characteristics in childhood (parent, teacher, and clinician ratings), cognitive functioning (aptitude and achievement tests), and familial-environment factors (SES, parent mental disorder, family stability). Discriminant function analyses were used to determine the relationship between these predictors and current mental status at age 18. Childhood variables did not significantly predict adolescent mental disorders.

Mannuzza, Klein, Abikoff, and Moulton (2004) investigated whether low to moderate levels of childhood ODD and CD behaviors in children with ADHD contribute to the development of clinically diagnosed CD in adolescence and APD in adulthood. An initial childhood cohort of 207 boys with ADHD (mean age = 8) was systematically assessed in adolescence (94%, mean age = 18) and adulthood (85%, mean age = 25). Logistic regression analyses were used to examine the relationship between childhood predictors and later outcome. Results showed that childhood CD behaviors predicted diagnosable CD in adolescence and APD in adulthood, while ODD behaviors did not.

Overview of Current Study

The current research is a data analysis of a long-term prospective follow-up of children with ADHD. This study will examine whether childhood neuropsychological test performance and behavioral ratings predict adult outcome in psychiatric status and major functional domains 16 years later. In addition, the study will examine the relationship between severity of ADHD symptoms and neuropsychological test performance given the somewhat inconsistent and limited findings referred to above. This the only prospective prediction study to examine a pure ADHD sample with no comorbid CD in childhood. This is important because it circumvents the interpretive difficulties of other studies due to comorbidity. Furthermore, trained clinical evaluators (i.e., doctorate in social work in private practice and Ph.D. in clinical psychology) with established reliability conducted multiple systematic assessments blind to ADHD childhood status and study hypotheses, and attrition was relatively low (88% retention).

Neuropsychological test performance was measured using multiple tests that were chosen based on the empirical and clinical literatures on the deficits associated with ADHD. These tests included the Beery Developmental Test of Visual-Motor Integration (VMI), Porteus Mazes, Visual Sequential Memory Test of the Illinois Test of Psycholinguistic Abilities (ITPA), Wechsler Intelligence Scale for Children (WISC/WISC-R), a Continuous Performance Test, and a Paired Associate test. The Conners Teacher Rating Scale (CTRS; Conners, 1969) was used to assess the childhood behavioral predictors included in this study, specifically severity of ADHD symptoms and conduct and oppositional defiant disorder behaviors. Given the importance of this subject matter and strengths of this study, findings have the potential to contribute to the literature in this area.

Candidate's Involvement in Current Study

As previously indicated, the present research represents a secondary analysis of data from a major, prospective follow-up study of children with ADHD into adulthood. Although only young adult outcome at age 25 was addressed in the current analyses, the parent project included an initial childhood assessment (mean age, 9) and three subsequent follow-up periods during late adolescence (mean age, 18), young adulthood (mean age, 25), and middle adulthood (mean age, 41). The current author was first acquainted with the ADHD follow-up project as a research assistant in the summer of 2002. She entered diagnostic data, proofread manuscripts, became familiar with the instruments used in the middle adulthood follow-up, and observed assessments of study subjects. The author was later asked by the Co-Investigators of the project, Drs. Rachel Klein and Sal Mannuzza, to serve as Project Coordinator. Over the next 2 years (2004-2006), her responsibilities were numerous and highly diversified, e.g., enlisting the cooperation of participants who were first seen 33 years prior, coordinating all study procedures, assisting in the development and field-testing of a 200-page psychiatric interview, participating in reliability studies using a scale of overall functioning, and supervising research assistants. Two activities were most pertinent for the present research. First, the author conducted an extensive review of the childhood clinic charts, which provided an understanding of these individuals as children. Second, in recruiting subjects, she had the opportunity to speak with subjects, their spouses, and various family members, which provided me with a familiarity of their current lives and functioning. Stated differently, she developed an appreciation for the participants as real individuals. Her involvement with this study continues to the present day. She continues to contribute to, and co-author, scientific papers from the project, specifically, one was published in *American Journal of Psychiatry*, a second in *Journal of Attention Disorders*, and a third is currently in press in *Archives of General Psychiatry.*

Hypotheses and Research Questions

Cross-Sectional (Time 1, Childhood, Mean Age 9)

Aim 1. To understand the relationship between neuropsychological test performance and severity of disruptive behaviors to children's IQ and SES.

Hypothesis 1. Neuropsychological test performance at Time 1 and teacher ratings of disruptive behaviors are significantly correlated with children's IQ and SES.

Aim 2. To investigate the relationship between neuropsychological functioning and childhood disruptive behaviors.

Hypothesis 2. There is a negative correlation between neuropsychological functioning in children with ADHD and severity of childhood disruptive behaviors (symptoms of ADHD, CD, and ODD), i.e., the poorer the functioning, the greater the severity and vice versa.

Aim 3. To explore differences in neuropsychological functioning between ADHD children with and without comorbid CD behaviors.

Hypothesis 3a. ADHD children with CD behaviors demonstrate poorer verbal ability than those without CD behaviors.

Hypothesis 3b. ADHD children with and without CD behaviors perform similarly on nonverbal measures of neuropsychological functioning.

Longitudinal (Time 2, Adulthood, Mean Age 25)

Aim 4. To determine whether severity of childhood disruptive behaviors predict outcome across major functional domains and prevalence of adult mental disorders.

Hypothesis 4a. Greater severity of childhood disruptive behaviors (symptoms of ADHD, CD, and ODD) predicts poor outcome across major functional domains of adult functioning (educational, occupational, social).

Hypothesis 4b. Greater severity of childhood disruptive behaviors predicts increased prevalence of adult mental disorders.

Aim 5. To study whether, and to what extent, childhood neuropsychological test performance predict outcome across major functional domains and prevalence of adult mental disorders.

Hypothesis 5a. There is a positive relationship between childhood neuropsychological test performance and later functioning in major adult domains (educational, occupational, social), i.e., the poorer the test performance, the poorer the adult functioning, and vice versa.

Research Question 5b. Do certain neuropsychological deficits exhibit substantially greater predictive validity with respect to long-term functioning?

Hypothesis 5c. There is an inverse (negative) relationship between childhood neuropsychological test performance and the prevalence of adult mental disorders, i.e., the poorer the test performance, the greater the prevalence.

Research Question 5d. Do certain neuropsychological deficits exhibit substantially greater predictive validity with respect to adult mental disorders?

Method

Participants

Participants were 103 middle class, White boys ranging in age from 6 to 12 years old (mean = 9.3 [SD = 1.4] years) who were referred to a no-cost child psychiatric research clinic in New York between 1970 and 1975. These boys met the following inclusion criteria: (1) referred by teachers due to behavior problems; (2) rated ≥ 1.8 on the Hyperactivity factor of the Conners Teacher Rating Scale (CTRS; Conners, 1969); (3) rated 2 (*pretty much*) or 3 (*very much*) on the "restless, overactive" item on the CTRS; (4) elevated ratings (at least 28 out of a possible 44 on 11 items scored 0-4) on the Parent Hyperactivity Scale (Werry & Sprague, 1970); (5) a diagnosis of DSM-II (APA, 1968) Hyperkinetic Reaction of Childhood based on systematic evaluation by a child psychiatrist with parent and child; (6) Verbal or Performance IQ ≥ 85; (7) no evidence of psychosis or a neurological disorder; (8) English-speaking parents and a home telephone to facilitate communication with study personnel.

Of the 103 hyperactive boys, 100 completed the Wechsler Intelligence Scale for Children and the Wide Range Achievement Test (WRAT). We compared the scores on these measures to assess the rate of learning disability in the childhood sample. Criterion A of DSM-IV Reading Disorder states, "Reading achievement, as measured by individually administered standardized tests of reading accuracy or comprehension, is substantially below that expected given the person's chronological age, measured intelligence, and age-appropriate education." Although there are no guidelines on what constitutes "substantially below," only eight of the 100 boys had an IQ-Wide Range Achievement Test difference that was greater than or equal to 1.5 SD (i.e., ≥ 23), and only one boy had a difference that was greater than or equal to 2.0 SD (i.e., ≥ 30). Given recent emphasis on Criterion B of DSM-IV related to impairment, we also determined the number of boys who had WRAT reading standard scores below or equal to 80. Only seven of the 100 boys had a score below or equal to 80. Based on this information, it is likely that reading disorder was relatively rare in this sample.

To rule out CD, children were excluded if the school referral included aggressive or other serious antisocial behaviors (e.g., vandalism, fighting, and stealing) or if the psychiatric assessment with the parent revealed a pattern of antisocial activities. Since formal criteria for CD were not introduced until 1980, this diagnosis could not be used as exclusionary. Nonetheless, to determine whether CD was successfully excluded, we examined ratings on items corresponding to DSM-IV CD behaviors (lying, stealing, truancy, etc.) on the Conners Teachers Rating Scale (Conners, 1969). The overall mean of teacher ratings on these items was 0.8 (SD = 0.6) out of a possible 3.00 on a 4-point scale ranging from 0 (*not at all*) to 3 (*very much*), which demonstrates that conduct problems were rare. This finding suggests that children with diagnosable CD were eliminated from this sample.

All 103 children would have met criteria for DSM-IV ADHD Combined type because: (1) cross-situationality of hyperactivity was required; (2) all subjects were clinically impaired by their symptoms, as indicated by school referral due to behavior problems; (3) severe hyperactivity was required; (4) mean ratings on the Conners Teacher Rating Scale items of restless/overactive, inattentive/distractible, and excitable/impulsive (rated 0-3) were 2.88, 2.59, and 2.31, respectively; and (5) classroom observation ratings by blind observers were significantly different for ADHD and “normal” children on items related to hyperactivity (“out of chair”), inattention (“off task”), and impulsivity (“interference;” Abikoff, Gittelman, & Klein, 1980).

Assessment in Childhood

Children and their parents were interviewed by a child psychiatrist to confirm the diagnosis of Hyperkinetic Reaction of Childhood. Participants were administered the WISC/WISC-R (Wechsler, 1949, 1974) by a psychologist to ensure an IQ ≥ 85. Behavioral rating scales also were used to evaluate behavior at home (completed by parents), adjustment at school (completed by teachers), and behavior observed at the clinic by a psychiatrist and psychologist. For the variables included in the current study, we relied exclusively on teacher ratings due to the potential limitations associated with parent reports (Mannuzza, Klein, & Moulton, 2002).

Neuropsychological/cognitive tests. Subjects who met all inclusion criteria were later administered a variety of psychometric tests by a psychologist. These tests included the Beery Developmental Test of Visual-Motor Integration, Porteus Mazes, Visual Sequential Memory Test of the Illinois Test of Psycholinguistic Abilities (ITPA), a Continuous Performance Test, and a Paired Associate Test.

Beery Developmental Test of Visual-Motor Integration. The Developmental Test of Visual-Motor Integration (VMI) is a series of 24 geometric forms that subjects copy using pencil and paper. According to Beery (1976), this test was devised as a measure of the degree to which visual perception and motor behavior are integrated in young children. The raw score obtained represents the number of forms passed up to three consecutive failures. For instance, if a child passes the first 10 forms, fails the next three, and then passes the next one, his raw score is 10. This raw score is used to determine the age equivalency.

Beery (1976) provides several estimates of different forms of reliability. Based on a number of studies, he concluded high interjudge reliability (.98), test-retest reliability (.80 to .90), and internal consistency (.78 to .93). According to Beery (1976), the correlation between VMI scores and chronological age is .89 for children between 2- and 15-years-old. Also, VMI correlations with reading achievement in the first grade are higher than those between IQ and reading achievement. In addition, scores are more related to integrative functions than to individual functions suggesting that the VMI is a measure of children’s coordinating abilities (Beery, 1976).

Paired Associate Test. This is a test of rote visual association. Children are shown a series of 10 meaningless designs, each paired with a familiar object. Each pairing is presented on a teaching machine for five seconds. The meaningless design is then displayed again and the subject is asked to recall the familiar object. The score obtained represents the number of trials needed to learn a series of 10 pairings. Therefore, the lower the score, the more rapid the rote learning (Gittleman-Klein & Klein, 1976). No norms or measures of reliability or validity are available given that the original investigators created this version of the test.

Porteus Mazes. This test consists of a series of mazes, with each maze progressively more difficult than the preceding one. According to Riddle and Roberts (1977), the test is a reliable and valid measure of foresight, planning ability, judgment, impulsiveness, ability to delay gratification, and future time perspective. A quantitative score (Test Age; TA) is obtained. The quantitative score is a measure of the ability to solve a maze and successfully trace through it. This score reflects the difficulty of the highest level maze successfully completed and the number of trials required to solve each maze. TA was converted into a Test Quotient in the same way that mental age (MA) is converted to IQ on many intelligence tests (Riddle & Roberts, 1977).

Krikorian and Bartok (1998) published developmental data on the Porteus in 340 normal subjects aged 7 to 21 years. Scores had a significant but weak relationship with socioeconomic status ($r = -.15$) and IQ ($r = +.17$). This study also provided an estimate of internal consistency reliability (Cronbach's coefficient alpha = .81). Gow and Ward (1982) administered the Porteus to 90 subjects. They divided subjects into 3 groups of 30: one with IQs between 135 and 116, one with IQs between 115 and 86, and one with IQs of less than 85. They found significant differences among the groups, indicating that the Porteus is sensitive to intelligence.

Continuous Performance Test. The CPT is a measure of vigilance/inhibition. In this version of the CPT developed by the original investigators (based on the Conners version of the CPT), the child is directed to press a button when a red circle appears on the display window of a teaching machine. The red circle randomly appears among other geometric figures that may be red or blue (Gittleman-Klein & Klein, 1976). There were a total of 26 trials. Similar to the Paired Associate Test, no norms or measures of reliability or validity are available given that the original investigators created this version of the test. Due to these constraints, interpretation of possible results is limited.

Visual Sequential Memory Test. This is one of the subtests of the Illinois Test of Psycholinguistic Abilities (ITPA). This subtest measures the ability to reproduce motorically a series of stimuli presented visually (Paletz & Hirshoren, 1972). The child is presented with a card, for a fixed period of time, with a series of geometric figures on it. He is then given several chips and asked to reproduce the sequence on the card from memory. The numerical scores obtained have age norms (Gittleman-Klein & Klein, 1976; Paletz & Hirshoren, 1972).

There have been many studies relating the ITPA to other psychometric tests. Most of the studies, however, relate the global score to IQ's or mental ages (Kirk & Kirk, 1978). Huizinga (as cited in Kirk & Kirk, 1978) found that the ITPA correlated .90 with the Binet and .80 with the WISC Full Scale IQ. They also reported that the visual-motor subtests correlated .68 with the Binet and .58 with the Performance IQ on the WISC. Waugh (1975) reported that internal consistency measures for the subtests of the ITPA are acceptable (r = .48 to .96) and that test-retest coefficients are adequate (r = .12 to .86). Newcomer, Hare, Hammill, and McGettigan (1975), however, administered the ITPA to 167 normal children and found low reliability (.36) and poor construct validity for the Visual Sequential Memory Test. Despite these limitations, the Visual Sequential Memory Test was included in this study due to the theoretical significance of visual and spatial working memory in the existing literature of neuropsychological deficits associated with ADHD.

Wechsler Intelligence Scale for Children. The WISC/WISC-R (Wechsler, 1949, 1974) includes 10 subtests. In addition to the full scale IQ, we will use three subtests (Arithmetic, Digit Span, and Coding) to calculate the Freedom From Distractibility (FFD) Index and two of the subtests (Arithmetic and Digit Span) to calculate the Working Memory (WM) Index.

Childhood behavioral ratings. The Conners Teacher Rating Scale (CTRS) was used to define the severity of the core symptoms of ADHD, CD behaviors, and ODD behaviors. Each item was rated on a 4-point scale from 0 (*not at all*) to 3 (*very much*). The CTRS is a commonly used research and clinical tool for assessing children's behavior in the classroom. The major purpose of the scale is to provide information to assist clinicians and researchers in understanding several important domains of child behavior. The CTRS has well-established reliability, validity, and clinical utility (Conners, Sitarenios, Parker, & Epstein, 1998). Given its excellent psychometric properties, the CTRS has been used in hundreds of research studies (Conners et al., 1998). Several research reports on normative data have been published, although many of these studies include geographically specific and modest-sized samples (Conners et al, 1998). Since Trites, Blouin, and Laprade's (1982) sample was the largest of those published on the original CTRS, the normative results from their sample of over 9,000 Canadian children are most often used (Conners et al., 1998). Of the 6 factors extracted by these researchers, the Hyperactivity and Conduct Disorder factors are most relevant to the current research study (Trites et al., 1982). It is important to note that the Hyperactivity factor includes items that represent inattention and short attention span. The Cronbach's alphas for these two factors were .94 and .93, respectively (Trites et al., 1982). Coefficients of congruence calculated between factors derived from analyses of the whole sample and factors calculated on random half samples of the data ranged from .99 to .87 for these two factors. These researchers also reported high test-retest and interrater reliability for the CTRS. They found significant correlations between ratings of the same children by different teachers and ratings of the same children by different teachers over 1 year. In addition, higher CTRS scores predicted referrals to school psychologists (Trites, et al., 1982).

Severity of CD behaviors. Four of the 15 items listed under DSM-IV CD criteria are included in the CTRS: destructive, lies, steals (with/without confrontation not distinguished), and truancy. Severity of CD behaviors was represented by the mean of these ratings.

Severity of ADHD behaviors. The CTRS includes three items corresponding to inattention (short attention span, inattentive/distractible, and daydreams), one item corresponding to impulsivity (excitable/impulsive), and two items corresponding to hyperactivity (restless/overactive and fidgeting). Severity of ADHD behaviors was represented by the mean of these six ratings.

Severity of ODD behaviors. Four of the eight items listed under DSM-IV Oppositional Defiant Disorder criteria are included in the CTRS: temper outbursts, quarrelsome, defiant/uncooperative, disturbs other children. Severity of ODD behaviors was represented by the mean of these ratings.

Socioeconomic status. Parental socioeconomic status (SES) was assessed during initial evaluations with participating families by a staff social worker.

Parental SES. Parents' socioeconomic status was rated using the Hollingshead and Redlich index (Hollingshead & Redlich, 1958), which ranges from 1 (*lower class*) to 5 (*upper class*) and is based on parent educations and occupations.

Assessment at Adult Follow-Up

Of the 103 hyperactive boys, 91 (88%) were systematically interviewed in adulthood (Mean age = 25.5, *SD* = 1.3 years) by trained clinicians (a clinical psychologist and a private practitioner with a doctorate in psychiatric social work) who were blind to the subjects' childhood status and study hypotheses, and who completed an extensive training program on differential diagnosis, psychiatric assessment, and narrative composition.

CHAMPS. Subjects were administered the Schedule for the Assessment of Conduct, Hyperactivity, Anxiety, Mood, and Psychoactive Substances (CHAMPS; Mannuzza & Klein, 1987), a semistructured psychiatric interview that was specifically designed for use in two prospective follow-up studies of individuals with ADHD and separation anxiety disorder in childhood. Extensive sections on antisocial and substance use disorders were included since extant data showed that children with ADHD were at increased risk for developing these disorders (Gittelman, Mannuzza, Shenker, & Bonagura, 1985). Similarly, extensive sections were included on anxiety symptoms and disorders since there was ample convergent evidence supporting a relationship between childhood separation anxiety and adult panic disorder and agoraphobia (Gittelman & Klein, 1984).

Several semistructured interview schedules were consulted in developing the CHAMPS. Items on the anxiety and mood disorders were derived primarily from the Schedule for Affective Disorders and Schizophrenia- Lifetime Anxiety Version (Mannuzza, Fyer, Klein, & Endicott, 1986). Items on DSM-III-R criteria were based on the Structured Clinical Interview for DSM-III-R (Spitzer, Williams, & Gibbon, 1986). Items on antisocial behaviors were taken from the Diagnostic Interview Schedule (Robins, Helzer, Croughan, & Ratcliff, 1981).

Coverage of the CHAMPS. The CHAMPS includes the following DSM-III (APA, 1980) and DSM-III-R lifetime diagnoses: conduct disorder and antisocial personality disorder; ADHD with and without hyperactivity; all adult anxiety disorders; separation anxiety disorder; all mood disorders; all psychoactive substance abuse and dependence disorders, including alcoholism; and psychotic symptoms. Inquiry also includes nondiagnostic information, such as educational and occupational histories and social functioning. In addition, the CHAMPS includes a section on Other Disorders and Psychiatric Treatment History, which allowed the clinician interviewers to explore diagnosable conditions not explicitly covered, e.g., hypochondriasis, pathological gambling, and paranoid personality disorder. In fact, only a single subject in the present research was diagnosed with a disorder not included in the CHAMPS. Specifically, this subject was diagnosed as having an ongoing avoidant personality disorder, in addition to ongoing diagnoses of social and specific phobias at adult follow-up (Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993).

Field-testing of the CHAMPS. An earlier version (January 1987) of the CHAMPS was administered to 50 adults between the ages of 22 and 35 by advanced-level clinical psychology doctoral students. Based on the feedback from the interviewers, as well as numerous critical readings of the January version, the final (November 1987) version evolved.

Diagnostic reliability of the final version. Reliability assessments were based on the evaluations of the blind clinicians who participated in the current research, i.e., a clinical psychologist (Ph.D.) and a private practitioner with a doctorate in social work. Fifty audiotaped interviews were quasi-randomly selected to represent a variety of diagnoses. A senior staff clinician, who was blind to group membership, was given the audiotapes and asked to formulate DSM-III-R diagnoses. Based on this assessment of interrater reliability, chance-corrected kappa values for major diagnoses were as follows: ADHD, .70; APD, .69; Substance Use Disorders, .80; Mood Disorders, 1.00; Any DSM-III-R Disorder, .67. These values suggest good to excellent agreement on all major disorders (Shrout, Spitzer, & Fleiss, 1987).

Narratives. Interviewers wrote detailed clinical narrative summaries that described symptomatology, provided examples of functional disruption, documented diagnostic criteria, and specified levels of diagnostic certainty (discussed below). To assure quality control, these narratives were blindly reviewed by a senior staff clinician for diagnostic accuracy and completeness.

Major functional domains. Below are the domains of functioning assessed at adulthood.

Educational attainment. Defined by the highest grade completed (e.g., 09 = 9th grade, 12 = high school, 16 = 4 years of college, etc.).

Social functioning. Clinicians rated adult social functioning on a 6-point scale ranging from 1 (*poor*) to 6 (*superior*) based on questions on the CHAMPS regarding long-term friendships, dating history, group memberships, leisure time activities, etc.

Occupational functioning. Clinicians rated adult work history on a 6-point scale ranging from 1 (*poor*) to 6 (*superior*) based on questions on the CHAMPS regarding duration of longest continuous employment, promotions, merit raises, job problems, reprimands, terminations, premature quitting, etc.

Occupational rank. Rated using the Hollingshead and Redlich Occupation Rank, an 8-point scale ranging from 1 (*higher executives, proprietors of large concerns, major professionals*) to 8 (*unemployed*). For the purposes of this study, this variable was transformed into a dichotomous variable scaled 0 (*Blue Collar workers*) and 1 (*White Collar workers*). "Blue Collar" workers include skilled manual, semi-skilled, and unskilled workers, while "White Collar" workers include higher executives, professionals, proprietors, business managers, administrative personnel, and sales persons.

Overall adult functioning. To capture deficits in adult functioning regardless of functional domain, a dichotomous variable was constructed and scaled 0 (*deficient*) and 1 (*average or above*). "Deficient" included those subjects who never graduated HS (i.e., 11 or less on Highest Grade Completed) or were rated as fair/poor on social or occupational functioning. Those subjects considered "average of above" graduated from high school and were rated at least average on social and occupational functioning.

Psychiatric status. Clinical interviewers formulated definite and probable DSM-III-R diagnoses. A definite diagnosis was made when criteria were fully met. A probable diagnosis was given when fewer than all criteria were reported (e.g., only 4 of the required 5 symptoms of major depression), but functional impairment was present. For the purpose of this study, probable and definite diagnoses will be combined as was done in previous follow-up reports of this sample (Mannuzza et al., 1993). Given that the required number of symptoms is often arbitrary, greater emphasis was placed on functional disruption, which is consistent with clinical practice.

In this study, ongoing (rather than lifetime) diagnoses will be addressed. An “ongoing” disorder was defined as one that fulfilled DSM-III-R criteria within 2 months of the follow-up interview at mean age 25. The two exceptions were antisocial personality and psychoactive substance use disorders. These diagnoses were considered ongoing if subjects met criteria during the past 6 months. Although any stipulation of remission is arbitrary, a 6-month period for these disorders seemed reasonable given the chronic nature of these syndromes.

Results

Cross-Sectional (Time 1, Childhood, Mean Age 9)

Descriptive statistics of predictors. Descriptive statistics of childhood characteristics are presented in Table 1. Since 100 of the 103 boys (97%) completed all childhood measures, results are limited to these subjects. Mean rating of severity of ADHD behaviors was high 2.40 out of a possible 3.00. In contrast, severity of CD behaviors was very low. On average, participants were rated between 0 (*Not at all*) and 1 (*Just a little*). Severity of ODD behaviors was also relatively low. Children in this sample were of average intelligence (M = 103; SD = 11.4) and grew up in middle class homes. These findings were anticipated as childhood inclusion and exclusion criteria mandated normal IQ, severe ADHD symptoms, and no CD.

Table 1

Descriptive Statistics of Childhood Predictors

Variables	Mean	SD	Minimum	Maximum
Neuropsychological Tests				
Beery Visual Motor Integration				
Mental Age (months)	91.1	19.1	58	141
Paired Associates Test				
Number of Trials	7.6	3.5	2	16
Porteus Mazes				
Quantitative IQ	111.7	14.9	78	135
Continuous Performance Test				
Number of Trials	31.2	8.2	22	60
Number Correct	26.0	1.9	19	32
Omission Errors	5.3	7.9	0	41
Visual Sequential Memory Test of the ITPA				
Scaled Score	22.4	4.9	12	34
Conners Teacher Rating Scale Items[a]				
Inattention[b]	2.2	0.6	0.3	3.0
Impulsivity[c]	2.3	0.8	0	3.0
Hyperactivity[d]	2.6	0.5	1.0	3.0
ADHD behaviors[e]	2.4	0.4	1.3	3.0
CD behaviors[f]	0.8	0.6	0	2.7
ODD behaviors[g]	1.9	0.8	0	3.0
Other Characteristics				
Full Scale IQ[h]	103.0	11.4	75	133
Freedom from Distractibility Factor[i]	28.0	5.9	15	42
Working Memory Index[j]	19.2	4.6	10	30
SES (1-Lower to 5-Upper)[k]	2.6	1.0	1	5

Notes: The top third of the table is based on 100 boys with ADHD who were tested between the ages of 6 and 12 years. This represents 97% of all 103 male subjects who met childhood entry criteria and were later targeted for follow-up. The bottom two-thirds of the table are based on all 103 male subjects.
[a]Items were rated 0-Not at all, 1-Just a little, 2-Pretty much, 3-Very much.
[b]Mean of teacher ratings on 3 items representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”].
[c]Teacher rating on impulsivity item [“excitable/impulsive”].
[d]Mean of teacher ratings on 2 items representing hyperactivity [“restless/overactive,” “fidgeting”].
[e]Mean of teacher ratings on variables b, c, d.
[f]Mean of teacher ratings on 4 Conduct Disorder items: “destructive,” “lies,” “steals,” and “truancy.”
[g]Mean of teacher ratings on 4 Oppositional Defiant Disorder items: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children.”
[h]WISC-R Full Scale IQ (Wechsler, 1949).
[i]Sum of Arithmetic, Digit Span, and Coding subtests of the WISC-R.
[j]Sum of Arithmetic and Digit Span of the WISC-R.
[k]Childhood socioeconomic status (Hollingshead & Redlich, 1955).

The average performance on the Beery was at approximately the 91-month level, indicating a maturational lag over a year. In contrast, on the Visual Sequential Memory Test, the average obtained by this group is comparable to the norms for 9-year-old children. On the Paired Associate Test, the children required an average of 7.6 trials to learn 10 consecutive associations. Children failed to press the button when the criterion stimulus appeared (omission errors) on the Continuous Performance Test an average of 5 times. The means of the WISC-R's FFD factor and WM index were within the average range.

Correlations among childhood predictors. Children's Full Scale IQ and SES were not significantly correlated with behavioral ratings on the CTRS or performance on any of the neuropsychological tests (Table 2). However, Full Scale IQ was significantly correlated with FFD and WM, which is to be expected given that these indexes are derived from subtests of the WISC-R. These correlations remain significant after a Bonferroni procedure (.05/12 = .004) was used to correct for inflated Type I error due to multiple contrasts.

Most of the correlations among neuropsychological tests were moderate (+.20 to +.35) and all were in the expected direction (Table 2). Among childhood behavioral ratings (Table 2), severity of childhood ADHD behaviors was positively correlated with severity of CD and ODD behaviors (r's = +.22 and +.26, $p < .03$ and $p < .009$, respectively). However, neither correlation remains significant after a Bonferroni correction, setting $\alpha = .004$. Curiously, severity of ODD behaviors was inversely correlated with severity of CD behaviors ($r = -.41$, $p < .0001$) at a level that exceeded the Bonferroni adjustment. When symptoms of inattention, impulsivity, and hyperactivity were examined separately (Table 3), severity of CD behaviors was positively correlated with hyperactivity symptoms ($r = +.25$, $p < .01$), and severity of ODD behaviors was positively correlated with impulsivity symptoms ($r = +.40$, $p < .0001$). Only the latter correlation remains significant after a Bonferroni correction.

Relationship between neuropsychological functioning and childhood behaviors. Two significant correlations were found between childhood behavioral ratings and neuropsychological test performance. Severity of childhood ODD behaviors was positively correlated to the Beery ($r = +.45$, $p < .0001$); and severity of childhood ADHD behaviors was inversely correlated to FFD ($r = -.21$, $p < .04$). When symptoms of inattention, impulsivity, and hyperactivity were examined separately (Table 3), FFD and WM were inversely related to attentional problems (r's = −.37 and −.24, $p < .0001$ and $p < .02$, respectively). The positive relationship between ODD behaviors and the Beery and the inverse relationship between FFD and attentional problems remained significant after a Bonferroni correction ($\alpha < .004$ and $\alpha < .005$, respectively).

Neuropsychological functioning in ADHD children with and without CD behaviors. Children were divided into two groups based on the presence or absence of CD behaviors. Neuropsychological and intellectual test results for these two groups are presented in Table 4. Results of *t*-tests showed no significant differences between CD and no CD subgroups on neuropsychological tests. However, children with CD behaviors had significantly lower Verbal IQs than children without CD behaviors (102+12 vs. 108 +13, p < .03). This finding was no longer significant after a Bonferroni procedure (.05/10 = .005) was used to correct for inflated Type I error due to multiple contrasts. No significant differences were found on Performance or Full Scale IQ.

Table 2

Pearson Correlations of Childhood Predictors

Variables		Beery	PAT	PM	VSM	CPT Omission	FFD	WM	ADHD	CD	ODD	SES	IQ
Beery	r	1.00	-.059	**.235**	**.199**	**-.302**[†]	**.266**	**.276**	.010	.057	**.453**[†]	-.111	.157
	(p)		(.560)	**(.018)**	**(.047)**	**(.002)**	**(.007)**	**(.005)**	(.919)	(.575)	**(.000)**	(.270)	(.119)
PAT	r		1.00	**-.312**[†]	**-.257**	**-.255**	-.181	-.087	.038	.110	.086	.008	-.177
	(p)			**(.002)**	**(.010)**	**(.010)**	(.072)	(.387)	(.709)	(.274)	(.393)	(.935)	(.079)
PM	r			1.00	**.266**	**-.252**	.149	.136	.128	.091	.126	-.052	.196
	(p)				**(.007)**	**(.011)**	(.140)	(.178)	(.204)	(.367)	(.213)	(.609)	(.051)
VSM	r				1.00	-.142	.137	.052	.062	.099	.062	.174	.118
	(p)					(.158)	(.173)	(.604)	(.542)	(.324)	(.541)	(.083)	(.241)
CPT Omission	r					1.00	-.078	-.115	.066	.063	-.102	-.098	-.155
	(p)						(.440)	(.254)	(517)	(.534)	(.314)	(.334)	(.123)
FFD	r						1.00	**.852**[†]	**-.207**	-.098	-.003	.074	**.691**[†]
	(p)							**(.000)**	**(.036)**	(.323)	(.974)	(.460)	**(.000)**
WM	r							1.00	-.125	-.095	.016	.051	**.639**[†]
	(p)								(.209)	(.339)	(.869)	(.611)	**(.000)**
ADHD	r								1.00	**.218**	**.257**	-.085	-.007
	(p)									**(.027)**	**(.009)**	(.393)	(.946)
CD	r									1.00	**-.414**[†]	-.049	-.024
	(p)										**(0)**	(.624)	(.807)
ODD	r										1.00	-.110	-.117
	(p)											(.270)	(.241)
SES	r											1.00	-.119
	(p)												(.213)
IQ	r												1.00
	(p)												

Notes: Significant results ($p \le .05$) are bolded for ease of inspection. [†]Findings remaining significant after Bonferroni correction for multiple contrasts since .05/12 = .004. Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R); ADHD- Mean of teacher ratings on 6 items on the Conners Teacher Rating Scale representing measures of Inattention, Impulsivity, and Hyperactivity; CD- Mean of teacher ratings on 4 items: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of teacher ratings on 4 items: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children”; SES- Childhood socioeconomic status (Hollingshead & Redlich, 1955); IQ- Full Scale IQ (WISC-R; Wechsler, 1949).

Table 3

Pearson Correlations of ADHD Predictors

Variable	A [Attentional Problems]		I [Impulsivity]		H [Hyperactivity]		ADHD	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Beery	-.086	.394	.030	.765	.075	.456	.010	.919
PAT	.040	.694	-.018	.860	.081	.423	.038	.709
PM	.083	.413	.101	.319	.056	.577	.128	.204
VSM	-.062	.452	.105	.297	.048	.634	.062	.542
CPT Omission	.127	.208	-.013	.896	.042	.681	.066	517
FFD	**-.366**[†]	**.000**	.007	.942	-.113	.245	**-.207**	**.036**
WM	**-.237**	**.016**	.002	.983	-.045	.654	-.125	.209
CD	.023	.819	.166	.094	**.249**	**.011**	**.218**	**.027**
ODD	-.117	.238	**.403**[†]	**.000**	.107	.284	**.257**	**.009**
SES	.026	.795	-.083	.406	-.107	.281	-.085	.393
IQ	-.170	.085	.025	.804	.143	.151	-.007	.946

Notes: Significant results ($p \leq .05$) are bolded for ease of inspection. [†]Findings remaining significant after Bonferroni correction for multiple contrasts since .05/11 = .005.
Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R); CD- Mean of 4 items on the Conners Teacher Rating Scale (CTRS): “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of 4 items on the CTRS: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children”; SES- Childhood socioeconomic status (Hollingshead & Redlich, 1955); IQ- Full Scale IQ (WISC-R; Wechsler 1949). A- Mean of 3 items on the CTRS: “short attention span,” “inattentive/distractible,” and “daydreams”; I- 1 item on the CTRS: “excitable/impulsive”; H- Mean of 2 items on the CTRS: restless/overactive” and “fidgeting”; ADHD- Mean of the 6 items on the CTRS described above for A, I, and H.

Table 4

Test Performance of Children with ADHD with and without Conduct Disorder Behaviors in Childhood

Variable	With CD (*n* = 77)		Without CD (*n* = 26)		*t*	*p*
	Mean	SD	Mean	SD		
Beery	92.64	20.11	86.54	15.33	1.41	.16
PAT	7.86	3.66	7.00	2.87	1.09	.28
PM	111.91	14.88	110.92	15.16	0.29	.77
VSM	22.30	4.72	22.58	5.34	0.25	.80
CPT Omission*	5.72	8.70	3.96	5.02	1.24	.22
FFD	27.79	5.95	28.65	5.85	0.64	.52
WM	19.10	4.73	19.58	4.07	0.46	.65
WISC Verbal IQ	**101.97**	**11.84**	**108.23**	**13.12**	**2.27**	**.03**
WISC Performance IQ	102.18	11.90	100.81	12.70	0.50	.62
WISC Full Scale IQ	102.29	10.91	105.23	12.62	1.14	.26

Notes: For ease of inspection, the row showing the only *p*-value $\leq$ .05 is bolded. This finding was no longer significant after Bonferroni correction for multiple contrasts since .05/10 = .005.
*Levene's Test revealed that the variances were not homogenous. Therefore, a t-test for unequal variances was used.
Without CD- signifies that children were rated as not having any DSM-IV Conduct Disorder behaviors on the Conners Teacher Rating Scale (i.e., children received 0's (0-Not at all) on all 4 Conduct Disorder items: “destructive,” “lies,” “steals,” and “truancy”); Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom from Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span on the WISC-R); WISC- Wechsler Intelligence Scale for Children (Wechsler, 1949).

Longitudinal (Time 2, Adulthood, Mean Age 25)

Descriptive statistics of adult functional domains. Descriptive statistics of adult functional domains are presented in Table 5.

Table 5

Descriptive Statistics of Adult Functional Domains

Variable	
Highest Grade Completed by Adult Follow-Up	
Mean (SD)	12.32 (2.35)
Minimum-Maximum	7 - 17
Clinician Global Rating of Social Functioning in Adulthood [N (%)]	
1- Poor	6 (7)
2- Fair	21 (23)
3- Average	43 (47)
4- Good	17 (19)
5- Very Good	4 (4)
6- Superior	0 (0)
Mean (SD)	2.91 (0.93)
Clinician Global Rating of Occupational Functioning in Adulthood [N (%)]	
1- Poor	13 (14)
2- Fair	19 (21)
3- Average	30 (33)
4- Good	20 (22)
5- Very Good	8 (9)
6- Superior	1 (1)
Mean (SD)	2.93 (1.21)
Occupational Rank of Current/Most Recent Position [N (%)]	
0- Blue Collar	46 (50)
1- White Collar	45 (50)
Overall Functioning [N (%)]	
0- Deficient	51 (56)
1- Average or Above	40 (44)

Note: For all of the above adult outcome variables, the higher the score, the more favorable the outcome. Occupational Rank: Blue Collar- Workers (Skilled Manual, Semi-Skilled, Unskilled); White Collar- Workers (Higher Executives, Professionals, Proprietors, Business Managers, Administrative Personnel, Sales Persons); Overall Functioning: Deficient- Never graduated HS or fair/poor on clinician rating of Social Functioning or fair/poor on clinician rating of Occupational Functioning; Average or Above- graduated HS and rated at least Average on clinician rating of Social and Occupational Functioning.

At mean age 25, study participants had completed an average of 12 years of schooling (*M* = 12.32; *SD* = 2.35). Most participants showed average an average of 12 years of schooling (*M* = 12.32; *SD* = 2.35). Most participants showed average or above social and occupational functioning (70% and 65%, respectively). Despite as very good or above social and occupational functioning (70% and 65%, respectively). Despite these percentages, however, participants' social and occupational functioning were rarely rated as very good or superior (4% and 10%, respectively). Ratings tended to be skewed toward the lower levels of functioning. With regards to occupational rank, participants were equally divided into "blue" and "white collar" workers. Taking into account multiple domains of functioning, over half (56%) of the sample was considered "deficient" in at least one area (i.e., never graduated high school or fair/poor on clinician rating of social functioning or fair/poor on clinician rating of occupational functioning).

Behavioral childhood predictors of adult functional domains. To determine whether severity of ADHD, CD, and ODD behaviors in childhood were predictive of adult educational, social, and occupational functioning, linear and logistic regression analyses were conducted. Given that childhood IQ and SES were significantly correlated with many of the outcome variables (Table 6), we controlled for IQ and SES in regression analyses. Results from regression analyses are presented in Table 7. Severity of childhood CD behaviors was significantly associated with adult educational attainment and social functioning ($p < .01$ for both). These findings (i.e., not the trends described below) exceeded the modified Bonferrroni adjustment ($\alpha = .02$). There were also trends for severity of CD behaviors predicting occupational functioning and rank ($p < .09$ and $p < .10$, respectively). As expected, the more severe the childhood CD behaviors, the less formal education completed, the poorer the social functioning, the worse the occupational functioning, and the more likely a "blue collar" worker (i.e., skilled manual, semi-skilled, or unskilled). Among the adult functional domains, severity of childhood ADHD was only associated with occupational rank at the level of a trend ($p < .10$). Severity of ODD behaviors was not significantly related to any of the outcome variables. Similar patterns of results were found in unadjusted models (i.e., not controlling for childhood SES and IQ). Percentages of variances accounted for educational attainment (14 – 19%) were relatively higher than for social and occupational functioning (3 – 11%).

With regards to the overall adult functioning variable, severity of childhood CD behaviors was predictive of whether an adult was later considered “deficient” or “average or above” (Table 8, OR = .33, $p < .01$). This finding exceeded the modified Bonferrroni adjustment ($\alpha = .02$). Neither severity of childhood ADHD or ODD behaviors was related to the overall outcome variable. Similar patterns of results were again found in unadjusted models.

Prevalence of adult mental disorders. Prevalence of ongoing (i.e., present at adult follow-up at mean age 25) DSM-III-R psychiatric disorders are presented in Table 9. APD and non-alcohol SUD are most prevalent in this sample (18% and 17%, respectively). Approximately one third of subjects met criteria for one or more of the studied psychiatric disorders (i.e., 31% excluding functionally disruptive adult ADHD symptoms and 33% including functionally disruptive adult ADHD). Mood and anxiety disorders were relatively uncommon (7%).

Table 6

Pearson Correlations of Adult Outcome Variables and Childhood IQ and SES

Childhood Variables		Variables based on Adult DSM-III-R Psychiatric Disorders								Variables based on Adult Functional Domains			
		Antisocial Personality Disorder	Alcohol SUD	Non-Alcohol SUD	Any SUD	Any Mood or Anxiety Disorder	ADHD	Any Disorder, Including ADHD	Any Disorder, Excluding ADHD	Education	Social Func-tioning	Occu. Func-tioning	Occu. Rank
IQ													
	r	-.021	.138	.025	.015	.068	-.068	-.108	-.029	**.224**	**.224**	-.143	**.306**
	(*p*)	.841	.193	.815	.891	.519	.494	.307	.787	**.033**	**.033**	.175	**.003**
SES													
	r	.006	**.213**	.085	.126	**.216**	-.018	.013	.015	**.305**	**.305**	-.126	**.303**
	(*p*)	.953	**.043**	.424	.234	**.040**	.852	.906	.886	**.003**	**.003**	.234	**.004**

Notes: For ease of inspection, $p \leq .05$ (2-tailed) results are bolded.
SUD- Substance Use Disorder; ADHD- Clinically Significant ADHD symptoms: Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up; Occu.- Occupational; IQ- Full Scale IQ (WISC-R, Wechsler, 1949); SES- Childhood socioeconomic status (Hollingshead and Redlich, 1955).

Table 7

Behavioral Childhood Predictors of Adult Outcome Across Major Functional Domains

Childhood Predictors	Adult Outcome Variables															
	Educational Attainment				Social Functioning				Occupational Functioning				Occupational Rank			
	B (SE)	CI	*p*	R^2	B (SE)	CI	*p*	R^2	B (SE)	CI	*p*	R^2	B (SE)	OR	CI	*p*
ADHD	-.65 (.55)	-1.75 – .46	.25	.14	-.29 (.23)	-.75 – .17	.21	.06	-.05 (.30)	-.65 – .56	.88	.03	**-.98 (.59)**	**.40**	**.12 – 1.19**	**.10**
CD	**-1.01[†] (.40)**	**-1.80 – (-.21)**	**.01**	**.19**	**-.43[†] (.17)**	**-.76 – (-.10)**	**.01**	**.11**	**-.38 (.22)**	**-.82 – .07**	**.09**	**.06**	**-.71 (.42)**	**.49**	**.22 – 1.12**	**.10**
ODD	-.32 (.38)	-1.08 – .43	.40	.14	.14 (.16)	-.18 – .45	.40	.05	.03 (.21)	-.39 – .44	.90	.03	-.04 (.39)	.96	.45 – 2.07	.93

Notes: This table includes the results of regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Full Scale IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios for the only dichotomously-defined variable, Occupational Rank, were adjusted accordingly. Similar patterns of results were found in unadjusted models (i.e., not controlling for SES and IQ).

Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. [†]Findings remaining significant after Bonferroni correction for multiple contrasts since .05/3 = .02.

ADHD- Mean of ratings on 6 items on the Conners Teacher Rating Scale (CTRS), representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”], Impulsivity [“excitable/impulsive”], and Hyperactivity [“restless/overactive,” “fidgeting”]; CD- Mean of ratings on 4 items on the CTRS, re2presenting measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of ratings on 4 items on the CTRS, representing measures of Oppositional Defiant Disorder: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children”.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 8

Behavioral Childhood Predictors of Overall Adult Functioning

Childhood Predictors	Overall Adult Functioning[*]				
	B	SE	OR	CI	*p*
ADHD	-.51	.53	.60	.21 – 1.71	.34
CD	**-1.12**[†]	**.44**	**.33**	**.14 – 1.09**	**.01**
ODD	-.08	.37	1.08	.53 – 2.22	.83

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Full Scale IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly. Similar patterns of results were found in unadjusted models (i.e., not controlling for SES and IQ).

For ease of inspection, the row showing the only *p*-value $\leq$ .05 is bolded. [†] This finding remains significant after Bonferroni correction for multiple contrasts since .05/3 = .02.

*Defined by creating a dichotomous variable (“Deficient” or “Average or Above”). “Deficient” was defined as never graduated HS or fair/poor on clinician rating of Social Functioning or fair/poor on clinician rating of Occupational Functioning. “Average or Above” was defined as persons who graduated high school and who were rated at least Average on Social and Occupational Functioning.

ADHD- Mean of ratings on 6 items on the Conners Teacher Rating Scale (CTRS), representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”], Impulsivity [“excitable/impulsive”], and Hyperactivity [“restless/overactive,” “fidgeting”]; CD- Mean of ratings on 4 items on the CTRS, representing measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of ratings on 4 items on the CTRS, representing measures of Oppositional Defiant Disorder: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children”.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 9

Prevalence of Ongoing DSM-III-R Psychiatric Disorders

Variable	N (%)
Antisocial Personality Disorder	
0- No	75 (82)
1- Yes	16 (18)
Alcohol Substance Use Disorder	
0- No	86 (94)
1- Yes	5 (6)
Non-Alcohol Substance Use Disorder	
0- No	76 (84)
1- Yes	15 (17)
Alcohol or Non-Alcohol Substance Use Disorder	
0- No	75 (82)
1- Yes	16 (18)
Any Mood or Anxiety Disorder	
0- No	85 (93)
1- Yes	6 (7)
Inattention, Impulsivity, or Hyperactivity	
0- No	81 (89)
1- Yes	10 (11)
Any Disorder Excluding ADHD	
0- No	63 (69)
1- Yes	28 (31)
Any Disorder Including ADHD	
0- No	61 (67)
1- Yes	30 (33)

Notes: Ongoing indicates that the disorder was present at adult follow-up (mean age, 25 years). For all variables, the lower the score, the more favorable the outcome, i.e., 0 = absence of disorder, and 1 = presence.

Behavioral childhood predictors of adult mental disorders. Similar to patterns observed among functional domains, severity of CD behaviors emerged as the only significant predictor of increased prevalence of adult mental disorders. Results of logistic regression analyses are presented in Tables 10 and 11. CD behaviors in childhood significantly predicted increased prevalence of APD (OR = 2.92, $p < .03$) and increased prevalence of a mood or anxiety disorder (OR = 5.99, $p < .02$) at mean age 25. The association between CD behaviors and functionally disruptive ADHD symptoms in adulthood reached the level of a trend ($p < .10$). The association between childhood CD behaviors and adult mood or anxiety disorders remained significant after the Bonferonni correction ($\alpha = .02$). None of the childhood behavioral predictors was associated with adult substance use disorder (i.e., alcohol SUD, non-alcohol SUD, or any SUD, Table 11). In combination, the prevalence of all studied DSM-III-R psychiatric disorders, including and excluding functionally disruptive adult ADHD symptoms, was significantly associated with childhood CD behaviors (Table 12) at the modified Bonferroni level of significance ($\alpha = .02$). Again, similar patterns of results were found in all unadjusted models (i.e., not controlling for IQ and SES).

Given the predictive power of CD behaviors, we were interested in examining descriptive statistics of the four individual items (i.e., “destructive,” “lies,” “steals,” and “truancy”) on the CTRS. Destructive behavior (i.e., Vandalism) was the most frequently rated item (*M* = 1.24; *SD* = 1.08) followed by lies (*M* = .96; *SD* = .99), steals (*M* = .34; *SD* = .67), and truancy (*M* = .15; *SD* = .47).

Exploratory analyses were conducted to determine whether the relationship between conduct disorder behaviors in childhood and adult outcomes was moderated by ADHD behaviors at baseline. No significant interactions between ADHD and CD behaviors in childhood were

Table 10

Behavioral Childhood Predictors of Adult DSM-III-R Psychiatric Disorders (Other than SUD)

Childhood Predictors	Adult Outcome Variables														
	Antisocial Personality Disorder					Any Mood or Anxiety Disorder					ADHD Symptoms*				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
ADHD	-.72	-.65	.49	.14–1.73	.27	-.53	.92	.59	.10–3.58	.57	-.63	.79	.53	.11–2.50	.43
CD	**1.07**	**.50**	**2.92**	**1.10–7.74**	**.03**	**1.78**†	**.78**	**5.99**	**1.29–27.23**	**.02**	**.99**	**.60**	**2.70**	**.84–8.69**	**.10**
ODD	.39	.47	1.48	.59–3.72	.40	-.06	.71	.95	.24–3.77	.94	-.33	.55	.72	.25–2.10	.55

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Full Scale IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly. Similar patterns of results were found in unadjusted models (i.e., not controlling for SES and IQ).

Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. †This finding remains significant after Bonferroni correction for multiple contrasts since .05/3 = .02.

*ADHD Symptoms - Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.

ADHD- Mean of ratings on 6 items on the Conners Teacher Rating Scale (CTRS), representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”], Impulsivity [“excitable/impulsive”], and Hyperactivity [“restless/overactive,” “fidgeting”]; CD- Mean of ratings on 4 items on the CTRS, representing measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of ratings on 4 items on the CTRS, representing measures of Oppositional Defiant Disorder: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children;” SUD- Substance Use Disorders.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed .

Table 11

Behavioral Childhood Predictors of Adult DSM-III-R Substance Use Disorders

Childhood Predictors	Adult Outcome Variables														
	Alcohol SUD					Non-Alcohol SUD					Any SUD				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
ADHD	-1.01	1.02	.37	.05 – 2.72	.33	-.66	.65	.52	.14 – 1.85	.31	-.67	.64	.51	.15 – 1.77	.29
CD	-.69	.90	.50	.09 – 2.96	.45	.50	.49	1.64	.63 – 4.25	.31	.33	.48	1.38	.54 – 3.53	.50
ODD	.06	.77	1.06	.24 – 4.74	.94	-.41	.46	.66	.27 – 1.63	.37	-.27	.45	.76	.32 – 1.84	.55

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Full Scale IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly.
ADHD- Mean of ratings on 6 items on the Conners Teacher Rating Scale (CTRS), representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”], Impulsivity [“excitable/impulsive”], and Hyperactivity [“restless/overactive,” “fidgeting”]; CD- Mean of ratings on 4 items on the CTRS, representing measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of ratings on 4 items on the CTRS, representing measures of Oppositional Defiant Disorder: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children;” SUD- Substance Use Disorders.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 12

Behavioral Childhood Predictors of Any Adult DSM-III-R Psychiatric Disorder

Childhood Predictors	Adult Outcome Variables									
	Any DSM-III-R Disorder Excluding ADHD*					Any DSM-III-R Disorder Including ADHD*				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
ADHD	-.73	.54	.48	.17 – 1.41	.18	-.58	.54	.57	.20 – 1.61	.28
CD	**1.01**[†]	**.42**	**2.74**	**1.19 – 6.29**	**.02**	**1.06**[†]	**.43**	**2.89**	**1.26 – 6.66**	**.01**
ODD	-.02	.37	.99	.47 – 2.04	.97	.10	.37	1.11	.54 – 2.30	.78

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Full Scale IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly. Similar patterns of results were found in unadjusted models (i.e., not controlling for SES and IQ).

Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. [†]Findings remaining significant after Bonferroni correction for multiple contrasts since .05/3 = .02.

*ADHD- Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.

ADHD- Mean of ratings on 6 items on the Conners Teacher Rating Scale (CTRS), representing measures of Inattention [“short attention span,” “inattentive/distractible,” “daydreams”], Impulsivity [“excitable/impulsive”], and Hyperactivity [“restless/overactive,” “fidgeting”]; CD- Mean of ratings on 4 items on the CTRS, representing measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; ODD- Mean of ratings on 4 items on the CTRS, representing measures of Oppositional Defiant Disorder: “temper outbursts,” “quarrelsome,” “defiant/uncooperative,” and “disturbs other children”.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

found for any of the adult outcomes. This suggests that the effect of CD behaviors on adult outcomes was not worsened by the severity of childhood ADHD behaviors.

Given the significant main effects of severity of CD behaviors and IQ and the finding that Verbal IQ scores were significantly different for children with and without CD behaviors (Table 4), exploratory analyses were also conducted to determine whether the relationship between IQ scores and adult outcomes was moderated by CD behaviors at baseline. No significant interactions between IQ scores (defined as either Verbal or Full Scale IQ) and CD behaviors (defined as either severity of CD behaviors or the dichotomous variable scaled 0, absence of CD behaviors, and 1, presence of CD behaviors) in childhood were found for Overall Adult Functioning or Any DSM-III-R Disorder, excluding or including ADHD.

Neuropsychological childhood predictors of adult functional domains. To determine whether neuropsychological test results in childhood were predictive of adult educational, social, and occupational functioning, linear and logistic regression analyses were conducted. Given the conceptual overlap between neuropsychological and intellectual functioning, childhood IQ was not covaried in the following regression analyses. However, childhood SES was covaried, as in other analyses. Results are presented in Table 13. For educational attainment, the WM index of the WISC-R was the only neuropsychological variable whose association with this functional domain reached the level of a trend ($p < .09$). For social functioning, CPT omission scores and WM significantly predicted outcome in this adult domain ($p < .05$ and $p < .01$, respectively). Fewer omission errors on the CPT and higher working memory scores predicted improved social functioning at mean age 25. Although none of the neuropsychological tests results predicted occupational functioning, several significant results and trends emerged for occupational rank. The FFD index significantly predicted occupational rank. VSM and WM were associated with

Table 13

Neuropsychological Childhood Predictors of Adult Outcome Across Major Functional Domains

Childhood Predictors	Adult Outcome Variables															
	Educational Attainment				Social Functioning				Occupational Functioning				Occupational Rank			
	B(SE)	CI	*p*	R^2	B(SE)	CI	*p*	R^2	B(SE)	CI	*p*	R^2	B(SE)	OR	CI	*p*
Beery	.01(.01)	-.02–.03	.80	.11	.01(.01)	-.01–.02	.14	.04	.01(.01)	-.01–.02	.59	.01	.02(.01)	1.02	.99–1.04	.20
PAT	.01(.07)	-.13–.15	.87	.11	-.03(.03)	-.08–.03	.37	.03	.01(.04)	-.06–.08	.83	.01	-.07(.07)	.93	.82–1.06	.28
PM	-.02(.02)	-.06–.01	.20	.12	.01(.01)	-.01–.01	.96	.02	-.01(.01)	-.02–.01	.71	.01	-.01(.02)	.98	.96–1.02	.39
VSM	.02(.05)	-.08–.12	.71	.11	.01(.02)	-.03–.06	.56	.02	.01(.03)	-.04–.07	.62	.01	**.09(.05)**	**1.09**	**.98–1.21**	**.10**
CPT Omission	-.02(.03)	-.08–.05	.57	.11	**-.03(.01)**	**-.05–.01**	**.05**	**.06**	.01(.02)	-.03–.04	.81	.01	-.02(.03)	.98	.93–1.04	.52
FFD	.06(.04)	-.02–.14	.12	.12	-.03(.02)	-.01–.06	.12	.05	.03(.02)	-.02–.07	.23	.03	**.11(.04)**†	**1.12**	**1.03–1.21**	**.01**
WM	**.09(.05)**	**-.02–.20**	**.09**	**.12**	**.06 (.02)**†	**.01–.10**	**.01**	**.09**	.03(.03)	-.02–.09	.24	.03	**.09(.05)**	**1.09**	**.99–1.21**	**.09**

Notes: This table includes the results of regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses, and odds ratios for the only dichotomously-defined variable, Occupational Rank, were adjusted accordingly.
Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. †Findings remaining significant after Bonferroni correction for multiple contrasts since .05/7 = .01.
Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R).
B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed; R^2- Coefficient of Determination.

occupational rank at the level of trend. All parameter estimates were in the expected direction. WM significantly predicted social functioning and FFD significantly predicted occupational rank after a Bonferroni correction ($\alpha = .01$).

With regards to overall functioning, FFD and WM significantly predicted whether an adult was later considered “deficient” or “average or above” across major functional domains (Table 14). Higher childhood FFD and WM scores were associated with increased likelihood of attaining “average or above” adult functioning (OR = 1.10, $p < .02$ and OR = 1.14, $p < .01$, respectively). Only the relationship between WM and overall functioning met the modified Bonferroni correction ($\alpha = .01$). PM was associated with overall adult functioning at the level of a trend ($p < .07$). The parameter estimate was not in the expected direction.

Neuropsychological childhood predictors of adult mental disorders. The results of the logistic regression analyses are presented in Tables 15, 16, and 17. Overall, childhood neuropsychological performance was not predictive of the prevalence of adult DSM-III-R psychiatric disorders. Scores on the PAT significantly predicted increased prevalence of APD (OR = .79, $p < .04$). The greater the number of trials needed to learn a series of 10 pairings, the greater the likelihood of APD at mean age 25. The significance of this finding did not exceed the Bonferonni correction ($\alpha = .01$). PM and CPT omission errors were associated with non-alcohol SUD disorders at the level of a trend ($p < .10$ and $p < .09$). PM continued to be significant for any SUD (i.e., alcohol and non-alcohol SUD combined). None of the neuropsychological tests was associated with the outcome examining presence or absence of any DSM-III-R disorder, excluding or including ADHD (Table 17).

Exploratory analyses were conducted to determine whether neuropsychological tests could be examined in combination. All the neuropsychological measures were subjected to an

Table 14

Neuropsychological Childhood Predictors of Overall Adult Functioning

Childhood Predictors	Overall Adult Functioning*				
	B	SE	OR	CI	*p*
Beery	.01	.01	1.01	.99 – 1.03	.32
PAT	.03	.06	1.03	.91 – 1.16	.69
PM	**-.03**	**.02**	**.97**	**.95 – 1.00**	**.07**
VSM	.05	.05	1.05	.96 – 1.15	.31
PT Omission	-.02	.03	.98	.92 – 1.04	.45
FFD	**.10**	**.04**	**1.10**	**1.02 – 1.19**	**.02**
WM	**.13**[†]	**.05**	**1.14**	**1.03 – 1.27**	**.01**

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses, and odds ratios were adjusted accordingly.
Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. [†]This finding remains significant after Bonferroni correction for multiple contrasts since .05/7 = .01.
*Defined by creating a dichotomous variable ("Deficient" or "Average or Above"). "Deficient" was defined as never graduated HS or fair/poor on clinician rating of Social Functioning or fair/poor on clinician rating of Occupational Functioning. "Average or Above" was defined as persons who graduated high school and who were rated at least Average on Social and Occupational Functioning.
Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R).
B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 15

Neuropsychological Childhood Predictors of Adult DSM-III-R Psychiatric Disorders (Other than SUD)

Childhood Predictors	Adult Outcome Variables														
	Antisocial Personality Disorder					Any Mood/Anxiety Disorder					ADHD Symptoms*				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Beery	.01	.01	1.00	.98 – 1.03	.78	-.01	.03	.99	.94 – 1.04	.63	-.02	.02	.98	.95 – 1.02	.33
PAT	**-.24**	**.12**	**.79**	**.63 – .99**	**.04**	-.24	.18	.79	.56 – 1.12	.19	-.02	.10	.98	.81 – 1.19	.83
PM	.03	.02	1.03	.99 – 1.07	.14	-.01	.03	1.00	.94 – 1.06	.96	-.01	.02	.99	.94 – 1.03	.52
VSM	-.02	.06	.98	.87 – 1.11	.74	.03	.09	1.03	.87 – 1.22	.75	-.12	.08	.89	.76 – 1.04	.13
CPT Omission	-.02	.04	.98	.91 – 1.06	.66	.05	.05	1.05	.95 – 1.17	.33	.01	.04	1.00	.92 – 1.09	.97
FFD	.02	.05	1.02	.93 – 1.11	.70	-.05	.08	.96	.82 – 1.12	.57	.03	.06	1.03	93 – 1.14	.58
WM	-.02	.06	.98	.86 – 1.11	.73	-.07	.10	.93	.76 – 1.14	.49	-.13	.08	.99	.85 – 1.50	.87

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses, and odds ratios were adjusted accordingly.

Significant results ($p \leq .05$) and trends ($p \leq .10$) are bolded for ease of inspection. Finding was no longer significant after Bonferroni correction for multiple contrasts since .05/7 = .01.

*ADHD Symptoms- Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.

Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R); SUD- Substance Use Disorders.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 16

Neuropsychological Childhood Predictors of Adult DSM-III-R Substance Use Disorder

Childhood Predictors	Adult Outcome Variables														
	Alcohol SUD*					Non-Alcohol SUD*					Any SUD*				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Beery	.01	.03	1.01	.96 – 1.07	.66	-.01	.02	1.00	.97 – 1.03	.78	-.01	.02	1.00	.97 – 1.03	.86
PAT	-.14	.17	.87	.62 – 1.21	.40	.08	.08	1.08	.93 – 1.26	.31	.06	.08	1.06	.91 – 1.24	.44
PM	.02	.04	1.02	.95 – 1.09	.62	**-.03**	**.02**	**.97**	**.93 – 1.01**	**.10**	**-.03**	**.02**	**.97**	**.93 – 1.01**	**.10**
VSM	-1.00	.11	.91	.73 – 1.13	.38	-.03	.06	.97	.86 – 1.10	.67	-.02	.06	.98	.87 – 1.10	.69
CPT Omission	-1.00	.16	.91	.67 – 1.23	.54	**.06**	**.03**	**1.06**	**.99 – 1.12**	**.09**	.05	.03	1.05	.99 – 1.12	.11
FFD	.10	.09	1.11	.92 – 1.33	.28	.06	.05	1.07	.97 – 1.17	.20	.07	.05	1.07	.97 – 1.17	.18
WM	.12	.12	1.13	.90 – 1.41	.30	.05	.07	1.05	.92 – 1.19	.45	.05	.06	1.05	.93 – 1.20	.47

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses, and odds ratios were adjusted accordingly.

Trends ($p \leq .10$) are bolded for ease of inspection.

*SUD- Substance Use Disorder

Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission-Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R).

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 17

Neuropsychological Childhood Predictors of Any Adult DSM-III-R Psychiatric Disorder

Childhood Predictors	Adult Outcome Variables									
	Any DSM-III-R Disorder Excluding ADHD*					Any DSM-III-R Disorder Including ADHD*				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Beery	-.01	.01	1.00	.97 – 1.02	.68	-.01	.01	1.00	.97 – 1.02	.73
PAT	-.07	.07	.93	.81 – 1.07	.30	-.08	.07	.93	.81 – 1.06	.27
PM	-.01	.02	1.00	.97 – 1.03	.73	-.01	.02	1.00	.97 – 1.03	.76
VSM	-.04	.05	.96	.87 – 1.06	.45	-.05	.05	.95	.86 – 1.05	.30
CPT Omission	.04	.03	1.04	.98 – 1.10	.17	.03	.03	1.03	.98 – 1.09	.27
FFD	.02	.04	1.02	.95 – 1.10	.56	.01	.04	1.01	.94 – 1.09	.75
WM	-.03	.05	.98	.88 – 1.08	.63	-.04	.05	.96	.87 – 1.06	.40

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses, and odds ratios were adjusted accordingly.
*ADHD- Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.
Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct); FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R).
B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed

exploratory factor analysis using a Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable. This variable was then used to explore whether the combined neuropsychological factor would be predictive of adult outcome across major functional domains or prevalence of psychiatric disorders. The results of these regression analyses are presented in Tables 18-22. The neuropsychological factor was not predictive of any of the studied domains of adult functioning or DSM-III-R psychiatric disorders.

Summary of longitudinal findings after corrections for multiple contrasts. Table 23 provides a summary of significant findings after Bonferroni corrections for multiple contrasts. Childhood CD behaviors continued to significantly predict adult educational attainment, social functioning, overall functioning, any mood or anxiety disorder, and any DSM-III-R disorders. With regards to neuropsychological variables, the FFD factor continued to predict occupational rank and the WM index continued to predict social and overall functioning.

Discussion

The present study examined the neuropsychological test performance of children with ADHD and assessed whether test performance and childhood disruptive behaviors predicted adult outcome in psychiatric status and major functional domains. The main findings concerning the relationship between childhood characteristics, behaviors, and test performance were that: (a) children did not exhibit significant difficulty on tasks of visual motor integration, planning, distractibility, and verbal and spatial working memory; (b) neuropsychological test performance and severity of ADHD, CD, and ODD behaviors were not related to children's IQ and SES; (c) neuropsychological functioning was not associated with severity of childhood behaviors with the exception of a positive relationship between ODD behaviors and performance on a test of visual motor integration (Beery), and an inverse relationship between a measure of distractibility (FFD

Table 18

Neuropsychological Factor as a Childhood Predictor of Adult Outcome Across Major Functional Domains

Childhood Predictor	Adult Outcome Variables																
	Educational Attainment				Social Functioning				Occupational Functioning				Occupational Rank				
	B(SE)	*CI*	p	R^2	B(SE)	CI	p	R^2	B (SE)	CI	p	R^2	B (SE)	OR	CI	p
Neuropsych. Factor*	-.21 (.39)	-1.00–.57	.59	.14	.16 (.16)	-.15–.47	.31	.11	-.06(.21)	-.48–.37	.79	.03	.21(.41)	1.23	.56–2.72	.61

Notes: This table includes the results of regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Verbal IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and the odds ratio for the only dichotomously-defined variable, Occupational Rank, was adjusted accordingly.

*Neuropsych. Factor- Neuropsychological measures [Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct)] were subjected to an exploratory factor analysis using Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed; R^2- Coefficient of Determination

Table 19

Neuropsychological Factor as a Childhood Predictor of Overall Adult Functioning

Childhood Predictor	Overall Adult Functioning[b]				
	B	SE	OR	CI	*p*
Neuropsych. Factor[a]	–.17	.38	.84	.40 – 1.76	.65

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Verbal IQ (WISC-R; Wechsler, 1949) were covaried, and odds ratios were adjusted accordingly.

[a]Neuropsych. Factor- Neuropsychological measures [Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct)] were subjected to an exploratory factor analysis using Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable.

[b]Defined by creating a dichotomous variable ("Deficient" or "Average or Above"). "Deficient" was defined as never graduated HS or fair/poor on clinician rating of Social Functioning or fair/poor on clinician rating of Occupational Functioning. "Average or Above" was defined as persons who graduated high school and who were rated at least Average on Social and Occupational Functioning.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed

Table 20

Neuropsychological Factor as a Childhood Predictor of Adult DSM-III-R Psychiatric Disorders (Other than SUD[a])

Childhood Predictor	Adult Outcome Variables														
	Antisocial Personality Disorder					Any Mood or Anxiety Disorder					ADHD Symptoms[c]				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Neuropsych. Factor[b]	.76	.54	2.13	.74 – 6.09	.16	.14	.81	1.15	.24 – 5.60	.87	-.35	.52	.70	.25 – 1.95	.50

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Verbal IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly.

[a]SUD- Substance Use Disorders

[b]Neuropsych. Factor- Neuropsychological measures [Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct)] were subjected to an exploratory factor analysis using Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable.

[c]ADHD Symptoms- Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 21

Neuropsychological Factor as a Childhood Predictor of Adult DSM-III-R Substance Use Disorder

Childhood Predictor	Adult Outcome Variables														
	Alcohol SUD[b]					Non-Alcohol SUD[b]					Any SUD[b]				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Neuropsych. Factor[a]	.08	.93	1.09	.18 – 6.71	.93	-.73	.46	.48	.20 – 1.19	.11	-.66	.45	.52	.21 – 1.25	.14

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Verbal IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly.

[a]Neuropsych. Factor- Neuropsychological measures [Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct)] were subjected to an exploratory factor analysis using Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable.

[b]SUD- Substance Use Disorder.

B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 22

Neuropsychological Factor as a Childhood Predictor of Any Adult DSM-III-R Psychiatric Disorder

Childhood Predictor	Adult Outcome Variables: Any DSM-III-R Disorder Excluding ADHD[b]					Adult Outcome Variables: Any DSM-III-R Disorder Including ADHD[b]				
	B	SE	OR	CI	*p*	B	SE	OR	CI	*p*
Neuropsych. Factor[a]	-.12	.38	.89	.42 – 1.85	.75	-.03	.38	.97	.46 – 2.02	.93

Notes: This table includes the results of logistic regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 8 years) for whom adult outcome data were obtained at mean age 25. Childhood socioeconomic status (Hollingshead & Redlich, 1955) and Verbal IQ (WISC-R; Wechsler, 1949) were covaried in all analyses, and odds ratios were adjusted accordingly.
[a]Neuropsych. Factor- Neuropsychological measures [Beery- Beery Visual Motor Integration (Mental Age); PAT- Paired Associates Test (Number of Trials); PM- Porteus Mazes (Quantitative IQ); VSM- Visual Sequential Memory (Scaled Score); CPT Omission- Continuous Performance Test (Number of Trials – Number Correct)] were subjected to an exploratory factor analysis using Maximum Likelihood estimation and Varimax rotation. One factor was extracted. Z-scores were averaged to create a single variable.
[b]ADHD- Inattention, Impulsivity, and/or Hyperactivity were considered functionally disruptive by the clinical interviewer at follow-up.
B- Unstandardized Coefficient; SE- Standard Error of Estimate; OR- Adjusted Odds Ratio; CI- 95% Confidence Interval; *p*- 2-tailed.

Table 23

Summary of All Significant Longitudinal Findings After Corrections for Multiple Contrasts

Childhood Predictors	Adult Outcome Variables															
	Educational Attainment		Social Functioning		Occupational Rank			Overall Functioning			Any Mood or Anxiety Disorder			Any DSM-III-R Disorder		
	B (SE)	*p*	B(SE)	*p*	B(SE)	OR	*p*	B(SE)	OR	*p*	B(SE)	OR	*p*	B(SE)	OR	*p*
CD	-1.01 (.40)	.01	-.43 (.17)	.01	ns			-1.12 (.44)	.33	.01	1.78 (.78)	5.99	.02	1.06 (.43)	2.89	.01
FFD	ns		ns		.11 (.04)	1.12	.01	ns			ns			ns		
WM	ns		.06 (.02)	.01	ns			.13 (.05)	1.14	.01	ns			ns		

Notes: This table includes the significant results of regression analyses of individuals who were diagnosed as having ADHD in childhood (mean age, 9 years) for whom adult outcome data were obtained at mean age 25 after a Bonferroni correction for multiple contrasts (alpha ranged from .02 to .01). Childhood socioeconomic status (Hollingshead & Redlich, 1955) was covaried in all analyses. Full Scale IQ (WISC-R; Wechsler, 1949) was covaried in analyses of behavioral childhood predictors (i.e., CD). Odds ratios for the dichotomously-defined variables were adjusted accordingly.
CD- Mean of ratings on 4 items on the CTRS, representing measures of Conduct Disorder: “destructive,” “lies,” “steals,” and “truancy”; FFD- Freedom From Distractibility Factor (Arithmetic, Digit Span, and Coding subtests of the WISC-R); WM- Working Memory Index (Arithmetic and Digit Span of the WISC-R).
B- Unstandardized Coefficient; SE- Standard Error of Estimate; *p*- 2-tailed; OR- Adjusted Odds Ratio; ns- $p > .02$, 2-tailed, after correction.

factor) and attentional problems and; (d) ADHD boys with CD behaviors demonstrated lower verbal ability than those without CD behaviors, but performed similarly on all other measures. The main findings concerning the predictive utility of childhood variables and adult outcome were that: (a) severity of childhood CD behaviors (not ADHD or ODD behaviors) predicted adult functioning in major domains (educational, social, and overall functioning) and prevalence of adult mental disorders (APD, any mood or anxiety disorder, and any DSM-III-R Disorder) and; (b) the WM index and FFD factor emerged as the only neuropsychological indexes to predict domains of adult functioning (occupational rank and social functioning, respectively, and both predicted overall functioning). It is important to note that this finding may be due to the relationship between childhood IQ and domains of adult functioning. The overall conclusion is that in this pure-ADHD sample (absence of CD) of clinic-referred, middle class, White boys with average intelligence and intact neuropsychological functioning, severity of childhood CD behaviors emerged as the most consistent predictor of adult functioning and psychiatric status.

Our finding that children with ADHD did not exhibit significant difficulty on tasks of visual motor integration, planning, distractibility, and verbal and spatial working memory contradicts the two meta-analyses reviewed earlier (Pennington & Ozonoff, 1996, Willcutt et al., 2005). Willcutt and colleagues (2005) emphasized, however, that effect sizes for EF tasks were moderate and much smaller than differences in symptoms between groups with and without ADHD. Nigg et al. (2005) point out that these modest effect sizes along with greater ADHD sample variance suggest: (1) ADHD and non-ADHD performance distributions overlap to a substantial degree in all studies, and (2) some children with ADHD perform in the normal range. Thus, children with a “bad score” are likely to have ADHD, but only a minority of children with ADHD will exhibit a deficit on any specific test. Furthermore, Nigg et al. (2005) reviewed empirical evidence from three active research centers with expertise in ADHD on a handful of widely studied neuropsychologic measures. These researchers found that generally no more than half of the children with ADHD, Combined type can be reasonably classified as “impaired” on any given measure and that batteries of neuropsychologic measures yield relatively weak sensitivity/specificity indices for clinical purposes. These data, which are representative of the findings in the literature, suggest that any reasonable cutoff will leave many children with ADHD as “unaffected” or else classify a large number of control children as “affected.” Nigg and colleagues conclude that between 35% and 50% of children with ADHD, Combined type may have a particular neurologic dysfunction that contributes to the disorder, while the remaining 50% to 70% may have some other etiology, including problems in motivation, adaptation, or context.

Nigg et al.’s (2005) assertion that only a subgroup of children with ADHD have executive deficits may partially explain differences in findings between our study and the previously referred to meta-analyses. However, other explanations are possible. Differences in sample characteristics related to gender, comorbidity, and ADHD subtypes may have impacted findings. Alternatively, the neuropsychological tests used in the current research may not have been sufficiently sensitive or comprehensive to capture existing deficits.

According to Jonsdottir and colleagues (2006), previous studies have demonstrated that measures of EF tend to correlate with IQ. Our results do not support this observation, perhaps having to do with the way in which studies assess intellectual ability. Alternatively, by study inclusion criteria, our restricted range in intellectual ability (i.e., Verbal or Performance IQ $\geq$ 85 and obtained SD = 11) may have made significant findings less likely.

We replicated past findings from multiple studies that neuropsychological test performance was not associated with severity of childhood disruptive behaviors. Jonsdottir et al. (2006) reported uniformly low and non-significant correlations (the highest correlation was .17) between items on the Conners Parent and Teacher Rating Scales and scores on the Conners Continuous Performance Test. We similarly found no significant correlations between means of items on the Conners Teacher Rating Scales (i.e., variables defined as severity of ADHD, CD, and ODD behaviors) and scores on a continuous performance test. Naglieri and colleagues (2005) found that aspects of EF (planning, vigilance, and working memory) were not significantly related to symptoms of ADHD or teacher ratings of aggression or conduct problems. Measuring similar areas of EF, we too found no significant correlations between performance and teacher rated disruptive problems. In contrast to the present study's findings, Oosterlaan et al. (2005) reported a significant correlation between teacher-rated ADHD (not parent rated) and EF task performance. These conflicting results may reflect significant differences in sample characteristics (gender, ADHD subtype, comorbidity, etc.) and the use of different rating scales to assess ADHD symptoms and different tasks to assess EFs.

Although generally neuropsychological test performance was not associated with severity of childhood disruptive behaviors in our study, a positive relationship emerged between ODD behaviors and performance on a test of visual motor integration (Beery). This finding contradicts our hypotheses and is difficult to explain. Oosterlaan et al. (2005) found some evidence, however, that ODD/CD behaviors were associated with enhanced performance on some EF measures. The presence of comorbid ODD/CD in children with ADHD was found to reduce the impulsive planning strategy evident in children with ADHD without ODD/CD. Whereas children with ADHD did not adjust their planning time with increasingly difficulty level (i.e., planning times remained similar across difficulty level), ADHD children with comorbid ODD/CD showed some increase in planning time with increasing difficulty level (Osterlaan et al., 2005).

The second exception to the finding that neuropsychological test performance was not associated with childhood disruptive behaviors is the significant relationship between the FFD factor and ratings of attentional problems (mean of 3 items on the CTRS: “short attention span,” “inattentive/distractible,” and “daydreams”). Findings throughout the literature are inconsistent regarding the association between the FFD factor and ADHD. While many studies have found an association, others have failed to support this relationship (Perugini, Harvey, Lovejoy, Sandstrom, & Webb, 2000).

Our finding that ADHD boys with CD behaviors demonstrated lower verbal ability than those without CD behaviors is consistent with Nigg et al. (1998)’s findings and population-based studies that ADHD children with comorbid CD demonstrate verbal deficits (lower Verbal IQ) not found in pure-ADHD groups. Although differences in verbal ability emerged between ADHD children with and without CD behaviors in the current study, verbal ability was not impaired in those with CD behaviors, i.e., the ADHD with vs. without CD difference was relative, yet significant.. This may reflect the fact that CD was excluded in our study and, therefore, CD behaviors were not severe enough to produce deficits. In fact, as previously discussed, the mean of the four items (“destructive,” “lies,” “steals,” and “truancy”) on the CTRS representing CD was between 0 *(not at all)* and 1 *(just a little)*. Our failure to identify other neuropsychological impairment in the ADHD plus CD behaviors group compared with the noncomorbid group is in line with Nigg et al. (1998)’s findings, but runs counter to major findings from some population-based studies in Dunedin and elsewhere. There are several possible explanations for these discrepant findings. First, as previously mentioned, ADHD with a few CD behaviors may differ from ADHD with comobid, diagnosable CD with regards to etiology or impairment. Second, deficits in children with ADHD and CD may be specific to certain executive functions not assessed by our measures. Third, the CTRS only includes four of the 15 behaviors recognized by DSM-IV CD criteria. It is not known whether a more representative sampling of CD behaviors would have resulted in different findings.

Consistent with our hypotheses, greater severity of childhood CD behaviors predicted poorer educational attainment, social functioning, and a measure of overall functioning 16 years later. Our results also suggest a possible relationship between CD behaviors and later occupational functioning and rank. These findings are consistent with studies demonstrating that conduct problems in childhood are associated with poor adolescent and adult outcome across major functional domains, including school performance, social functioning, work record, and arrest history (Bagwell et al., 2001; Fischer et al., 1993; Hechtman et al., 1984; Loney et al., 1983; Satterfield & Schell, 1997; Satterfield et al., 2007). Our results extend current findings by demonstrating that even low levels of CD behaviors are associated with adult functional impairments.

We also replicated past findings that greater severity of childhood CD behaviors predict increased prevalence of psychiatric disorders (Biederman et al., 1996; Fischer et al., 2002). Our results demonstrated that greater severity of CD behaviors predicted increased prevalence of APD, any mood or anxiety disorder, and any DSM-III-R disorder. As previously indicated, the association between childhood CD behaviors and adult APD did not remain significant after controlling for multiple contrasts ($p < .03$ vs. Bonferroni = .02). In the current study, severity of CD behaviors did not predict prevalence of alcohol or non-alcohol substance use disorders (SUD). This finding is not consistent with previous studies in which CD-related behaviors (i.e., childhood aggression, antisocial behavior, or conduct problems) were associated with later alcohol problems and substance use/abuse (Loney et al., 1983; Hechtman et al., 1984; Wilens et al., 2011). In line with our findings, however, Barkley and colleagues (2004) found that severity of conduct problems did not predict later drug use. Nonetheless, the inconsistent findings may reflect differences in the severity of CD behaviors across samples. The majority of the aforementioned studies made no attempt to exclude children with CD at initial assessment and, therefore, likely contain a significant number of children with ADHD plus comorbid CD. Our sample, in contrast, excluded children with comorbid CD. Thus, our failure to find an association between CD behaviors and SUDs may reflect a lack of comorbid CD or more frequent CD behaviors. Alternatively, the fact that several studies did not use DSM criteria to define substance use problems may have impacted findings. In addition, high, possibly selective attrition and lack of blind investigators may have affected the results of studies reporting significant relationships.

In contrast to CD behaviors, neither severity of ADHD nor ODD behaviors predicted adult outcome in our study. Similar studies have reported inconsistent findings with respect to the association between severity of childhood ADHD and adult outcome (Biederman et al., 1996; Fischer et al., 1993; Hechtman et al., 1984; Kessler et al., 2005; Landberg et al., 2011; Loney et al., 1983; Mannuzza et al., 1990; Molina & Pelham, 2003; Satterfield & Schell, 1997). The predictive power of ODD also remains unclear given that most studies tend to combine ODD and CD behaviors or include predictor variables, such as “aggressivity” or “frustration tolerance,” which are representative of both disorders (e.g., Molina & Pelham, 2003; Hechtman et al., 1984). A few studies that included ODD behaviors as predictor variables have reported inconsistent findings. While Wilens et al. (2011) found that comorbid ODD predicted SUD in young adulthood, Langberg et al. (2011) demonstrated that severity of ODD behaviors was not associated with academic outcomes in adolescence. It is unclear how to reconcile these differences.

Our failure to demonstrate a relationship between childhood ODD behaviors and adult outcome may seem surprising since ODD behaviors would appear to be strongly related to CD behaviors – their more severe counterpart. Interestingly, however, we found a significant inverse relationship between ODD and CD behaviors. In other words, greater severity of ODD behaviors was associated with fewer CD behaviors and vice versa. Furthermore, in a previous report on this sample, we found that ODD behaviors did not predict adolescent CD or APD in adulthood (Mannuzza et al., 2004). Perhaps, by restricting the range of CD behavior severity (i.e., excluding children with diagnosable CD), the relationship between CD and ODD was affected. Stated differently, perhaps children with ADHD and comorbid CD (excluded from the present sample) are etiologically distinct from children with ADHD and low levels of comorbid CD behaviors, which may imply that the relationships between these two syndromes and ODD also differ.

The findings of the current study are consistent with and an extension of the aforementioned study (i.e., Mannuzza et al., 2004). In line with our findings, Mannuzza and colleagues (2004) found that low levels of childhood CD behaviors contribute to the development of CD in adolescence and APD in adulthood. The current study extends these findings by demonstrating that low levels of childhood CD behaviors also predict outcome across major functional domains (educational, social, and overall functioning) and greater prevalence of adult internalizing disorders (i.e., mood or anxiety disorders) as well as any DSM-

III-R disorder. These findings further underscore the significance of even low levels of such childhood behaviors.

Results from another previous report on this sample (Mannuzza et al., 1990) are somewhat inconsistent with our current findings. Mannuzza and colleagues (1990) found no association between childhood predictors and adolescent psychiatric status. There are several possible explanations for these discrepant findings. Predictor variables were defined differently (i.e., predictors defined as parent and teacher ratings on individual items on the CTRS rather than the mean of several teacher ratings grouped into diagnostic categories [e.g., steals vs. severity of CD behaviors]). The previous study reported on adolescent outcome, whereas the current study investigated adult outcome. Furthermore, outcome at these distinct time points was defined differently. The previous study examined the following 3 outcomes: (1) CD with or without any other diagnosis, (2) Pure ADHD in the absence of CD and SUD, and (3) No DSM-III diagnosis. Lastly, the previous study used different statistical analyses (i.e., multiple discriminant analysis vs. linear and logistic regression) to examine the relationship between predictors and outcomes.

As previously indicated, longitudinal studies investigating the relationship between childhood neuropsychological test performance and outcomes later in life are rare. Our results demonstrate that measures of working memory and distractibility (i.e., WISC-R's WM index and FFD factor) in childhood may be predictive of specific domains of adult functioning (occupational rank and social functioning, respectively, and both predicted overall functioning). Again, it is important to note that this finding may be due to the relationship between childhood IQ and domains of adult functioning. We also found some evidence that a measure of behavioral inhibition (i.e., CPT omission errors) in childhood was associated with adult social functioning ($p = .05$). Given that the longest follow-up interval in this area of study is approximately 3 years, it is difficult to compare our results to other studies. In line with our findings, however, cross-sectional and brief follow-up studies provide some evidence for an association between childhood measures of working memory and behavioral inhibition and later functioning (Biederman et al., 2004; Diamantopoulou et al., 2007; Wahlstedt et al., 2008). Notably, EF alone without high levels of ADHD symptoms was not associated with concurrent or future functioning (Biederman et al., 2004; Diamantopoulou et al., 2007).

Limitations

Since the sample consisted of clinic-referred, White boys with ADHD who are of average intelligence and have intact neuropsychological functioning results cannot be generalized beyond these characteristics.

This sample is not representative of all ADHD children since both epidemiological and clinical studies show that between 30% and 50% of these children have comorbid conduct disorders. The absence of conduct disorder in this sample, however, may be viewed as a positive feature of the current study. By studying a CD-free sample, we were able to examine the neuropsychological functioning and isolate childhood predictors of adult outcome for the 50% to 70% of children with ADHD without comorbid CD.

Another limitation pertains to the neuropsychological measures used in this study. Certain measures (PAT and CPT) were constructed by the initial investigators and, therefore, lacked reliability and validity estimates or normative data rendering scores difficult to interpret. Furthermore, although there is no standard battery in the field, the measures in this study are not representative of all EF domains (e.g., set shifting).

Not all DSM-IV ODD and CD behaviors were represented by the childhood ratings. Therefore, it is possible that behaviors not represented could have a significant impact on adult outcomes. The excluded behaviors, however, have been shown to be rare, so it seems unlikely that these behaviors would have altered the findings (Frick et al., 1994).

Future Research

The results of this study highlight several areas for future research. Together with results from other studies (e.g., Nigg et al., 2005), our finding that ADHD boys with CD behaviors demonstrated lower verbal ability than those without CD behaviors raises the question whether these verbal deficits are a consequence or precursor of CD behaviors. Although several hypotheses are possible, it may be that verbal deficits are a risk factor for the development of later CD behaviors. The inability to effectively express oneself may increase a child's feelings of aggression and elicit acting out behaviors. Given the finding that childhood CD behaviors are associated with poor prognosis in adulthood, understanding developmental precursors of these behaviors has multiple implications.

This study and others have demonstrated the likelihood that only a subset of children with ADHD exhibit a deficit in a given neurocognitive mechanism believed to contribute to the disorder. As suggested by Nigg et al. (2004), "Creation of a provisional set of criteria in DSM-V for defining an 'executive deficit type' could stimulate research to validate the first etiologic subtype of ADHD and spur the development of more sophisticated causal models, which in the longer term may give clinicians ways to target and tailor treatment" (p. 1224). Furthermore, researchers may be interested in clarifying other possible causal pathways leading to those cases without EF deficits. Studies should also continue to explore at the behavioral level to clarify cognitive heterogeneity in ADHD. For example, studies should consider whether children with ADHD show distinct cognitive profiles if they have a comorbid presentation or meet criteria for a specific DSM-IV subtype. This focus on comorbidity and DSM-IV subtypes is also important with regards to longitudinal studies in which conclusions are made about predictors of later outcome.

Our results regarding childhood CD behaviors and poor prognosis in adulthood also encourage the development of treatment studies in which low levels of CD behaviors are targeted in children with ADHD. It would also be of interest if such studies included a comparison group of children with ADHD plus comorbid, diagnosable (i.e., full-blown) CD to determine whether treatment responsivity differed among pure ADHD, ADHD/CD behaviors, and ADHD/CD groups. There would be significant clinical implications if future treatment and subsequent follow-up studies found that targeting these childhood behaviors led to improved outcomes.

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