DO NEUROPSYCHOLOGICAL OR BEHAVIORALLY DERIVED EXECUTIVE FUNCTION DEFICITS UNDERLIE SOCIAL DEFICITS IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER?

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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Mom, thank you for your kind encouragement.
In memory of Hank, whose charming personality brightened my spirits for six happy years.

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TABLE OF CONTENTS

LIST OF TABLES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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Objective: To examine the relationships between executive functions and social functioning in a group of children with ADHD compared to typically developing children. Method: Participants were 107 8- to 12-year-old children; 45 were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and 62 were typically developing children. Parents completed report measures of executive function (BRIEF) and social functioning (SSRS), and the children completed neuropsychological measures of executive function, specifically inhibition and working memory tasks. Parent report of execution function and the child's performance on the neuropsychological tasks were used to predict the child's level of social functioning in three areas: prosocial behavior, problem behavior, and social desirability. Consistent with previous studies, the children with ADHD had lower social functioning in all three areas as compared with the typically developing children. Parent report of executive function predicted social functioning in all three areas, but neuropsychological performance did not. When ADHD symptom severity was taken into account, it explained a significant amount of the variance in problem behavior that had been accounted for by executive function. For prosocial behavior, both ADHD symptom severity and executive function uniquely contribute to the prediction of social functioning. Both ADHD symptom severity and executive function contributed to the prediction of social desirability, but neither accounted for a significant portion of the variance. Conclusion: The findings suggest that social functioning is impacted by both ADHD symptomatology and executive function.

CHAPTER 1
INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is defined as a persistent pattern of inattention, and/or hyperactivity-impulsivity that is more frequent and severe than is observed in individuals at a comparable level of development, which interferes with social, academic, or occupational functioning. Some impairment must exist prior to age seven and there must be evidence of impairment in more than one setting. It is imperative that a situation specific behavior problem is ruled out (American Psychiatric Association, 1994).

The current estimated prevalence of ADHD, as diagnosed according to DSM-IV criteria, is 3-5% in school-aged children. ADHD is more common in males than in females, with a male to female ratio of 9:1 in clinically referred samples (American Psychiatric Association, 1994). In community samples, males are three to four times more likely to meet criteria for ADHD (McDermott, 1996). Studies suggest that children diagnosed with ADHD do not simply grow out of their diagnosis. Actually, adolescent children with ADHD continue to have behavioral, emotional, academic, and social problems; nearly identical patterns of symptoms and associated characteristics have been found in children and adolescents with ADHD (Biederman, Faraone, & Taylor, 1998).

History of ADHD

ADHD has historically been characterized by one of its symptoms, hyperactivity, which is present in some cases of ADHD, but not all. The initial research into the behavioral impairments of ADHD began with children who had suffered brain damage (e.g., encephalitis, birth trauma, and trauma brain injury) who displayed hyperactivity, and whose symptoms were ascribed to minimal brain disorder or minimal brain dysfunction (Barkley, 1991). Although some of the symptoms of ADHD may negatively impact cognitive functioning, most children with ADHD perform within the normal range on intelligence tests. Some symptoms of ADHD are found to fade with development. For example, restlessness and fidgetiness tend to fade in adolescence. Other symptoms, such as difficulties in concentrating, impulsivity, the appearance of a lack of social perceptiveness, excitement seeking and self-control problems, tend to continue into adulthood.

Baddeley (1986) defined executive control as processes involved in the selection, activation, and manipulation of information in working memory. He coined the term dysexecutive syndrome to refer to a neurological disorder in which the central executive is impaired, and suggested that damage to the frontal cortex often leads to this disorder. Patients with orbitofrontal lesions exhibit disinhibition of emotional responses and inappropriate social behavior (e.g., Phineas Gage, a nineteenth century railroad foreman who sustained an injury in which an iron rod passed through his orbitofrontal cortex). The behavior of patients with prefrontal lesions is marked by inefficiencies, failure to complete tasks, and rule infractions (Anderson, Iidaka, & Cabeza, 2000).

A meta-analysis (Aron & Poldrack, 2005) of the neuroanatomic correlates of response inhibition provides a compelling argument for localization of response inhibition to the right prefrontal cortex. Aron, Fletcher, Bullmore, Shakian, and Robbins (2003) compared 19 patients with unilateral right frontal damage to 17 patients with unilateral left frontal damage and 20 healthy control subjects using a stop-signal task, which requires the individual to stop a prepotent response when signaled by a sound. Localization and extent of damage to each hemisphere was estimated within five sectors: the superior, middle, inferior, orbital frontal gyri, and a medial area (encompassing the anterior cingulate and supplementary motor area) using structural magnetic resonance imaging techniques. Patients with right frontal lesions had significantly slower stop-signal task response times than patients with left frontal lesions. There were no differences between patients with left frontal lesions and control subjects. The amount of damage to the right inferior frontal cortex (and no other region of right or left prefrontal cortex) was shown to be inversely correlated with performance on a stop-signal task.

A meta-analysis (Giedd, Blumenthal, Molloy, & Castellanos, 2001) of structural imaging studies in children with ADHD cited consistent findings of smaller total cerebral volume and smaller prefrontal cortex, with larger differences in the right hemisphere when individuals with ADHD are compared to non-ADHD peers. One study found that the volume of right frontal cortex was correlated with behavioral measures of response inhibition in ADHD children (Casey et al., 1997). Children with ADHD have decreased cortical volume and surface area, which is due to decreased cortical folding throughout the cerebral cortex rather than decreased cortical thickness (Wolosin, Richardson, Hennessey, Denckla & Mostofsky, 2009).

Functional magnetic resonance imaging studies of response inhibition have been less conclusive. Some studies have shown increased activity during response inhibition tasks associated with impaired performance in children (Durston, 2003), whereas other studies have shown reduced activity associated with impaired performance adolescents (Rubia et al., 1999); yet localization of activity to the right prefrontal cortex was consistent for both studies. Suskauer and colleagues (Suskauer et. al., 2009) found reduced activity bilaterally in the pre-supplementary motor area in children with ADHD as compared with typically developing peers during a response inhibition task. The pre-supplementary motor area has been associated with motor response preparation and previous findings have related poor motor response preparation with intra-individual variability in response time in children with ADHD (Mostofsky et. al., 2001; Toplak & Tannock, 2005).

Theories regarding neuromodulation in ADHD have been, in part, based upon the effects of methylphenidate on measures of executive function performance. Methylphenidate has been shown to improve performance on measures of response inhibition (Aron et al., 2003; Bedard et al., 2003) and working memory (Bedard, Martinussen, Ickowicz, & Tannock, 2004) in children with ADHD. Methylphenidate affects both noradrenergic, dopaminergic, and serotoninergic systems and these neurotransmitter systems are interactive (Arnsten, Steere, & Hunt, 1996). Finally, tonic versus phasic modes of dopamine may differentially impact the maintenance versus the updating of working memory (Bilder, Volavka, Lachman, & Grace, 2004).

Models of ADHD

Barkley presented a unifying theory of ADHD (Barkley, 1997), which identified the central deficiency in ADHD as behavioral disinhibition—defined as the ability to stop an ongoing response and the inability to ignore external and internal disruptions. Conversely, behavioral inhibition permits the proficient performance of executive function. Barkley (1997) theorized that deficits in inhibition (i.e., disinhibition) disrupt the executive functions; thus immediate context and its consequence control the behavior of those with ADHD. Barkley differentiated executive function into four domains: working memory, internalization of speech, self-regulation of affect-motivation-arousal, and reconstitution (analysis and synthesis of behavior), and provided examples of representative behaviors and activities for each execution function as follows:

- WORKING MEMORY: Holding events in mind; Manipulating or acting on the events; Imitation of complex behavior sequences; Hindsight; Foresight; Anticipatory set; Sense of time; and Cross-temporal organization of behavior

- EMOTIONAL REGULATION: Emotional self-control; Objectivity/social perspective taking; Self-regulation of drive and motivation; Regulation of arousal in the goal directed action

- INTERNALIZATION OF SPEECH: Description reflection; Rule-governed behavior (instruction); Problem solving/self questioning; Generation of rules; Moral reasoning

- RECONSTITUTION: Analysis and synthesis of behavior; Verbal fluency/behavioral fluency; Goal-directed behavioral creativity; Behavioral simulations; Syntax of behavior

In addition to his hypothesis that behavioral disinhibition will lead to executive function deficits, Barkley predicted significant deficiencies in the performance of social skills (i.e., sharing, cooperation, etc.) as well as other adaptive behaviors, which are predicated on valuing the immediate context over future personal and social consequences. Barkley stated that the knowledge of social and adaptive skills or behaviors is not at issue, it is the application of that knowledge in day-to-day functioning that is impaired, which he described as the same problem seen with patients with injuries to the prefrontal cortex (Barkley, 1997 p.78).

Sonaga-Barke (2005) proposed that there are two distinct causal models of ADHD that characterize different subsets of the ADHD population: the motivational developmental model and the cognitive developmental model. In the motivational developmental model, the underlying deficit begins with impaired decision making when delayed rewards are a factor (Sonuga-Barke, 2005; Sonuga-Barke, Sergeant, Nigg, & Willcutt, 2008). Negative emotional response to delayed reward compels avoidance of delays, leading to impulsivity when faced with a choice between an immediate and a delayed reward, even when the delayed reward is of higher value. When delay cannot be avoided, attempts are made to mitigate the aversiveness of the delay by attending to interesting aspects of the environment (i.e., diverting attention from the delay) or acting on the environment to make it more interesting or to gain other rewards (e.g., attention from others). These compensatory behaviors present as inattention and hyperactivity. The authors asserted that impulsivity, inattention and hyperactivity is associated with the avoidance of delay and missed opportunity to learn to cope with delay aversion, leading to further avoidance and lack of opportunity to develop coping skills. In support for this model, (Antrop, Buysse, Roeyers, & Van

Oost, 2002) found that children with ADHD display more symptoms of activity and inattention increase during delays.

The cognitive developmental model focuses on the role of executive dysfunction resulting from behavioral disinhibition as proposed by Barkley's unifying theory of ADHD. Sonuga-Barke (2005) suggested that those with inhibitory-based executive deficits have executive task aversion and subsequently avoid situations with high executive demand, thus limiting their opportunity to develop executive skills and compounding their underlying neurobiological executive deficits. In conclusion, for some, ADHD symptoms result from impairments in motivational processes that lead to an aversion to delayed rewards; these impairments can be distinguished from those due to executive function, both within and across individuals. When performance on tasks tapping executive function (reaction time in a stop-signal task) and delay aversion (proportion of large delayed choices in a choice delay task) were compared within the same sample, task performances were uncorrelated, yet they both were associated with ADHD (Solanto, Marks, Mitchell, Wasserstein, & Kofman, 2008; Sonuga-Barke, Dalen, & Remington, 2003). In this study, four distinct groups of children could be identified using a cutoff of performance scores that are worse than 90% of the control group: 23% had only an inhibitory deficit; 15% had delay aversion only; 23% showed both characteristics; and 39% had neither deficit (Sonuga-Barke et al., 2003). Delay aversion and executive function deficits seemed to be dissociable constructs implicated in ADHD, often affecting a different subpopulation of cases.

Heterogeneity in Neuropsychological Findings

Willicutt, Doyle, Nigg, Faraone, and Pennington (2005, p.1336) stated that executive functions represent “top-down” cognitive inputs that facilitate decision making by maintaining information about possible choice in working memory and integrating this knowledge with information about the current context to identify the optimal action for the situation. The executive function model of ADHD was thought to arise from a primary deficit in executive control that is necessary and sufficient to cause ADHD. Willicutt and colleagues (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005, p.1336) argued that to establish this primary deficit the following criteria must be met: 1. groups with ADHD must consistently exhibit weakness on executive function measures after controlling for other potential confounding variables; 2. executive function weaknesses must account for a substantial proportion of the variance in ADHD symptoms; 3. executive function weaknesses must be present in most individuals with ADHD; 4. executive function weaknesses and ADHD symptoms must be attributable to common etiologic influences. Support for the first criterion was found. Meta-analyses (Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Pennington & Ozonoff, 1996; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) have confirmed that children with ADHD as a group consistently demonstrated lower scores on executive function tasks. These studies found that the strongest and most consistent findings have been in the domains of response inhibition, vigilance, working memory and planning with effect sizes in the moderate range. Nigg and colleagues (Nigg, Willcutt et al., 2005) noted that these moderate effect sizes suggest considerable, approximately 50%, overlap between the ADHD and non-ADHD samples. They observed that the ADHD samples showed greater variability than their comparison samples and the group differences were driven by a subset of the ADHD sample that demonstrated executive function impairment. These observations call into question the evidence for criteria 2 and 3. Nigg and colleagues (Nigg, Stavro et al., 2005) provided some support for the fourth criterion with an adult ADHD sample: executive function was uniquely associated with an inattention and disorganization factor, but not hyperactivity–impulsivity when both were entered as predictors. This finding seems plausible given that symptoms of hyperactivity and impulsivity generally diminish with age. These researchers theorized that multiple neurodevelopmental pathways lead to symptom profiles of ADHD. Willcutt and colleagues (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) suggested that ADHD is attributable to additive or interactive effect of dysfunction in multiple neural networks in the same individual. Nigg and colleagues (Nigg, Stavro et al., 2005; Nigg, Willcutt et al., 2005) suggested that executive dysfunction is a domain of impairment for a subset of those with ADHD and should be considered a subtype within the ADHD population, not a universal criterion.

Impairments in executive function have been found to be related to inattentive symptoms but not hyperactive/ impulsive symptoms in children (Wahlstedt, 2009) and adolescents (Martel, Nikolas & Nigg, 2007). The combination of ADHD and executive function deficits has been associated with increased risk of negative outcome in both children and adults. Biederman and colleagues (Biederman et al., 2004) demonstrated that children with ADHD and executive function deficits (determined by neuropsychological testing) were at an increased risk for academic deficits as compared to peers with ADHD, without executive function deficits. In an adult sample using the same design, Biederman and colleagues (2006) found that adults with ADHD and neuropsychologically defined executive function deficits had lower socioeconomic status, education attainment and occupational attainment compared to adults with ADHD without executive function deficits. Biederman and colleagues (Biederman et al., 2008) compared four groups of adults with ADHD based on presence of neuropsychologically defined executive function deficits (EFD), presence of behaviorally-defined executive function deficits based on self-report, presence of both types of executive function deficits or absence of executive function deficit. Participants with ADHD plus neuropsychologically defined executive function deficits (EFD) had lower IQ and achievement testing and those with ADHD plus self-reported EFD had more severe ADHD symptomatology, psychiatric comorbidity, and interpersonal deficits. All three groups with ADHD plus EFD had lower SES and education that their peers with ADHD without EFD. In conclusion, self-report measures of executive function and neuropsychological measures that tap executive function do not seem to assess the same construct; however, both contribute unique measurement of deficits that are present in over half of this adult sample (63%) and these deficits associated with negative outcomes in life achievements (i.e., academic and occupational attainment and SES).

Biederman and colleagues' (2008) finding that in the adult ADHD sample, psychometrically defined EFD was associated with lower IQ may relate to Mahone and colleagues (2002) finding of a multivariate group interaction between group (ADHD v. Control) and IQ level. Mahone et al. (2002) found that neuropsychological measures differentiate children with and without ADHD with an average IQ level; however, neuropsychological measures were shown to have reduced discriminatory power at high average and superior IQ levels. Neuropsychological tests have largely been developed to assess deficits, not necessarily the wide range of abilities of above average and intellectually gifted individuals. The neuropsychological measures used in this study were: Rey-Osterreith Complex Figure Task (ROCFT), Tests of Variables of Attention-Visual Test (TOVA-V), and letter and semantic fluency.

There is evidence for lowered executive function when groups of individuals with ADHD are compared to non-ADHD peers; however, the distributions overlap to a great degree. The ADHD groups often show a greater range of scores on executive function tasks; some perform in the intact range and others show impairment (Nigg, Willcutt et al., 2005). Behavioral rating scales and neuropsychological measures of executive function appear to identify different types of executive function deficits in adults (Biederman, et al., 2008). Correlations between neuropsychological tasks that tap execution function and behavioral rating scales that are purported to measure similar constructs have been small to medium in ADHD samples (Loftis, 2005; Bodnar, Prahme, Cutting, Denckla, & Mahone, 2007; Toplak, Bucciarelli, Jain & Tannock, 2009), suggesting that they capture different facets of children's functioning and may tap different aspects of executive dysfunction.

Most of the research on ADHD has focused on the behavioral symptoms of hyperactivity, impulsivity, and inattention. Less attention has been focused on the impact of these symptoms on functioning. ADHD is theorized to be a heterogeneous disorder, which may have multiple causes. Many of those with the disorder display a profile of deficits in executive function that interfere with self-monitoring and effective execution of social behavior (Voeller, 1994; Barkley, 1997). There is converging evidence that children with ADHD often display problems with social functioning (Greene, Biederman, Faraone, & et al., 2001; Greene et al., 1996; Mrug, Hoza, Pelham, Gnagy, & Greiner, 2007; Erhardt & Hinshaw, 1994). Children with ADHD are often rejected by peers (Pelham & Bender, 1982) and have fewer friends than their non-ADHD peers (Hinshaw & Melnick, 1995). Studies of social status, which ask children to name the three most favorite and three least favorite classmates, have found that children displaying symptoms of ADHD-Combined Type tend to be least liked by the peers (Goldstein, 2000; Hinshaw, 2002)

Voeller (1994) described three subtypes of children with social competence deficits. The first subtype (Type 1) was characterized by aggressive and hostile behavior. Their behavioral profile was consistent with conduct disorder or oppositional defiant disorder without comorbid ADHD. The second subtype (Type 2) displayed impaired ability to read social skills or perceive the feelings of others. Their behavioral profile was consistent with Pervasive Developmental

Disorder- Not Otherwise Specified; however, other diagnoses were associated with this profile (e.g., anxiety, depression, obsessive-compulsive disorder, schizotypal, schizoid disorder, and nonverbal learning disability). The primary deficit was theorized to be socioemotional processing; however, impairments in visuospatial skills, attention, and arithmetic were also common but not primary or universal. The third subtype (Type 3) displayed awareness of the feelings of others, but were unable to regulate their own behavior and their resulting behavior was unintentionally disruptive and disorganized. The primary deficit was theorized to be executive function and their behavioral profile was consistent with ADHD. Voeller (1994, p. 527) theorized that social-emotional information processing of social and emotional cues utilizes the right hemisphere, while the left hemisphere provides verbal labels for emotional and social behavior. She hypothesized that the prefrontal cortex processes incoming social-emotional information, relating the information to self and other, evaluating the information in terms of past experiences, and comparing it to representations of expected behavior. This information is then used to inhibit inappropriate responses and generate appropriate social behavior.

Models of Social Adjustment

Most models of social impairment depict social functioning as an interaction of social skill knowledge and ability to make appropriate use of that knowledge. The models differ on whether the social impairments are knowledge driven or performance driven and how (Gresham & Elliott, 1984; Cavell, 1990; Crick & Dodge, 1994). Gresham and Elliott (1984) described a model of social functioning with four potential mechanisms underlying the social impairment: social skill deficits (lack of knowledge about appropriate social skills), social skill performance deficits, self-control deficits (lack of knowledge about appropriate self-control), and self-control performance deficits.

Cavell (1990) suggested a tri-component model of social adjustment with social skill knowledge as the base, which he defined as the discrete knowledge and abilities which are necessary but not sufficient for adequate social skill performance. Social skill knowledge included overt behavior, and social, cognitive and emotional regulation. Social performance and social functioning was determined by individual's ability to use his or her social skill knowledge in the dynamic social environment. Social skill performance was thought to be only one contributor to social adjustment, which was defined as the extent to which one is currently achieving important developmental goals. Successful social adjustment included other factors such as gender, race, physical appearance, athletic ability, and academic skills in addition to adequate social skill performance.

In his seminal paper on social information processing, Dodge (1986), proposed that when faced with a social cue, children engage in four mental steps before enacting competent social behaviors. The first step is encoding situational cues. The second step is interpretation and creation of a mental representation of the cue. In the third step, a mental search is conducted for all possible responses to the situation. Step four is the selection of a response and step five is the execution of the response. Each step builds upon the previous step, thus an error or a deficit in an earlier step will preclude the child from effective social information processing. Once the behavior is enacted, the social situation is modified. The responses from others to the behavior are encoded and the first step begins again. At each step, children refer to their database of cognitive representations of social situations developed from past social experiences. Each child's behavior is limited in scope by their stored concepts and their biologically determined cognitive processing and behavioral execution abilities.

Crick & Dodge (1994) revised this model to take into account that the steps were occurring simultaneously with reciprocal effects, and past events (such as the experience of social rejection by others and the experience of early attachments to adult figures) influence future social information processing and behavior. Scripts of social interactions and models of relationships based on past experiences are integrated with other memories into a general mental structure (i.e., their database) that guides the processing of future social cues and the enactment of behavior. The general mental structure (i.e., database) stores the individual's social knowledge. Early experiences lay down neural paths that are traversed repeatedly in subsequent social interactions, enhancing efficiency; over time these patterns become more automatic and rigid. Crick & Dodge (1994) asserted that children simplify rules to make processing more efficient and often rely on these cognitive heuristics rather than effortfully process each social cue. This increasingly efficient focus may automatically exclude relevant social information resulting in errors, and these errors may be repeated again and again as the patterns become more automatized, resulting in what

Crick and Dodge referred to as biases (1994). As children's cognitive processing abilities develop with age, the complexity of the social demands also develop simultaneously, and thus these biases may become more problematic over time and may result in missed opportunities to learn and develop effective social knowledge. Previous interactions are stored and expectations about how an individual will act will be based on previous interactions with that individual. Following a negative interaction with someone, information about the interaction is stored in memory and representations of it are created, such as expectations of additional negative interactions, attributions to that individual (e.g., he/she is argumentative) or internalizations that affect self-concept (e.g., I'm not good at getting along with people or people don't like me). Crick & Dodge (1994) defined social adjustment as the degree to which children get along with their peers; the degree to which they engage in adaptive, competent social behavior; and the extent to which they inhibit aversive, incompetent behavior. These expectations, attributions, and biases are added to the database of social knowledge and impact subsequent social information processing.

Studies of Social Functioning in ADHD

Studies of social adjustment have focused on two domains, peer status and social behavior. Peer status is a reaction to the child, whereas behavior is an act by the child. The distinction between peer status and social behavior has important implications for examination of the social adjustment-social information processing relation in that some aspects of social information processing might be expected to lead directly to behavior, whereas other aspects might be an outcome of peer status (Crick & Dodge, 1994). Given the interaction between the two in social environment and within the individual's database of experience, true separation can only occur in an abstract sense.

Peer Status

Peer status has also been labeled as sociometric status, which has been assessed by interviewing children in the environment (e.g., classroom) and asking them to provide nominations of three children whom they like and three whom they did not like (Thurber, Heller, & Hinshaw, 2002). Children with high rates of positive nominations (e.g., liked) are classified as accepted and children with high rates of negative nominations (e.g., not liked) are classified as rejected. Children with ADHD are often rejected by peers after brief interactions (Pelham & Bender, 1982; Erhardt & Hinshaw, 1994). Peer status was assessed in the MTA study, which found that 52% of boys and girls with ADHD were classified as rejected and less than 1% were classified as popular (Hoza et al., 2005).

Peer status has been shown to be stable over time. Thurber, Heller, and Hinshaw (2002) found that negative nominations from over a five-week period correlated at r = .88 and positive nominations at r = .64, for girls with and without ADHD. Coie and Dodge (1983) followed third and fifth graders for five years documenting social status; those with a rejected status in third grade maintained that status for at least three years and those with rejected status in fifth grade maintained that status throughout. These findings suggest that once these social difficulties appear, they are resistant to change.

Social Behavior

Social behavior has been assessed by coding behaviors observed in a naturalistic setting (e.g., playground activity), in laboratory based environments, and by informant report (i.e., parent, teacher, self, or peer) via interview or questionnaire. Naturalistic observations often represent a limiting sampling of behavior and have generally been conducted in the school environment or at research based summer camps (Hinshaw, 2002). Laboratory based measures have included social interactions with confederates (Mikami, Huang-Pollock, Pfiffner, McBurnett, & Hangai, 2007) or a presentation of a social interaction via video (Schafer & Semrud-Clikeman, 2008), auditory or written vignette followed by a request for information about the social interaction (e.g., social cues, nonverbal behavior) or the generation of subsequent behaviors to enact in a situation (e.g., what would you do in that situation).

The following studies of social behavior were conducted in a summer camp environment. Mrug and colleagues (2007) found that the behaviors that emerged as best predictors of initial peer status were following activity rules, helping, whining, and inattention. Subsequent helping behaviors and activity rule following predicted some changes in peer status, but their contributions were small. Although non-behavioral variables (e.g., attractiveness and intellectual ability) explained peer liking to some degree, positive and negative behaviors were more strongly associated with the boys' peer status (Erhardt & Hinshaw, 1994). Thurber, Heller, & Hinshaw (2002) found that compared with typically developing girls, girls with ADHD were less compliant (e.g., refusing to follow directions), and more verbally and physically aggressive towards adults and peers.

Compared to their same age peers, girls with ADHD aged 6-12 were observed to display more relational and overt aggression as rated by adult (i.e., parents and teachers) and peer report (Mikami, Lee, Hinshaw, & Mullin, 2007). Peer and parent report of relational and overt aggression were obtained via interview. Peer report of relational aggression was obtained by nomination of which girls were most likely to spread rumors, gossip, tell lies about peers, and threaten not to be friends anymore when angry. Peer report of overt aggression was obtained by nomination of the three girls most likely to hit, kick, push, call names, or physically attack peers. A follow up, 4.5 years later, revealed that these girls still displayed more relational and overt aggression than their typically developing peers as rated by adults. Parents and teachers rated relational aggressive behavior using the children's social behavior scale and rated overt behavior using aggressive behavior subscale of the Achenbach Child Behavior Checklist (CBCL) and Teacher Report Form (TRF). The girls' self-ratings of relational and overt aggression at follow up were not statistically different from their typically developing peers.

Mikami, Lee, and colleagues (2007) observed children aged 7-12 during a computerized chat room task, in which they were encouraged to join in the conversation and interact with four computer simulated peers. Compared to typically developing peers, children with ADHD-Combined Type demonstrated more off topic and hostile responses, whereas children with ADHD-Inattentive

Type demonstrated more off topic responses, fewer responses overall, and poorer memory for the conversation. Parent and teacher report of social behavior using the Social Skills Rating System (SSRS; Gresham & Elliott, 1990) correlated (moderately) with the behavior of the children with ADHD both during the chat room task and during the live observation of unstructured interaction (i.e., snack and free play activities), which included only the children with ADHD.

Causal Theories of Social Functioning in ADHD

Symptoms of ADHD are consistent with the types of behaviors that lead to social rejection. A meta-analysis of peer status (Newcomb, Bukowski, & Pattee, 1993) found that rejected children show more disruptive, physically aggressive, negative, and other aggressive behaviors, as well as more withdrawn behaviors. They also participated in fewer social activities and engaged in less prosocial behavior compared to average status children. Popular children exhibited fewer disruptive, negative, and aggressive behaviors; lower levels of withdrawal; better problem-solving skills; and more prosocial behaviors (e.g., helping peers and being supportive) compared to peers with average sociometric status. Frederick and Olmi (1994) completed a meta-analysis of social skill deficits in children with ADHD and concluded that symptoms of ADHD: difficulties with impulsivity, hyperactivity, disruptive behavior, and inappropriate levels of attention led to the display of poor social skills and the ensuing impaired interactions with and rejection by peers.

In a camp environment over a period of three days, Erhardt and Hinshaw (1994) observed three broad types of behavior: positive social behaviors (on-task and prosocial behavior), negative social behaviors (noncompliance/disruption, verbal aggression, and physical aggression), and socially isolated behaviors (isolation and sadness-dysphoria). Peer rejection was predicted by the presence of negative behaviors, such as aggression and noncompliance. Dimensional ratings of liking were related to a wide range of behaviors, including aggression, noncompliance, and prosocial behavior. In another study, children both with ADHD and without ADHD cited prosocial behaviors and similar interests as reasons for liking others and verbal and physical aggression as reasons for disliking peers (Hinshaw & Melnick, 1995).

Kats-Gold, Besser, & Priel (2007) found that children with ADHD were impaired on a simple emotion recognition computerized task. They were asked to assign emotional states (e.g., happy, sad, scared, and angry) to the presented faces. The ADHD group showed the most difficulty with the negative emotion faces (e.g., sad, scared, and angry), and performed worse than typically developing children. The authors found that errors on the emotion recognition task were related to social impairments for the ADHD group, but not for the typically developing group. The authors suggested that difficulty interpreting the reactions of others, particularly negative reactions, may underlie the social impairments seen in ADHD. For example, if children with ADHD do not recognize the negative reaction (i.e., social cue) they will not know to modify their behavior and thus the behavior that resulted in the negative reaction will continue. The authors asserted that inattention and hyperactivity put children with ADHD at further risk by aggravating the negative effect of faulty emotion recognition on their social skills.

Mikami, Lee, and colleagues (2007) examined Crick & Dodge's (1994) model in a sample of adolescent girls with and without ADHD and found that the relationships between attribution biases (e.g., belief that someone's behavior towards you has negative intent) and overt and relational aggression were stronger for typical developing girls than for girls with ADHD. Authors suggested that aggressive behavior and peer rejection were more prevalent in the ADHD group and were associated with a wide spectrum of problems. They also theorized that perhaps the ADHD group's aggressive behavior was above the threshold where aggressive behavior cannot be explained by social information processing theory biases. I would suggest that some of the additional variance in aggressive behavior with the ADHD group may be due to impairments in cognitive processing (e.g., due to a limited behavior repertoire from Crick & Dodge step 3 or due to the choice of an ineffective response from Crick & Dodge step 4) or the impaired execution of the chosen behavioral response.

Greene and colleagues (Greene et al., 2001; Greene et al., 1996) advocate viewing social impairments in ADHD as similar to academic impairments by using an algorithm to compare expected social functioning based on performance on intelligence tests with actual social functioning. Greene and colleagues (1996) used a structured interview with parents to measure social functioning. They found that 22% of ADHD boys and 0% typically developing boys would be considered socially disabled (Greene et al., 1996). In a follow up study examining girls, Greene found that 15% of ADHD girls and 1% of typically developing girls were socially disabled (Greene et al., 2001). Stein, Szumowski, Blondis, and Roizen (1996) argued that Greene's social disability construct was confounded by the increased frequency of comorbid diagnoses of psychological distress or disruptive behavior in those children identified as having a social disability. The assertion (Stein et al., 1996) that comorbidity predicts social deficits or social disability is consistent with Voeller's type 1 social competence deficits; however, Greene's social disability group included both those with comorbidities and those without. Perhaps the type of social difficulities of those without comorbidities is different from those with comoribities, as described by Voeller as type 3 social competence deficits. Those with difficulty carrying out overlearned prosocial behaviors to an extent that is greater than would be expected given their intellectual abilities are likely to have an underlying cognitive pathology that impairs their abilities to appropriately process and execute social behavior akin to the biologically determined capabilities of the Crick & Dodge (1994) model. These difficulties are not due to distress arising from a comorbid psychological disorder.

The ability to suppress prepotent responses is thought to continue to develop through adolescence (Bedard et al., 2003; Bedard et al., 2002), presumably aided by ongoing myelination and pruning of frontal cortical neural networks (Benes, 2001) and socialization and learning. Perhaps for children with ADHD or a subset of those with ADHD, the ability to inhibit or suppress the prepotent response is impaired or delayed due to abnormalities in myelination and pruning of frontal cortical neural networks, which diminishes their ability to learn from social experiences and develop social competence at the same rate as their peers. In their meta-analysis of neuropsychological findings in ADHD, Nigg, Willicut, and colleagues (2005) concluded that studies of the neuropsychology of ADHD have not adequately addressed the interplay of socialization and interpersonal process in early childhood along with development of the self-regulatory abilities. They suggested that, “The neglect of this integration might in part be due to a misguided belief that because ADHD is highly heritable, socialization processes do not require intensive study. This belief is misguided because heritable effects are likely to be mediated at least in substantial part by socialization, through genotype–environment correlations or other mechanisms.” (Nigg, Willicut, et al., 2005 p. 1432).

Studies of Executive Function and Social Functioning in ADHD

To date, there are few studies that have examined the relationship between executive functions and social skills in ADHD. Fortner (1995) examined the relationship between performance on the Wisconsin Card Sorting Task (WCST), which captures one’s response to adjustment to feedback. The WCST predicted 3% of the variance in prosocial behavior as rated by parents on the Social Skills Rating System (Gresham & Elliott, 1990) in a group of boys with ADHD aged six to twelve years.

Cooper, Fennell, Selke, Johnson, & Siddiqi (2005) found significantly lower prosocial behavior, as measured by the parent report on the SSRS, in boys and girls with ADHD as compared to their same aged peers. Inhibition measured by parent report on the Behavior Rating Inventory of Executive Function (BRIEF; (Gioia, Isquith, Guy, & Kenworthy, 2000) predicted 33.2% of the variance in prosocial behavior of the ADHD group. Based on Barkley's model, Cooper and colleagues (2005) hypothesized that both working memory and inhibition would contribute to the prediction of prosocial behavior, a representation of goal-directed behavior; however, working memory did not account for a significant amount of the variance over and above that captured by inhibition. Neither inhibition nor working memory significantly predicted prosocial behavior in the typically developing children.

Jarratt, Riccio & Siekierski (2005) used two adult informant measures of behavior, the Behavioral Assessment System for Children (BASC; Reynolds & Kamphaus, 1992) and the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, et al., 2000), in comparison with parent and teacher ratings of behavior. Their sample included children aged 9-12 years of both genders; 38% were typically developing children and 62% of the sample had diagnosis of ADHD. Parent and teacher ratings of social skills were moderately correlated (-.56). Parent report of social skills was significantly correlated with nearly all the BRIEF subscales: Inhibit (-.51), Shift (-.57), Emotional Control (-.47), Initiate (-.62), Working Memory (-.47), Plan/Organize (-.52), Organization of materials (-.38), and Monitor (-.56). Teacher report of social skills was significant correlated with five of the BRIEF subscales: Shift (.-49), Emotional Control (-.41), Initiate (-.46), Working Memory (-.47) and Monitor (-.43). Neither the parent nor teacher report of social skills indicated significant difference between the two groups, suggesting that the BASC social skills subscale is not sensitive to differences in social behavior when comparing children with ADHD to their typically developing peers. Lower levels of social skills have been found in children with ADHD as compared with aged matched typically developing children using the Social Skills Rating System (SSRS). Van der Oord, et al. (2005) found diminished overall and subscale scores on the SSRS Parent, Teacher, and Child rating scales for children with ADHD as compared to controls; overall scores from the SSRS Parent, Teacher, and Child rating scales correctly classified 90% of the children as normal controls or children with ADHD.

Schafer & Semrud-Clikeman (2008) found that a subset of children with ADHD have perception deficits, which cause impairment in recognizing social cues and misinterpretation of the social environment (i.e., steps 1 and 2 of Crick & Dodge model). As outlined in social information processing theory, impairment in one step leads to impairment in the enactment of social behavior because the other steps will be relying on misinformation. They assessed social perception by using the Child and Adolescent Social Perception Measure (Magill-Evans, Koning, Cameron-Sadava, & Manyk, 1996), which consists of 10 video vignettes depicting situations with emotional content. Voice intonation was clear; however, the actual speech was filtered to be non-decipherable. The children were asked how the person in the video was feeling and how he/she could tell the person was feeling that way, yielding two scores: an emotion and social cue score. Children whose emotion or social cue scores were greater than or equal to 1.5 standard deviations below the mean for their age were classified as low social perception and those with scores within 1.25 standard deviations of the mean for their age were classified as having intact social perception. Both intact and low social perception groups were split subgroups based on presence of symptoms of hyperactivity-impulsivity. Children with six or greater hyperactivity-impulsivity symptoms endorsed during structured diagnostic interview (SIDAC) with the parent and/or T score of 65 or greater on the Hyperactivity subscale of the BASC were classified as having symptoms of hyperactivity-impulsivity and those with five or fewer endorsed hyperactivity-impulsivity symptoms were not. These classifications yielded four groups: children without symptoms of hyperactivity-impulsivity and intact social perception (TYP), children with symptoms of hyperactivity-impulsivity and intact social perception (ISP+H), children with symptoms of hyperactivity-implusivity and low social perception (LSP+H), and children without symptoms of hyperactivity-impulsivity and low social perception (LSP). The three clinical groups included children with the following diagnoses: ADHD-combined type or hyperactive-impulsivity type (ISP+H and LSP+H), ADHD- inattentive type (LSP), Nonverbal Learning Disability (LSP+H and LSP), and Asperger's Disorder (LSP+H and LSP). Comparison of group performance on measures that tap visual perception (e.g., Judgement of Line Orientation (JLO), Beery-B Visual Motor Integration Task (VMI), Rey-Osterrieth Complex Figure Task (ROCFT)) found that two groups with impaired social perception (LSP and LSP+H) had significantly lower performance on the ROCFT as compared to typically developing children (TYP), the children with hyperactivity-impulsivity and intact social perception (ISP+H) did not differ from the other groups. No group differences were found on the JLO or VMI. Schafer & Semrud-Clikeman (2008) theorized that social cue perception is associated with complex visual perception, planning, and motor output demand on the ROCFT and suggested that the skills required in completing the ROCFT overlap with those of the social perception task. Executive function was related to social perception impairment in this subset of children with ADHD and/or other diagnoses. The children's emotion and social cue scores were moderately correlated with the parent report of social behavior on the SSRS and the emotion cue score was correlated with the teacher SSRS; the parent BASC correlated with the emotion cue score but the teacher BASC did not correlate with either measure of social perception. In this study, the SSRS demonstrated greater sensitivity for the detection of social perception deficits than the BASC.

Biederman and colleagues (2008) assessed executive functions adults with ADHD using a self-report measure of behavioral sequelae of executive function deficits (e.g., difficulies with time management, planning and organizational skills), the Current Behavior Scale (Barkley, 1997) and neuropsychological measures. Cut off scores were used to determine deficits in both the self-report and the neuropsychological performance. For the self-report measure, executive function deficit (EFD) was defined as a score above the median of the ADHD participants' score on the scale. Neuropsychologic EFD was operationalized as scores 1.5 standard deviations below the mean of an age-matched non-ADHD control group, on two of the following executive measures: Rey-Osterrieth Complex Figure Task (ROCFT), Wisconsin Card

Sorting Task (WCST), California Verbal Learning Test (CVLT), Stroop, and a composite of the Wechsler Adult Intelligence Scale -Third Edition (WISC-III) Digit Span and Arithmetic subtests. Four groups were established: ADHD without self or neuropsychologically defined EFD (37%), ADHD with self-reported EFD (35%), ADHD with combined self reported and neuropsychologically defined EFD (14%), and ADHD with neuropsychologically defined EFD (14%). The two groups with self-reported executive deficits (EFD) had greater impairment in interpersonal relationships as measured by the Social Adjustment Scale-Self-Report (SAS-SR; Weissmann, 1999) than those with neuropsychologically defined EFD and those without EFD. The SAS-SR is purported to assess an individual's ability to adapt to and derive satisfaction from his or her social roles; higher scores indicate greater social adjustment problems (Allison, 2004). The authors found that compared to adults with neuropsychologically defined EFD or those without EFD, those self-reported executive function deficits had more symptoms of ADHD, greater risk of psychiatric comorbities, which seem to drive their functional deficits.

Diamantopoulou, Rydell, Thorell and Bohlin (2007) compared the predictive ability of executive function and ADHD symptom severity on social functioning in a community sample. Diagnostic status of subjects was not assessed. ADHD symptom severity predicted peer acceptance, physical aggression, and relational aggression. There was an interaction effect for ADHD symptom severity and execution function for prosocial behavior (as measured by peer nominations of people who are nice or helpful). ADHD symptom severity no longer predicted prosocial behavior when high levels of neuropsychological measured executive function deficits were present. Executive dysfunction was found to negatively impact peer acceptance for girls, but not boys.

Huang-Pollock, Mikami, Pfiffner and McBurnett (2009) used a general factor for executive function to test whether executive function mediated the relationship between ADHD symptom severity and social functioning. An exploratory factor analysis found that response inhibition (Stop Signal Reaction Time Task), working memory (WISC-IV Digit Span), planning, and visual spatial perception and integration (ROCFT) loaded on one factor. Social functioning measures included parent SSRS, and teacher report of peer status, and observational ratings of children's performance on a computer based chat task. Executive function mediated the predictive relationship between ADHD status and recognition of subtle verbal cues in the conversation and memory for the conversation. Executive function did not mediate the relationship between ADHD status and parent or teacher report of social functioning.

Current Study

The goal of the present study was to examine the relationships between executive functions and social functioning in a group of children with ADHD compared to typically developing children. This study focused on social skill performance rather than social skill knowledge; however, given the feedback nature of social learning these two constructs cannot be wholly separated. Our focus largely tapped the proportion of social behavior due to performance rather than knowledge. Our participants had an average or better level of intellectual functioning, absence of learning dysfunction, and an absence of comorbid diagnoses, other than simple phobia or oppositional defiant disorder, hence eliminating the potential confound suggested by Stein and colleagues (1996) and social impairments attributable to Voeller's type 1 (i.e., hostile and aggressive behavior associated with conduct disorder) rather than the type 3 social competence deficit profile (i.e., difficulty with execution of overlearned prosocial behaviors).

The Social Skills Rating System (SSRS) was chosen to measure social functioning, because it has been shown to be sensitive to the differences in social behavior in children with ADHD as compared with typically developing children (Van der Oord, et al., 2005; Cooper, et. al., 2005). Three variables of social functioning were examined in this study, prosocial behavior, problem behavior, and social desirability. Prosocial behavior (e.g., helping others and following rules) and negative social behavior or problem behavior (e.g., disruptive behavior) have been shown to predict peer rejection (Erhardt & Hinshaw, 1994; Frederick & Olmi, 1994; Mrug et al., 2007; Newcomb et al., 1993). In the Cooper et al. (2005) study, social behavior was operationally defined as the parent report of the child's execution of socially approved behaviors (i.e., prosocial behavior) at a frequency consistent with developmental expectations. This measure included information about how others respond to the child (e.g., is the child liked by others), but this information was not examined independently. The current study sought to provide a thorough examination of social behavior; the frequency of executing learned behaviors at appropriate times, the frequency of inappropriate or problematic behavior, as well as how well liked the child is. Together these variables comprise a holistic representation of the child's ability to effectively interact with others and respond to social cues. Erhardt & Hinshaw (1994) found that being liked by others was related to a wide range of behaviors. Capturing a wider sample of social competence will allow for a better test of Barkley's Model.

The domains of inhibition and working memory were chosen to test Barkley's model of ADHD. Further, these domains have been shown to have the most consistent findings with effect sizes in the moderate range (Nigg, Willcutt, Doyle, & Sonuga-Barke, 2005; Pennington & Ozonoff, 1996; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), suggesting that tests of these domains have adequate sensitivity for group differentiation. This study includes both parent report and performance based measures of inhibition and working memory, which have been shown to capture different facets of disinhibition and executive dysfunction.

The Conflicting Motor Programs and Go/ No- Go tasks were chosen to measure response inhibition. These tasks have a low cognitive to inhibitory demand ratio. This isolation of inhibitory capacity provides a nearly "pure" measure of response inhibition. Robust group differences comparing children with ADHD to typically developing children have been found based on performance on these measures (Mostofsky, Russell, Kofman, Carr, & Denckla, 2001; Mostofsky & Denckla, 2002) and both tasks have been shown to related to frontal neuroanatomic substrates using functional magnetic resonance imaging (Mostofsky, Abrams, et. al., 2002; Mostofsky et al., 2003). The tests differ in the presentation, the Conflicting Motor Programs is a face to face task, while the Go/ No- Go task is administered via computer. The differential presentation permits testing inhibitory processes across situations. The Digits Backward portion of the Digit Span subset from the Wechsler Intelligence Test for Children, Fourth Edition was used as a measure of working memory. This is a commonly used measure of verbal working memory, which has been shown to be sensitive to group differences in executive function in comparisons between children with ADHD and typically developing children (Bidwell, Willcutt, DeFries, & Pennington, 2010). The Behavior Rating Inventory of Executive Function (BRIEF) was chosen as measure of executive function because it is purported to measure executive function within day-to-day activities across situations. The BRIEF has been shown to differentiate children with ADHD from typically developing children and other clinical populations (Gioia, Isquith, Kenworthy, & Barton, 2002), on the dimension of inhibition and working memory, the executive function domains of interest in this study.

Hypotheses

Group comparisons of executive function using neuropsychological and parent report measures of inhibition and working memory were conducted to determine if the children with ADHD in this sample show evidence of lower inhibition and working memory abilities as compared to their typically developing peers. Previous studies have provided evidence for a relationship between parent report measures of executive function and lower social performance in individuals with ADHD (Biederman et al., 2008; Cooper et al., 2005). There is evidence that parent report measures of executive function capture different features of executive function than those identified by neuropsychological measures (Biederman et al., 2008). This study compares the contributions of both types of measures of executive function to the prediction of social functioning. It has been suggested that the symptoms of ADHD (i.e., inattention, hyperactivity and impulsivity) lead to poor social skills and rejection by peers (Frederick & Olmi, 1994). This study compared the contribution of executive function and ADHD symptom severity to the prediction of social functioning.

- Hypothesis 1: This study will demonstrate group differences in the direction of lower executive function, social skill performance and social desirability in children with ADHD as compared with typically developing children.
- Hypothesis 2: This study will replicate a previous finding that executive functions predict social skill performance, providing support for Barkley's Model of ADHD. This study will show that executive function predicts social desirability.
- Hypothesis 3: This study will demonstrate that executive function explains unique variance in social functioning in children with ADHD beyond what can be accounted for by ADHD symptom severity.

CHAPTER 2
METHODS

Recruitment and Subjects

Participants were recruited from outpatient clinics at the Kennedy Krieger Institute, and from Baltimore, Maryland area pediatricians, Maryland chapters of Children and Adults with Attention-Deficit/Hyperactivity Disorder (CHADD), schools, social/service organizations (e.g., Boy/Girl Scouts), and advertisements in the community (e.g., postings at libraries) as part of two ongoing research projects focusing on the neurological basis of response inhibition in ADHD and gender and executive function in ADHD. All children entering the study met the following the criteria: 1) between 8 years – 0 months and 11 years – 11 months; 2) Full Scale IQ estimate of 80 or higher based on a standardized IQ test given either during a prior school assessment (completed within one year of study assessment) or on the Wechsler Intellectual Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2003) given at time of testing; 3), no history of Speech/Language Disorder or a Reading Disability (RD) either screened out before a visit or based on prior school assessment (completed within one year of the current assessment). RD was based on a statistically significant discrepancy between a child's Full Scale IQ score and his/her Word Reading subtest score from the Wechsler Individual Achievement Test, Second Edition (WIAT–II; Wechsler, 2002), or a standard score below 85 on the Word Reading subtest, regardless of IQ score; and 4) no evidence of visual or hearing impairment, or history of other neurological or psychiatric disorder.

Diagnosis of ADHD was determined by a structured parent interview (Diagnostic Interview for Children and Adolescents, Fourth Edition (DICA-IV; Reich, Welner, & Herjanic, 1997) and administration of ADHD-specific and broad behavior rating scales, Conners' Parent Rating Scale-Revised, Long Form, (CPRS-R:L; Conners, 1997). Children with DSM-IV diagnoses other than Oppositional Defiant Disorder and mild anxiety disorders (e.g., Simple Phobias) were excluded. DSM-IV criteria were used to evaluate for all three ADHD subtypes (Predominantly Inattentive Type, ADHD-I; Predominantly Hyperactive-Impulsive Type, ADHD-HI; and Combined Type, ADHD-C). Children were assigned to the ADHD-I group if the T-score on the CPRS-R:L Scale L: DSM-IV Inattentive Symptoms (DSM-IV criteria for Predominantly Inattentive Type) was 65 or greater and their T-score was 60 or less on the CPRS-R:L Scale M (DSM-IV criteria for Predominantly Hyperactive-Impulsive Type). Children were diagnosed as ADHD-HI if the T-score on the CPRS-R:L Scale M: DSM-IV Hyperactivity-Impulsivity Symptoms (DSM-IV criteria for Predominantly Hyperactive-Impulsive Type) was 65 or greater and their T-score was 60 or less on the CPRS-R:L Scale L: DSM-IV Inattentive Symptoms (DSM criteria for Predominantly Inattentive Type). Children were assigned to the ADHD-C group if the T-Score on both the CPRS-R:L Scales L and M were both rated as 65 or higher. Children with ADHD taking longer acting longer-acting psychoactive medications (i.e., other than stimulants) were excluded from the study.

Controls were additionally required to meet the following criteria: 1) no history of mental health services for behavior or emotional problems; 2) no parent or teacher report of previous diagnosis of Oppositional Defiant Disorder or Conduct Disorder; 3) T-scores 60 or below on the ADHD (DSM IV Inattention; DSM IV Hyperactivity) subscales of Conners' Parent Rating Scale-Revised (CPRS-R:L; Conners, 1997); and 4) no history of academic problems requiring school based intervention services or history of defined primary reading or language-based learning disability, as established through medical history, psychological testing, or parental and teacher interview.

Prior to scheduling the appointment, parents of participants were briefly interviewed over the telephone in order to obtain demographic information, referral source, school and developmental history. If the child was determined to be eligible via the brief screen, the DICA-IV was administered by phone prior to scheduling an appointment for testing. Parents of children with ADHD were asked not to administer medication on the day of testing. On the day of the appointment, parents completed questionnaires and rating scales while the child completed testing. Participants provided written consent (caregivers) and assent (children) before beginning testing and received a copy of the consent form. Caregivers completed a brief background questionnaire as well as the Conners Parent Rating Scale-Revised, Long Form. The Hollingshead Index (1975) was used to determine socioeconomic status for each child who participated in the study.

Measures

Semi-structured Diagnostic Interview

The Diagnostic Interview for Children and Adolescents, Fourth Edition (DICA-IV, Reich et al., 1997) parent version was administered to parents about their child. This is a semi-structured interview that is designed for determining selected current and retrospective psychiatric diagnoses. The modules administered were those assessing present and retrospective reports of: Attention Deficit Hyperactivity Disorder, Conduct Disorder, Oppositional Defiant Disorder, Major Depressive Disorder, Bipolar Disorders, Dysthymic Disorder, Separation Anxiety Disorder, Panic Disorder, Generalized Anxiety Disorder, Specific Phobia, Obsessive Compulsive Disorder and Adjustment Disorders. The DICA-IV has been reported to be reliable for DSM-IV diagnoses.

Behavior Rating Scales

The Conners Parent Rating Scale-Revised, Long Form (CPRS-R:L, Conners, 1997) is a rating scale used to assess for attention-deficit/hyperactivity disorder in children and adolescents (aged 3-17), and can measure treatment changes and outcome assessment purposes. It measures the following constructs: Conduct Problems, Cognitive Problems, Anxiety Problems, and Social Problems. Subscales: Oppositional, Social Problems, Cognitive Problems/Inattention, Psychosomatic, Hyperactivity, DSM-IV Inattention Symptoms, DSM-IV Hyperactivity/Impulsivity Symptoms, DSM-IV Total Symptoms, Anxious-Shy, ADHD Index, Perfectionism, Conners Global Index. The BRIEF Parent Rating Scale (Gioia et al., 2000) is a rating scale used to assess executive function, in which the parent responds whether the child exhibits problems with specific behaviors or tasks. The BRIEF contains seven subscales: Inhibition, Shifting, Initiation, Working Memory, Planning/Organizing, Organization of materials, and Monitor, as well as a Global Executive Composite score. The SSRS Parent Rating Scale (Greshman & Elliott, 1990) assesses social behavior, including both prosocial behavior and problem behaviors. The scale's operational definition of social skills is socially acceptable, learned behaviors that enable a person to interact effectively with others and to avoid socially unacceptable responses (Greshman & Elliott, 1984). Examples of prosocial behavior are sharing, helping, and giving compliments. Examples of problem behavior are fighting, sulking, and disobeying rules.

Motor and Performance Tasks

The Go/No-Go task employed in this study was developed as a measure of motor response inhibition for fMRI studies in order to minimize extraneous cognitive and behavioral variables (Mostofsky, Schafer, Abrams, et. al., 2003). The Go/No-Go is presented on a computer. Subjects were instructed to push a button as fast as they can to a green "spaceship" and to refrain from pushing when they see a red "spaceship". Cues appear on the screen for 300 msec and were presented once every 1.8 seconds (1.5 sec interstimulus interval). Cues are weighted towards Go cues at a ratio of 3:1 (75% Go cues; 25% No-go cues), intensifying the need to inhibit a rapid, habitual skeletomotor response. Use of familiar color elements (green for "Go"; red for "No-go") contributes to relative isolation of skeletomotor response inhibition on this task by minimizing superimposed cognitive (working memory) processes. The Conflicting Motor Response Task was adapted from the Luria-Christensen Battery (Christensen, 1975). Subjects were told, "If I show you my finger, you show me your fist; if I show you my fist, you show me your finger." The examiner, using right hand, presents each of the two gestures 24 times (for a total of 48 presentations) in random sequence, at a rate of one per second. Variable of interest relevant to response inhibition is total number of errors.

Cognitive Tasks

The fourth edition of the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003) is a commonly used and well-normed measure (2,200 children who were divided into 11 age groups with 100 boys and 100 girls at each age level) individually administered for assessment of intellectual functioning of children aged 6 years through 16 years, 11 months. The Full Scale IQ was used as a measure of intellectual functioning and Digits Backward was used as a measure of working memory. The second edition of the Wechsler Individual Achievement Test (WIAT-II; Wechsler, 2001) was used to assess early reading (phonological awareness), word recognition, and decoding skills. The WIAT-II was developed to be used in conjunction with the WISC and provides age (sample of 2,950) and grade-based (sample of 3,600) Standard Scores for age 4 years through adults, including norms for college students.

Statistical Analyses

Scores on the BRIEF Inhibit and Working Memory subscales were converted to T scores using the normative data contained in the BRIEF manual

(Gioia et al., 2000), and then converted to *z* scores for data analyses. Scores on the neuropsychological measures purported to tap inhibition (Go No-Go omission errors and commission errors, Conflicting Motor Program Task) were converted to *z* scores using the mean and standard deviation from a population sample including all typically developing children between the ages of 8 to 12 years who have the met the inclusion and exclusion criteria described in the subject recruitment section above and who have consented to be included in a typically developing normative group. The population sample includes children who are not subjects in this research study. The scores on the inhibition measures were combined into a composite inhibition score by averaging the *z* scores of the three inhibition measures. The raw score for the WISC-IV Digits Backward task was converted to a scaled score using the normative data in the manual (Wechsler, 2003), and then the scaled score was converted to a *z* score to be used as a performance measure of working memory.

The social behavior scores were derived from the Social Skills Rating System Parent report form. Scores on the SSRS Prosocial and Problem Behavior scales were converted to Standard Scores using the normative data contained in the SSRS manual (Greshman & Elliott, 1990), and then converted to *z* scores for data analyses. Social desirability is derived from two items on Social Skills Rating System Parent report form (item 12: Makes friends easily and item 23: Is liked by others); scores may range from 0 to 4.

All dependent variables were converted to *z* scores, with exception of the social desirability variable. Continuous independent variables, including WISC-IV

FSIQ and WIAT-II Word Reading scores were also converted to *z* scores. Age was calculated as days divided by 365. Gender and ADHD subtype were dummy coded, and entered as nominal variables. Examinations of the skew and kurtosis of all continuous variables indicated that the variables were normally distributed. Examination of the variances of the variables indicated homoscedasticity. SSRS Prosocial Behavior and social desirability were not entered simultaneously into any equations to avoid singularity, given that the social desirability score was developed from two items on the Prosocial Behavior scale.

To test Hypothesis 1, three multivariate analyses of variance were conducted to test for significant group differences in social behavior (Prosocial and Problem Behavior), neuropsychologically defined executive function (Inhibition and Working Memory scores), and behaviorally defined executive function (BRIEF Inhibit and Working Memory subscale scores) between the ADHD and the typically developing cohorts. Univariate analyses of variance were used to test for a significant difference in social desirability between the ADHD and Control group.

To test Hypothesis 2, a series of linear regression analyses were conducted to examine the predictive ability of executive functions (behavioral inhibition and working memory) on social skill performance and social desirability. The BRIEF Inhibit and Working Memory scales served as the independent variables. The dependent variables were: SSRS Prosocial Behavior and Problem Behavior, and the measure of social desirability described above. These analyses were repeated with only the ADHD cohort to determine whether the relationships between executive function and social functioning in the overall group also applied to the ADHD cohort.

To test Hypothesis 3, linear regression analyses with the ADHD cohort were conducted to determine whether neuropsychological measures and ADHD symptom severity contribute to the prediction of social functioning beyond what is explained by behavioral measures of executive function. The independent variables for each of the linear regression analyses were determined based on the findings in Hypothesis 2. For the first set of analyses, SSRS Prosocial Behavior was the dependent variable. The independent variables include the scale(s) from the BRIEF that explain a significant portion of the variance in Prosocial Behavior and the corresponding neuropsychologically derived measure(s) of inhibition (inhibition composite) or working memory (WISC-IV Digits Backward). A subsequent linear regression analysis was conducted with CPRS-R:L DSM-IV total score added to the model. For the second set of analyses, SSRS Problem Behavior was the dependent variable and the independent variables included the scale(s) from the BRIEF that explain a significant portion of the variance in Problem Behavior and the corresponding neuropsychologically derived measure(s) of inhibition or working memory. Likewise, another linear regression analysis was conducted with CPRS-R:L DSM-IV Total Symptoms added to the model.

CHAPTER 3
RESULTS

Sample Characteristics

Univariate analyses of variance were conducted to assess for between group differences on demographic variables. Group means for the demographic variables of age, IQ, WIAT reading scores, and socioeconomic status are presented in Table 3-1. Correlational analyses were conducted with demographic variables and the variables under study. See APPENDIX for the correlational matrices for the entire sample, and for the ADHD group and the typically developing control group separately.

Gender

The ADHD group consisted of 18 girls and 27 boys. The control group included 31 boys and 31 girls. There were no between group differences in gender [t (105) = -1.020, p = .310].

Age

The ADHD sample was younger than the Control sample [ADHD = 9.56; Controls = 10.13: F (1, 105) = 6.078, p = .015]. The BRIEF Inhibit and the inhibition composite score were significantly correlated with age.

Race

Eighty percent of the ADHD group identified as Caucasian, 11.1% African American, 6.7% Asian, and 2.2% Native American. Seventy nine percent of the typical developing group identified as Caucasian, 12.9% African American, 1.6% Asian, 4.8% biracial, and1.6% Native American.

IQ

The ADHD sample had lower FSIQ [ADHD = 102.87; Controls = 113.18: F (1, 105) = 19.146, $p < .001$]. The BRIEF Working Memory, the neuropsychological measures of working memory (WISC-IV Digits Backward), inhibition (Inhibition composite score), and social desirability were significantly correlated with FSIQ.

Word Reading

There were no significant between group differences in word reading [ADHD = 107.89; Controls = 110.63: F (1, 105) = 1.436, $p = .234$]. WISC-IV Digits Backward was correlated with WIAT-II Word Reading.

Socioeconomic Status

There were no between group differences in socioeconomic status [ADHD = 50.25; Controls = 52.74: F (1, 103) = 1.588, $p = .210$] and none of the dependent variables correlated with socioeconomic status. Two subjects, one in each diagnostic group, were missing data on socioeconomic status.

ADHD Subtype

The ADHD group consisted of 33 children with ADHD Combined Type, 11 children with ADHD Inattentive Type, and 1 child with ADHD Hyperactive/Impulsive Type. The one child diagnosed with ADHD Hyperactive/Impulsive Type did not differ from ADHD sample on age [χ^2 (45) = 3.706, $p = .157$], IQ [χ^2 (45) = 1.350, $p = .509$], word reading [χ^2 (45) = .168, $p = .919$], or socioeconomic status [χ^2 (44) = 1.690, $p = .430$] as determined by the Kruskal Wallis test.

Tests of Study Hypotheses

Hypothesis 1

Children with ADHD were hypothesized to have lower scores on measures of executive function and social skill performance than typically developing children. Executive function measures included a behaviorally defined measure of executive function and neuropsychological measures of executive function. A multivariate analysis of covariance (with age and FSIQ as covariates) with the BRIEF Inhibition and Working Memory scales found a significant multivariate group effect (Pillai's) for the BRIEF scales [F (2, 102) = 211.537; p < .001, η_p^2 = .806]. Univariate tests revealed lower execution function in the ADHD group for both scales: Inhibition [F (1, 103) = 208.663; p < .001, η_p^2 = .670], and Working Memory [F (1, 103) = 362.224; p < .001, η_p^2 = .779]. Group means for the BRIEF Inhibition and Working Memory scales are presented in Table 3-2.

A subset of the ADHD and Control groups received neuropsychological testing of executive function (ADHD = 28; Controls = 48). A multivariate analysis of covariance (with age and IQ as covariates) with the neuropsychological measures of inhibition and working memory did not demonstrate a significant difference (Pillai's) between the ADHD and Control groups on the neuropsychological measures [F (2, 71) = .967; p = .385, η_p^2 = .027]. Group means for the neuropsychological measures are presented in Table 3-3. The subset of subjects who completed the neuropsychological testing did not differ from the subjects who did not complete the neuropsychological testing on the three of four study variables: Prosocial behavior [χ^2 (107) = .512, p = .474], Problem Behavior [χ^2 (107) = .1.345, p = .246],and BRIEF Inhibit [χ^2 (107) = .722, p = .396], however, the BRIEF Working Memory scores [χ^2 (107) = 3.739, p = .053] were significantly different between the two groups. The difference was in the direction of less impairment on the BRIEF Working Memory scale for those subjects who did not complete the neuropsychological testing.

Parents of sixteen subjects failed to complete the problem behavior scale of the SSRS; six of ADHD group and ten of Control group. The 16 subjects with missing data on the problem behavior scale did not differ from the entire sample on the study variables: Prosocial behavior [χ^2 (107) = .876, p = .349], BRIEF Inhibit [χ^2 (107) = 2.146, p = .143], BRIEF Working Memory [χ^2 (107) = .391, p = .532], Digits Backward [χ^2 (107) = .105, p = .746], and the Inhibition composite [χ^2 (107) = .003, p = .958]. A multivariate analysis of covariance (with age as a covariate) was conducted with the Prosocial and Problem Behavior scales from the parent form of the SSRS with those subjects who had complete data for both scales. A multivariate group effect (Pillai's) was found for the social functioning measures [F (2, 87) = 60.137, p < .001, η_p^2 = .580]. Univariate tests revealed that the ADHD group show lower social skill performance in both prosocial and problem behavior: Prosocial Behavior [F (1, 88) = 65.576; p < .001, η_p^2 = .427] and Problem Behavior [F (1, 88) = 111.551; p < .001, η_p^2 = .559]. Univariate analyses of covariance (with IQ as a covariate) revealed lower social desirability in the ADHD group as compared to Controls [F (2, 104) = 25.707, p < .001, η_p^2 = 1.98]. Group means for the social functioning measures are presented in Table 3-4.

Hypothesis 1 was partially confirmed. The ADHD group had lower scores on the social functioning measures and the behaviorally defined executive function measures than the Control group. Group differences were not found for the neuropsychological measures.

Hypothesis 2

It was hypothesized that the current study would replicate a previous finding that executive function predicts social skill performance. This prediction was tested with a series of linear regression analyses. See Table 3-5 for a summary of the linear regression analyses for the entire sample. Examination of the correlation matrices indicated large correlations between the BRIEF Inhibition and Working Memory scales and the SSRS Prosocial and Problem Behavior scales, and between the BRIEF Inhibition and Working Memory scales and the index of social desirability, for the total sample and the ADHD sample. A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and prosocial behavior as the dependent variable was conducted to determine the unique variance in prosocial behavior predicted by behaviorally measured inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of prosocial behavior, and both scales significantly contributed to the prediction ($R^2 = .570$, $p < .01$; Inhibit $\beta = .453$, $p < .01$; Working Memory $\beta = .333$, $p < .01$).

A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and problem behavior as the dependent variable was conducted to determine the unique variance in problem behavior predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of problem behavior, but only the Inhibit significantly contributed to the prediction ($R^2 = .718$, $p < .01$; Inhibit $\beta = .679$, $p < .01$; Working Memory $\beta = -.193$, $p = .07$).

A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and social desirability as the dependent variable was conducted to determine the unique variance in social desirability predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in social desirability, but only the Inhibit scale significantly contributed to the prediction ($R^2 = .322$, $p < .01$; Inhibit $\beta = .483$, $p < .01$; Working Memory $\beta = .097$, $p = .52$).

These predictive analyses were repeated using only the ADHD subjects. See Table 3-6 for a summary of the linear regression analyses for the ADHD sample. A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and prosocial behavior as the dependent variable was conducted to determine the unique variance in prosocial behavior predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of prosocial behavior, and both scales significantly contributed to the prediction ($R^2 = .298$, $p < .01$; Inhibit $\beta = .315$, $p < .05$; Working Memory $\beta = .352$, $p < .05$).

A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and problem behavior as the dependent variable was conducted to determine the unique variance in problem behavior predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of problem behavior, as with the total sample only the Inhibit significantly contributed to the prediction ($R^2 = .422$, $p < .01$; Inhibit $\beta = -.533$, $p < .01$; Working Memory $\beta = -.234$, $p = .09$).

A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and social desirability as the dependent variable was conducted to determine the unique variance in social desirability predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in social desirability; the Inhibit scale contributed to the prediction at a trend level ($R^2 = .157$, $p < .05$; Inhibit $\beta = .291$, $p = .06$; Working Memory $\beta = .188$, $p = .22$). When the regression was repeated without the Working Memory scale, the Inhibit scale predicted a significant portion of the variance in social desirability ($R^2 = .126$, $p < .05$; Inhibit $\beta = .354$, $p < .05$).

Hypothesis 2 was confirmed. Behaviorally derived measures of executive function predict social functioning, including prosocial behavior, problem behavior, and social desirability. Behaviorally based executive function was predictive of social behavior in the total sample and specifically in the ADHD sample.

Hypothesis 3

Hypothesis 3 examined whether behavioral measures of executive function explain the variance in social functioning that cannot be explained by symptom severity or by neuropsychological measures of executive function. In the ADHD sample, both the BRIEF Inhibit and the Working Memory scales contributed to prediction of prosocial behavior. A linear regression analysis with the BRIEF Inhibit and Working Memory scales, and neuropsychological measures of inhibition (a composite of inhibition measures) and working memory (WISC-IV Digits Backward) was conducted to determine if neuropsychological measures of the executive function constructs would account for unique variance in prosocial behavior. The BRIEF Inhibit scale is the only measure that contributed to prediction ($R^2 = .338$, $p < .05$; Inhibit $\beta = .376$, $p < .05$; Working Memory $\beta = .289$, $p = .14$; Inhibition composite $\beta = -.067$, $p = .71$; Digits Backward $\beta = -.220$, $p = .21$). A measure of ADHD symptom severity was added to determine if symptom severity accounted for the variance in prosocial behavior. Both symptom severity and BRIEF Working Memory accounted for the variance in prosocial behavior, BRIEF Inhibit did not contribute to the unique variance to the prediction ($R^2 = .437$, $p < .01$; Inhibit $\beta = .097$, $p = .55$; Working Memory $\beta = .299$, $p < .05$; CPRS-R:L Total $\beta = -.414$, $p < .05$). BRIEF Working Memory and symptom severity continued to account for unique variance in prosocial behavior after controlling for age and FSIQ ($R^2 = .449$, $p < .01$; Inhibit $\beta = .116$, $p = .50$; Working Memory $\beta = .311$, $p < .05$; CPRS-R:L Total $\beta = -.407$, $p < .05$; age $\beta = -.010$, $p = .94$; FSIQ $\beta = -.109$, $p = .39$).

In the ADHD sample, BRIEF Inhibit explained the significant portion of the variance in problem behavior. A linear regression analysis with the BRIEF Inhibit scale and a composite of neuropsychological measures of inhibition was conducted to determine which measure would better account for the variance in problem behavior. BRIEF Inhibit contributed to prediction, but the inhibition composite did not (R^2 = .366, p < .01; Inhibit β = -.612, p < .01;Inhibition composite β = .047, p = .79). A measure of ADHD symptom severity was added to determine if symptom severity accounted for a significant portion of the variance. BRIEF Inhibit continued to account for a significant portion of the variance in problem behavior; symptom severity did not contribute to the prediction of problem behavior (R^2 = .438, p < .01; Inhibit β = -.419, p < .01; CPRS-R:L Total β = .315, p = .06). After controlling for age, symptom severity accounted for a significant portion of the variance in problem behavior and BRIEF Inhibit did not (R^2 = .476, p < .01; Inhibit β = -.306, p = .09; CPRS-R:L Total β = .369, p < .05; age Total β = -.215, p = .13). FSIQ was not correlated with the independent or dependent variables in the ADHD sample, and thus it was not controlled for.

Finally, a series of linear regression analyses with social desirability as the dependent variable were conducted with ADHD sample. BRIEF Inhibit, which accounted for the significant portion of the variance in social desirability in Hypothesis 2, was entered as an independent variable along with the neuropsychological inhibition composite. This model did not significantly predict social desirability in the ADHD Combined Type sample (R^2 = .070, p = .39; Inhibit β =.258, p = .19; Inhibition composite β = .052, p = .78). ADHD symptom severity and the BRIEF Inhibit were entered as independent variables to predict social desirability to determine if symptom severity or inhibitory ability accounted for a significant portion of the variance in social desirability. Together inhibitory ability and symptom severity predict a small portion of the variance in social desirability, but neither account for unique variance (R^2 = .162, p < .05; Inhibit β = .282, p = .15; CPRS-R:L Total β = -.156, p = .42). After controlling for age, inhibitory ability and symptom severity continue to predict a small portion of the variance in social desirability, but again neither account for significant unique variance (R^2 = .185, p < .05; Inhibit β = .355, p = .09; CPRS-R:L Total β = -.120, p = .54; age Total β = -.163, p = .29). FSIQ was not correlated with the independent or dependent variables in the ADHD sample, and thus it was not controlled for.

Hypothesis 3 was confirmed. Behavioral measures of executive function explain unique variance in social functioning beyond what can be attributed to ADHD symptom severity. Neuropsychological measures of executive function do not explain unique variance in social functioning beyond what is accounted for by behavioral measures of executive function.

Additional analyses

Age

All additional analyses were conducted with only the ADHD sample. The ADHD group was split into two age groups: younger (8.0 to 9.9) and older (10.0 to 11.9) to examine whether younger or older children with ADHD tend to have worse social functioning. A multivariate analysis of variance conducted to examine the interactional relationship between age and diagnosis on prosocial and problem behavior (Pillai's) was not significant [F (2, 86) = 1.731, p .183, η_p^2 = .039]. T tests conducted to determine if there were younger versus older differences on the social functioning measures were not significant; prosocial behavior [t (43) = .192, p = .849], problem behavior [t (37) = 1.217, p = .231], and social desirability [t (43) = .438, p = .299].

Gender

T tests conducted to determine if there were gender differences on the social functioning measures were not significant; prosocial behavior [t (43) = 1.771, p = .084], problem behavior [t (37) = -.472, p = .640], and social desirability [t (43) = .339, p = .736].

ADHD Subtype

There were no significant group differences between the ADHD subtypes on the independent variables: gender [t (42) = -1.051, p = .299], age [t (42) = -1.893, p = .065], IQ [t (42) = .765, p = .448], word reading [t (42) = -.773, p = .444] or socioeconomic status [t (41) = -.728, p = .471]. T tests conducted to determine if there were ADHD subtype differences on the social functioning measures were not significant; prosocial behavior [t (42) = 1.481, p = .146], problem behavior [t (36) = -1.803, p = .080], and social desirability [t (42) = 1.143, p = .259].

The predictive analyses in Hypothesis 2 were repeated using only the ADHD Combined Type subjects. See Table 3-8 for a summary of the linear regression analyses for the ADHD Combined Types subjects. A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and prosocial behavior as the dependent variable was conducted to determine the unique variance in prosocial behavior predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of prosocial behavior, and only the Working Memory scale significantly contributed to the prediction ($R^2 = .254$, $p < .01$; Inhibit $\beta = .235$, $p = .17$; Working Memory $\beta = .258$, $p < .05$). A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and problem behavior as the dependent variable was conducted to determine the unique variance in problem behavior predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales predicted a significant portion of the variance in parent report of problem behavior, unlike the total and ADHD sample, both the Inhibit and the Working Memory scales significantly contributed to the prediction ($R^2 = .504$, $p < .01$; Inhibit $\beta = -.452$, $p < .01$; Working Memory $\beta = -.397$, $p < .05$). A linear regression analysis with the BRIEF Inhibit and BRIEF Working Memory scales as the independent variables and social desirability as the dependent variable was conducted to determine the unique variance in social desirability predicted by inhibition and working memory. The BRIEF Inhibit and Working Memory scales not a predict a significant portion of the variance in social desirability; the Inhibit scale contributed to the prediction at a trend level ($R^2 = .127$, $p = .13$; Inhibit $\beta = .322$, $p = .09$; Working Memory $\beta = .080$, $p = .66$). When the regression was repeated without the Working Memory scale, the Inhibit scale predicted a significant portion of the variance in social desirability ($R^2 = .122$, $p < .05$; Inhibit $\beta = .349$, $p < .05$).

Table 3-1. Means and standard deviations for demographic variables

	ADHD		Control	
	M	SD	M	SD
Age [a]	9.56	1.25	10.13	1.11
WISC-IV Full Scale IQ [b]	102.67	12.63	113.63	10.94
WIAT-II Word Reading [b]	107.89	12.63	110.63	10.94
Socioeconomic status	50.25	9.20	52.74	10.51

Note. [a] calculated as days/365. [b] Standard Scores (X=100, SD=15).

Table 3-2. Means and standard deviations for BRIEF scales

	ADHD		Control	
	M	SD	M	SD
Inhibition [a]	67.64	10.87	42.77	4.70
Working Memory [a]	71.73	6.83	43.47	6.65

Note. [a] T scores (X=50, SD=10).

Table 3-3. Means and standard deviations for neuropsychological measures

	ADHD		Control	
	M	SD	M	SD
Digits Backward [a]	9.37	3.30	10.90	2.64
Inhibition composite [b]	-.64	.69	-.18	.61
Conflicting Motor [c]	36.61	5.03	40.27	5.58
Go No-Go omission rate [c]	.05	.05	.02	.03
Go No-Go commission rate [c]	.40	.19	.38	.18

Note. [a] scaled score, [b] z scores, [c] raw scores.

Table 3-4. Means and standard deviations for social functioning measures

	ADHD		Control	
	M	SD	M	SD
Prosocial behavior [a]	86.28	14.99	113.44	15.64
Problem behavior [a]	111.77	13.48	87.69	7.29
Social desirability [a]	2.84	1.07	3.76	.53

Note. [a] Standard scores (X=100, SD=15).

Table 3-5. Linear regression analyses for the entire sample

Dependent Variable	Independent Variables	R	R Square	Adjusted R Square	Beta
Prosocial Behavior**		.755	.570	.562	
	Inhibit**				.453
	Working Memory**				.333
Problem Behavior**		.847	.718	.712	
	Inhibit**				-.679
	Working Memory				-.193
Social Desirability**		.567	.322	.309	
	Inhibit**				.483
	Working Memory				.097

Note. ***p* > .01, **p* > .05

Table 3-6. Linear regression analyses for ADHD group (Hypothesis 2).

Dependent Variable	Independent Variables	R	R Square	Adjusted R Square	Beta
Prosocial Behavior**		.546	.298	.265	
	Inhibit*				.315
	Working Memory*				.352
Problem Behavior**		.650	.422	.390	
	Inhibit**				-.533
	Working Memory				-.234
Social Desirability*		.396	.157	.117	
	Inhibit				.291
	Working Memory				.188
Social Desirability*		.354	.126	.105	
	Inhibit*				.354

Note. ***p* > .01, **p* > .05

Table 3-7. Linear regression analyses for ADHD group (Hypothesis 3).

Dependent Variable	Independent Variables	R	R Square	Adjusted R Square	Beta
Prosocial Behavior*		.582	.338	.223	
	BR-I*				.376
	BR-WM				.289
	NP Inhibition				-.067
	Digits Backward				-.220
Prosocial Behavior**		.661	.437	.395	
	BR-I				.097
	BR-WM*				.299
	CPRS-R:L Total*				-.414
Prosocial Behavior**		.670	.449	.377	
	BR-I				.116
	BR-WM*				.311
	CPRS-R:L Total*				-.407
	Age				-.010
	FSIQ				-.109
Problem Behavior**		.605	.366	.305	
	BR-I**				-.612
	NP Inhibition				.047
Problem Behavior**		.662	.438	.406	
	BR-I*				-.419
	CPRS-R:L Total				.315
Problem Behavior**		.690	.476	.429	
	BR-I*				-.306
	CPRS-R:L Total				.369
	Age				-.215
Social desirability		.265	.070	-.001	
	BR-I				.258
	NP Inhibition				.052
Social desirability*		.402	.162	.121	
	BR-I				.282
	CPRS-R:L Total				-.156
Social desirability*		.430	.185	.124	
	BR-I				.355
	CPRS-R:L Total				-.120
	Age				-.163

Note. ***p* > .01, **p* > .05

Table 3-8. Linear regression analyses for ADHD Combined Type.

Dependent Variable	Independent Variables	R	R Square	Adjusted R Square	Beta
Prosocial Behavior*		.504	.254	.204	
	Inhibit				.235
	Working Memory*				.258
Problem Behavior**		.710	.504	.466	
	Inhibit**				-.452
	Working Memory*				-.397
Social Desirability		.357	.127	.069	
	Inhibit				.322
	Working Memory				.080
Social Desirability*		.349	.122	.093	
	Inhibit*				.349

Note. $^{**}p > .01$, $^{*}p > .05$

CHAPTER 4
DISCUSSION

The goal of the present study was to examine the relationships between executive functions and social functioning in a group of children with ADHD compared to typically developing children. No differences were found on neuropsychological measures between the ADHD and typically developing control group; however, differences between the ADHD and typically developing group on parent report measures of executive function, social functioning, and social desirability were demonstrated. Compared to normally developing children, the ADHD sample had lower scores on scales measuring behavioral executive function, had poorer social functioning, and were less liked by peers. These findings suggest that this ADHD sample is similar to previously studied samples of children with ADHD and is likely representative of the ADHD population as a whole. The measure of social functioning that was used in this study, the SSRS parent report, is sensitive to the social impairments seen in children with ADHD. Parent report measures of executive function were sensitive to diagnostic group status. None of the typically developing children showed evidence of impairment (equal to or greater than 1.5 standard deviations below the mean) on either of the BRIEF scales used in this study; however 89% of the ADHD group showed impairments on at least one of the BRIEF scales.

The lack of group differences on measures of neuropsychological functioning is not startling. There is heterogeneity in the findings of neuropsychological impairment in ADHD. Across studies, ADHD samples show a wide range of variability in performance on neuropsychological measures of executive function and only a subset of children with ADHD have executive function impairment as measured by neuropsychological tests (Nigg, et. al., 2005). In this study, 18% of the ADHD sample demonstrated impairment (equal to or greater than 1.5 standard deviations below the mean) on two out of the four neuropsychological measures. Fifty-seven percent of ADHD sample and 27% of the typically developing children demonstrated impairment on at least one of the four neuropsychological measures. Although the most consistent findings of neuropsychological executive dysfunction have included the domains of response inhibition and working memory, our measures of inhibition and working memory did not differentiate ADHD and Controls after controlling for age and IQ. The measures in this study sought to capture the most basic components of inhibition and working memory, but were not the more cognitively demanding executive function tasks (e.g., ROCFT, Stroop task, verbal fluency) which have been used in other studies of social functioning (Diamantopoulou, et al., 2007; Huang-Pollock, et. al., 2009). The choice to go with simple rather than complex measures was a trade off. Simple measures allow for a purer measure of the construct of interest; however, the lack of cognitive demand may have resulted in a ceiling effect thereby reducing the predictive ability of these measures. It is notable that despite the low cognitive demand, the inhibition measures were moderately correlated with IQ. It was the removal of the variance due to IQ that prohibited the differentiation of the ADHD group from the control group based on their performance on the inhibition tasks. Complex tasks with greater cognitive load (e.g., ROCFT or Stroop tasks) may better capture the neuropsychological mechanisms involved in the dynamic cognitive processes involved in social perception and the execution of social behavior. Recently, Miller and Hinshaw (2010) found that neuropsychological measures of executive function predict teacher ratings of adolescent girls' peer acceptance (when the variance due to IQ was controlled for). A future study might compare the relative contribution of neuropsychological and behavioral measures of executive function to the prediction of teacher ratings of social functioning in younger children and among older pre-adolescent ADHD samples. The academic environment may elicit aspects of executive function that are beyond what is accounted for by intelligence or the more cognitively demanding tasks may be more similar to the demands of the academic environment than the purer measures of inhibition and working memory used in this study.

The current study sought to provide a thorough examination of social behavior: the frequency of executing learned behaviors at appropriate times, the frequency of inappropriate or problematic behavior, and social desirability. Capturing a wider sample of social competence allowed for a better test of Barkley's Model of Disinhibition in ADHD. Barkley asserted that inhibition contributes to effective executive functions (e.g., working memory), which allow for the execution of complex, goal oriented behavior, such as prosocial behavior. Both inhibition and working memory (as measured by the BRIEF) contributed to the prediction of goal directed behavior (i.e. prosocial behavior). This relationship was seen in the total sample (including both typically developing children and those with ADHD) and within the ADHD sample. When the analysis was confined to the ADHD Combined Type subgroup, only working memory remained as a significant predictor to the model. These findings support Barkley's theory that executive function directly predicts goal directed behavior (i.e., prosocial behavior). Barkley asserted that this model represents the ADHD Combined Type better than the ADHD Inattentive Type. There were too few ADHD Inattentive subjects to examine whether the model characterized this population.

Interestingly, both ADHD symptom severity and inhibition account for unique variance in prosocial behavior. Why might a parent report measure of executive function explain unique variance in the social functioning of children with ADHD that cannot be accounted for by ADHD symptom severity or performance on neuropsychological measures of execution function? The BRIEF captures the everyday functioning which includes performance during emotionally arousing situations, which laboratory measures of executive function are less likely to be able to capture. Other studies have found evidence that parent report measures of executive function capture different features of executive function than those identified by neuropsychological measures (Biederman et al., 2008). Laboratory measures may induce frustration, which is likely to impact executive function; however, it is unlikely that high positive emotional valence (e.g., excitement and joy) can be induced in a laboratory executive function task. Children with ADHD have more difficulty with self-control and tend to become sillier than non-ADHD peers when excited. A future study might consider the contribution of another domain of executive function in Barkley's model, self-regulation, to the prediction of social functioning.

In this study, the older children with ADHD (age 10-12 years) did not show worse social functioning than the younger children with ADHD (age 8-9.9 years). The age range in this study was relatively narrow, thus potentially limiting variability due to age. The subjects in this study were pre-adolescent, so the social demands in their environment may be less than would expected for adolescents. Another possible cause for the lack of age difference may due to the method of assessment. The SSRS Parent Rating scale was used across the age range and the manual does not provide age based norms. For older children with ADHD to show the same level of social development as a younger child with ADHD is quite problematic given that they are likely dealing with a more challenging social environment. It is possible that for children with ADHD social development may proceed at a slower rate. As a result of this type of "developmental lag" or slowing, they are likely to fall farther and farther behind peers as the environmental demands increase.

One aspect of social functioning that this study did not address is the ADHD child's perception of his or her social functioning. Some have suggested that children with ADHD show a positive "illusionary bias" for their level of competence (Hoza, et. al., 2004). Others have found that children with ADHD are accurate assessors of their lack of competence when elevated levels of depression are present (Ostrander, Crystal & August 2006). Ostrander and colleagues (2006) theorized that depression in children with ADHD develops in reaction to negative appraisals by others and leads to negative self-appraisal. These authors suggested that at a younger age (6-9 years), children with ADHD have a lack of awareness of their social deficits and for older children their ability to modify their behavior is impaired despite the awareness of their deficits. In future studies, it would be useful to look at a comparison of the child's perception of his or her performance to others' perceptions of his or her performance, as well as social functioning outcomes similar to those used in this study.

Reconstitution, another domain of executive function in Barkley's model, consists of evaluating one's own behavior by taking in feedback from the environment and modifying behavior to improve execution of goal directed behavior. Impaired reconstitution—low accuracy in perceiving feedback cues, lack of awareness of the effectiveness of one's behavior or an inability to use feedback to modify behavior—is likely to be predictive of poor social functioning. A complex decisional task, such as the Wisconsin Card Sorting Task (WCST), might be utilized in a future study. The WCST would capture the child's ability to modify his or her problem solving strategy in response to feedback about the correctness of a response. Such a task might relate to the child's ability synthesize feedback from his or her environment and make modifications to his or her behavior. The BRIEF Monitor scale may also capture these impairments (e.g., Does not realize that certain actions bother others and does not check work for mistakes). A study that includes measures that assess complex decision making, such as the WCST, the ability to use feedback to modify behavior, and social self-awareness would allow for exploration of relationship between social functioning and Barkley's proposed reconstitution domain of executive functioning

In summary, children with ADHD often have lower social functioning than their typically developing peers; however, the causal mechanism has eluded researchers. Some have hypothesized that their social problems are inherently due to the symptoms of ADHD (Frederick & Olmi, 1994). Others have proposed that biological mechanisms underlie the behavioral deficits seen in ADHD and give rise to social impairment (Barkley, 1997; Voeller, 1994). The relationship between executive function and ADHD symptoms has not been wholly explained. There are clear overlaps between the constructs and approximately 50% of children with ADHD show evidence of executive dysfunction. In this study, both ADHD severity and executive function predict prosocial behavior in an ADHD sample, but problem behavior is accounted for by ADHD symptoms. The findings in this study suggest that social functioning is impacted by both ADHD symptomatology and executive function. Children who have elevations on both are at high risk for social impairment. Inquiry about social functioning should occur within the context of the diagnosis or treatment of ADHD. For children with social impairment, assessment of ADHD symptoms and executive function will provide key information about how to intervene. To target the contribution of ADHD symptoms to social dysfunction, group interventions should target both learning and practicing prosocial behavior in the context of a dynamic, experiential activity that has a challenging problem solving component, but is also fun. With coaching, these interventions would allow children with ADHD to learn by both observing successful execution of goal behavior and experiencing it, which would provide two pathways for learning. This is a common approach for social skill groups for children with ADHD. Interventions that target the executive function contribution to social problems in ADHD should include training that addresses remediation of executive function deficits. Programs such as Tools of the Mind (Diamond, et al., 2007) target learning and practice of execution function skills such as inhibitory control, working memory, and cognitive flexibility by structuring the environment to maximize the focus on using those skills to complete age appropriate activities (e.g., reading and matching activities). In conclusion, for children with ADHD and social impairments, intervention should continue to include the commonly practiced social skill groups for children with ADHD. Interventions for children with ADHD and executive function impairments should additionally target enhancement of executive function skills.

A few limitations of this study should be noted. Although this study included both performance and parent report measures of executive function, it did not include a performance measure of social functioning. It is possible that the common assessment approach contributed to the high correlation between the parent report of social and executive functioning, thereby underestimating the potential contribution of the neuropsychological measures to the prediction of social functioning. The measure of social desirability was limited to two items, which is likely not adequate to assess such a complex construct. Social desirability is generally assessed by peer or teacher ratings. This author is not aware of the availability of a parent report measure of social desirability. Given that parents see their children across a variety of social environments, such a scale would be a useful contribution to the understanding of social functioning in children. Social desirability is impacted by the interaction of other factors, such as gender, race, physical appearance, athletic ability, and academic skills in addition to social skill performance. These factors were not addressed in this study, which focused on the neurobiological basis of social functioning.

APPENDIX

Table A-1. Correlational analyses for independent and dependent variables for all subjects.

	Age	IQ	Word Reading	SES	BR-I [a]	BR-WM [b]	Inhibition Composite	Working Memory	Prosocial Behavior	Problem Behavior	Social Desirability
Age	1	-.018	.156	.060	.304	.194	.406	-.044	.193	-.279	.075
N	107	107	105	105	107	107	77	106	107	91	107
IQ	-.018	1	-.586	.443	.274	.350	.383	-.434	.244	-.256	.249
N	107	107	105	105	107	107	77	106	107	91	107
Word Reading	.156	-.586	1	-.320	-.007	-.062	-.134	.400	-.017	.059	.026
N	105	105	105	103	105	105	75	104	105	89	105
SES	.060	.443	-.320	1	.031	.013	.116	-.066	.117	-.034	.143
N	105	105	103	105	105	105	76	104	105	89	105
BR-I	.304	.274	-.007	.031	1	.842	.277	-.100	.733	-.841	.565
N	107	107	105	105	107	107	77	106	107	91	107
BR-WM	.194	.350	-.062	.013	.842	1	.283	-.172	.714	-.764	.504
N	107	107	105	105	107	107	77	106	107	91	107
Inhibition composite	.406	.383	-.134	.116	.277	.283	1	-.300	.042	-.199	.130
N	77	77	75	76	77	77	77	76	77	63	77
Working Memory	-.044	-.434	.400	-.066	-.100	-.172	-.300	1	-.011	.084	-.062
N	106	106	104	104	106	106	76	106	106	90	106
Prosocial Behavior	.193	.244	-.017	.117	.733	.714	.042	-.011	1	-.748	.626
N	107	107	105	105	107	107	77	106	107	91	107
Problem Behavior	-.279	-.256	.059	-.034	-.841	-.764	-.199	.084	-.748	1	-.583
N	91	91	89	89	91	91	63	90	91	91	91
Social Desirability	.075	.249	.026	.143	.565	.504	.130	-.062	.626	-.583	1
N	107	107	105	105	107	107	77	106	107	91	107

Note. [a] BRIEF Inhibit Scale. [b] BRIEF Working Memory Scale.

Table A-2. Correlational analyses for independent and dependent variables for the ADHD group

	Age	IQ	Word Reading	SES	BR-I [a]	BR-WM [b]	Inhibition composite	Working Memory	Prosocial Behavior	Problem Behavior	Social Desirability
Age	1	-.284	.271	-.274	.311	.185	.382	.036	.068	-.357	-.056
N	45	45	44	44	45	45	29	44	45	39	45
IQ	-.284	1	-.609	.621	-.161	-.149	.205	-.374	.055	.086	.070
N	45	45	44	44	45	45	29	44	45	39	45
Word Reading	.271	-.609	1	-.424	.220	.166	.055	.496	-.044	-.097	.094
N	44	44	44	43	44	44	28	43	44	38	44
SES	-.274	.621	-.424	1	-.117	-.240	.275	-.034	.105	.095	.164
N	44	44	43	44	44	44	29	43	44	38	44
BR-I	.311	-.161	.220	-.117	1	.340	.047	.112	.434	-.611	.354
N	45	45	44	44	45	45	29	44	45	39	45
BR-WM	.185	-.149	.166	-.240	.340	1	-.231	.056	.459	-.412	.287
N	45	45	44	44	45	45	29	44	45	39	45
Inhibition composite	.382	.205	.055	.275	.047	-.231	1	.023	-.097	-.069	.064
N	29	29	28	29	29	29	29	28	29	24	29
Working Memory	.036	-.374	.496	-.034	.112	.056	.023	1	-.084	.003	.074
N	44	44	43	43	44	44	28	44	44	38	44
Prosocial Behavior	.068	.055	-.044	.105	.434	.459	-.097	-.084	1	-.688	.630
N	45	45	44	44	45	45	29	44	45	39	45
Problem Behavior	-.357	.086	-.097	.095	-.611	-.412	-.069	.003	-.688	1	-.472
N	39	39	38	38	39	39	24	38	39	39	39
Social Desirability	-.056	.070	.094	.164	.354	.287	.064	.074	.630	-.472	1
N	45	45	44	44	45	45	29	44	45	39	45

Note. [a] BRIEF Inhibit Scale. [b] BRIEF Working Memory Scale.

Table A-3. Correlational analyses for independent and dependent variables for the typically developing group

	Age	IQ	Word Reading	SES	BR-I [a]	BR-WM [b]	Inhibition composite	Working Memory	Prosocial Behavior	Problem Behavior	Social Desirability
Age	1	.053	.109	.252	.040	-.231	.324	-.037	.027	-.005	-.039
N	62	62	61	61	62	62	48	62	62	52	62
IQ	.053	1	-.575	.290	-.028	.125	.389	-.438	-.132	.048	.070
N	62	62	61	61	62	62	48	62	62	52	62
Word Reading	.109	-.575	1	-.236	.085	.025	-.235	.304	.189	-.061	.100
N	61	61	61	60	61	61	47	61	61	51	61
SES	.252	.290	-.236	1	-.207	-.222	.055	-.053	.007	.126	.027
N	61	61	60	61	61	61	47	61	61	51	61
BR-I	.040	-.028	.085	-.207	1	.435	-.102	.093	.405	-.469	.192
N	.760	.829	.514	.109		.000	.489	.471	.001	.000	.135
BR-WM	62	62	61	61	62	62	48	62	62	52	62
N	-.231	.125	.025	-.222	.435	1	.125	-.079	.176	-.178	-.023
Inhibition composite	62	62	61	61	62	62	48	62	62	52	62
N	.324	.389	-.235	.055	-.102	.125	1	-.436	-.300	.109	-.080
Working Memory	48	48	47	47	48	48	48	48	48	39	48
N	-.037	-.438	.304	-.053	.093	-.079	-.436	1	.336	-.082	-.017
Prosocial Behavior	62	62	61	61	62	62	48	62	62	52	62
N	.027	-.132	.189	.007	.405	.176	-.300	.336	1	-.321	.263
Problem Behavior	62	62	61	61	62	62	48	62	62	52	62
N	-.005	.048	-.061	.126	-.469	-.178	.109	-.082	-.321	1	-.240
Social Desirability	52	52	51	51	52	52	39	52	52	52	52
N	45	45	44	44	45	45	29	44	45	39	45

Note. [a] BRIEF Inhibit Scale. [b] BRIEF Working Memory Scale.

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BIOGRAPHICAL SKETCH

Karen L. Cooper was born and raised in Binghamton, New York. She received a Bachelor of Arts in psychology from Hobart and William Smith Colleges in Geneva, New York. After graduation, Ms. Cooper relocated to Washington, D.C. for an internship at the American Psychiatric Association. Following her internship, Ms. Cooper worked as an assistant on the early stage of the text revision of the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* and on the final stages of the *Practice Guideline for the Treatment of Panic Disorder.* Ms. Cooper left the American Psychiatric Association to work as a research assistant for the Klemm Analysis Group, also in Washington, D.C., a consulting firm that specialized in statistical analysis for health outcome research. Ms. Cooper followed her passion for working with children with developmental disorders and relocated to Baltimore, Maryland. to pursue a research position studying autism at Johns Hopkins University. Ms. Cooper transitioned into a research position at Kennedy Krieger Institute studying brain-behavior relationships in children with autism, Attention Deficit Hyperactivity Disorder (ADHD), learning disabilities, Tourette syndrome, neurofibromatosis type 1, velocardial facial syndrome holosprosencephaly, Down Syndrome, Rett Syndrome, and typically developing children using magnetic resonance imaging.

Ms. Cooper received a master's degree in clinical psychology from the University of Florida in 2004. Her master's thesis entitled, *Executive Function and Social Skills in Children and Adolescents with Attention Deficit Hyperactivity Disorder: A Pilot Test of Barkley's Model of Behavioral Disinhibition*, was her first foray into the examination of social behavior in children with ADHD. Ms. Cooper has extended the research begun with her master's thesis in her doctoral dissertation by capturing a broader range of social functioning and executive function. Ms. Cooper has also led social skill groups for children with ADHD that have further served to inform her understanding of social behavior in children with ADHD.

Ms. Cooper is currently completing a Clinical Internship at the University of New Mexico Health Science Center. Her internship has provided her with the opportunity to gain further clinical experience in the areas of pediatric neuropsychology and clinical child psychology. Her work in pediatric neuropsychology has included assessment within a clinic environment and through an outreach program with Native American tribes across the state. Her work in clinical child psychology has included therapy and assessment in an inpatient children's psychiatric hospital and an outpatient community health center, where she has worked with children with severe psychosocial trauma, brain dysfunction, developmental delay, and psychosis.