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Predicting the Early Developmental Course of Symptoms of Attention Deficit Hyperactivity Disorder

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Abstract

Data from the National Institute of Child Health and Human Development Study of Early Child Care were examined to test whether: attention deficit/hyperactivity disorder (ADHD) symptoms remain stable from 54 months through early elementary school; behavioral inhibition and attention deficits assessed at 54 months predict ADHD symptoms in elementary school, even after controlling for their temporal stability; and early behavioral inhibition and attention deficits moderate the longitudinal stability in ADHD symptoms. Data were examined using continuous and categorical measures of symptoms. Modest stability in ADHD symptoms from 54 months to third grade was found. Measures of inhibition and inattention predicted later teacher ratings uniquely, but no evidence was found for moderation. Measures of preschool behavioral inhibition also predicted “persistently at risk status” defined by elevated teacher ratings over time. Results are discussed in terms of executive and motivational facets of inhibition that may be related to early signs of ADHD.

Keywords

Symptoms of attention deficit/hyperactivity disorder; Child; Preschool; Behavioral inhibition; Executive function; Longitudinal design

1. Introduction

Over the past two decades attention deficit/hyperactivity disorder (ADHD) has become one of the most commonly diagnosed and studied childhood disorders (see, for review, American Academy of Pediatrics, 2000; Tannock, 1998). Major questions still remain, however, about its etiology and developmental course and about what early indicators may signal risk for the emergence of ADHD (Rowland, Lesesne, & Abramowitz, 2002).

In the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) (American Psychiatric Association, 1994), ADHD is defined by symptoms in two primary areas: hyperactivity–impulsivity and inattention. Childhood ADHD is associated with maladjustment in many domains of functioning over the course of development (American Academy of Pediatrics, 2000), including academic achievement and social relationships. Overall, children with ADHD disproportionately use medical and mental health services compared with children without ADHD (Rowland et al., 2002). The costly toll that ADHD

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takes on individual adjustment, family life, schools, and social services underscores the importance of understanding the developmental course of ADHD symptoms, with the ultimate goal of early identification and treatment.

Identifying early markers of ADHD symptomatology and charting its developmental course involve three fundamental tasks. First, the longitudinal stability of ADHD symptoms must be established. Second, potential early markers of ADHD symptoms must be identified. This search should be guided by theoretical models of ADHD and by empirical data. Third, the predictive power of these hypothetical markers must be tested in a community sample across time to avoid the biases associated with clinic referral, especially in young children (e.g., Lahey et al., 2004).

Examining the development of ADHD symptomatology in a community sample also necessitates investigating these questions at the symptom level rather than at the disorder level. Therefore, in the current study, we examine the longitudinal stability of ADHD *symptoms* from 54 months through first and third grades. Then, based on a review of the theoretical literature and empirical research, we explore whether behavioral inhibition and inattention in preschoolers predict ADHD *symptoms* as rated by teachers in first and third grades. In addition, we investigate whether poor behavioral inhibition or inattention in preschool-aged children exacerbates ADHD *symptoms* in early elementary school in children with higher levels of early *symptoms*. Finally, as we are ultimately motivated by our desire to understand attention deficit/hyperactivity *disorder*, we also examine these same questions as a function of elevated ADHD symptom levels across time.

1.1. Longitudinal Stability of ADHD

Although several studies have examined the longitudinal stability of early ADHD symptoms (Lahey et al., 2004; Lahey, Pelham, Loney, Lee, & Willcutt, 2005; Pierce, Ewing, & Campbell, 1999), they have not investigated potential mechanisms that may underlie this temporal stability. Lahey and colleagues (2004) examined the 3-year predictive validity of ADHD in children diagnosed between 4 and 6 years of age using DSM-IV criteria. They found that children who met full diagnostic criteria during their first assessment were likely to continue to meet diagnostic criteria for ADHD over the next 3 years (Lahey et al., 2004). Pierce et al. (1999) found that symptoms of ADHD identified in hard-to-manage preschool boys predicted continuing problems in middle childhood. The present study aims to examine both the stability in ADHD symptoms over time and also to advance current knowledge by examining the role played by potential early markers of ADHD symptoms: behavioral inhibition and inattention.

1.2. Theoretical Models of ADHD: The Role of Inhibition and Inattention

Over the past 15 years, several theoretical models of ADHD have emerged (Sergeant, Geurts, Huijbregts, Scheres, & Oosterlaan, 2003). Despite different emphases, these models all posit deficient behavioral inhibition and attention as central features of ADHD, but they differ in the precise definitions and roles of inhibition and attention deficits in the emergence of ADHD. For instance, Barkley (1997) identifies behavioral inhibition as an executive function in the Behavioral Inhibition Model, whereas Sonuga-Barke, Houlberg, and Hall (1994) view poor behavioral inhibition as a symptom of the inability to wait in the Delay Aversion Model. The models differ not only in their definitions, but also in whether they ascribe a primary or secondary role to underlying inhibition and attention deficits (Nigg, 2001). For example, the Behavioral Inhibition Model asserts that ADHD is driven primarily by an inhibition deficit, which, in turn, is responsible for an attention deficit (Barkley, 1997), whereas inhibition and attention deficits are both relegated to secondary roles in the Cognitive-Energetic Model (Sergeant, Oosterlaan, & van der Meere, 1999). On the extreme

end of this spectrum lies the Delay Aversion Model (Sonuga-Barke, Dalen, Daley, & Remington, 2002; Sonuga-Barke et al., 1994), which ascribes peripheral roles to both behavioral inhibition and inattention; it suggests that a hypersensitivity to delay is responsible for ADHD symptoms and is partly manifest as impulsive and/or inattentive behavior.

1.3. Behavioral Inhibition and Inattention

Despite the lack of agreement regarding the definitions of inhibition and inattention and the specific roles they play in the etiology of ADHD, as already noted, some form of inhibition and/or attention deficit is common to nearly all models of ADHD. In addition, the development of inhibition and sustained attention are important developmental tasks for preschool children who must learn to regulate behavior, control impulses, and attend in response to situational demands (Campbell, 2002). Thus, early indicators of poor behavioral inhibition and inattention are possible markers that can be studied in early childhood and may contribute to the development and maintenance of ADHD symptoms (Barkley, 1997). Based on the literature on ADHD, we use Barkley's (1997) definition of behavioral inhibition, that is, the ability to suppress a dominant response to an event. Suppression of the response may occur before the response is initiated or while the response is ongoing. Further, the failure to withhold dominant responses, despite either threat of punishment or loss of desirable rewards, is defined as a behavioral inhibition deficit.

1.4. Studies of Inhibition and ADHD Symptoms in Children

The emphasis on executive function deficits, such as deficient behavioral inhibition, in models of ADHD has progressed in tandem with empirical research exploring their interrelation (Barkley, 1997; Nigg, 2001; Pennington & Ozonoff, 1996). To date, the overwhelming majority of studies assessing various aspects of inhibition have demonstrated a concurrent inhibition deficit in school-aged children exhibiting ADHD symptoms compared with children without signs of ADHD (see, for reviews, Barkley, Grodzinsky, & DuPaul, 1992; Corkum & Siegel, 1993; Homack & Riccio, 2004; Losier, McGrath, & Klein, 1996; Oosterlaan, Logan, & Sergeant, 1998; Pennington & Ozonoff, 1996; Tannock, 1998). From these studies, we can conclude that behavioral inhibition deficits are related to ADHD symptoms. However, the majority of these studies have not examined the nature of this relationship over time or considered whether an early behavioral inhibition deficit, assessed at preschool age, may exacerbate the severity of ADHD symptoms in early elementary school. This study examines whether behavioral inhibition deficits moderate the longitudinal stability of ADHD symptoms.

Behavioral inhibition has been operationalized using a variety of measures, including the Continuous Performance Task (CPT) (see, for reviews, Barkley et al., 1992; Corkum & Siegel, 1993; Losier et al., 1996), delay of gratification tasks (DGTs) (Campbell, Douglas, & Morgernstern, 1971; Pennington & Ozonoff, 1996; Weyandt & Grant, 1994), and the Stroop Test (see for review, Homack & Riccio, 2004). Consistent with this literature, in the current study, behavioral inhibition is measured using CPT commission errors, DGT waiting time, and Stroop interference effects. An early marker of potential attention problems is also included, CPT omission errors, thought to index lapses in attention (Halperin, Sharma, Greenblatt, & Schwartz, 1991). These measures have been used extensively in research on school-aged children and they have also been used successfully with preschool-aged populations. This dual focus on deficits in both inhibition and attention is consistent with recent theoretical arguments suggesting multiple pathways to ADHD symptoms and implicating dysregulation in both inhibitory and attentional systems (Nigg, 2006).

Overall, the findings from studies focusing on school-aged children buttress the theoretically posited relationship between inhibition deficits and ADHD (Barkley, 1997). However, the aim of this study is to explore whether *early* behavioral inhibition and/or inattention deficits predict *later* symptoms of ADHD, and also to examine the roles that behavioral inhibition and inattention play in the development and maintenance of ADHD symptoms in preschool-aged children. Therefore, we now discuss the literature examining behavioral inhibition, inattention, and ADHD symptoms in preschool-aged children.

Initially stimulated by the work of Campbell and colleagues (Campbell, Pierce, March, Ewing, & Szumowski, 1994; Campbell, Szumowski, Ewing, Gluck, & Breaux, 1982), a growing body of studies have examined ADHD symptoms and behavioral inhibition in preschool children (Berlin, Bohlin, & Rydell, 2003; Marakovitz & Campbell, 1998). The majority of these studies (9/11) have found a significant association between ADHD symptoms and deficient behavioral inhibition (Berlin & Bohlin, 2002; Berlin et al., 2003; Byrne, DeWolfe, & Bawden, 1998; Campbell et al., 1982, 1994; Hughes, Dunn, & White, 1998; Marakovitz & Campbell, 1998; Sonuga-Barke et al., 2002; Sonuga-Barke, Dalen, & Remington, 2003), adding credence to the hypotheses that early behavioral inhibition predicts later ADHD symptoms and may influence the relationship between early and later ADHD symptoms.

Only three of these studies, however, have specifically examined the predictive relationship between behavioral inhibition at preschool age and ADHD symptoms at school age (Berlin et al., 2003; Campbell et al., 1994; Marakovitz & Campbell, 1998). Berlin and colleagues investigated the association between early inhibition deficits and later symptoms in a large community sample of boys and girls. Behavioral inhibition was measured at approximately 5 years of age and was operationalized using the go/no-go task. Teachers and parents rated ADHD symptoms when children were, on average, 8 years old. Preschool inhibition deficits predicted later ADHD symptoms both at school and home for boys and in the school context only for girls. Furthermore, Berlin et al. (2003) found that preschool inhibition and concurrent executive function measures contributed independently to the variance in ADHD symptoms in school for boys and the sample as a whole. Unlike in the current study, Berlin and colleagues did not examine the predictive association between preschool inattention and ADHD symptoms.

Campbell and colleagues (1994) examined the relationship between behavioral inhibition and ADHD symptoms in a sample of preschool boys identified by parents and/or teachers as "hard-to-manage." These boys met approximate criteria for Attention Deficit Disorder with Hyperactivity according to DSM-III. A group of boys who did not meet these criteria and were matched with the hard-to-manage boys on classroom and age constituted the control group. An additional group of "problem boys" were referred to the study by parents complaining about their son's overactivity, inattention, and discipline problems. At preschool age, behavioral inhibition was assessed using a DGT and a resistance-to-temptation task. A Continuous Performance Task (CPT) was used to measure behavioral inhibition and inattention at the follow-up visit, when the boys were approximately 6 years old. A significant longitudinal relationship was found for the entire sample between preschool delay performance and later observations of behavior during structured tasks in the laboratory, including cooperation, restlessness, attentional focus, task involvement, out-of-seat behavior, and distraction. Inattention, measured by CPT omission errors, was examined concurrently at follow-up. No main effect was found; that is, CPT omission errors did not differ between the "hard-to-manage" and comparison boys.

Marakovitz and Campbell (1998) followed these same children in elementary school and examined the relationship between measures of inhibition at ages 4 and 6 and a diagnosis of

attention deficit disorder (ADD) at age 9. A significant association was found between latency to touch an appealing toy on the resistance-to-temptation task at ages 4 and age 9 ADD diagnostic status. Specifically, boys diagnosed with ADD at age 9 were less able to resist touching the forbidden toy at age 4 than were control boys, although performance on the DGT was unrelated to later ADD status. Impulsive errors on the CPT at age 6 were not found to differentiate between ADD, non-ADD, and control groups at age 9, although power to detect differences was low. Inattention, measured by CPT omission errors, was also examined at ages 6 and 9. The authors report a significant concurrent relationship between ADD status and inattention at age 9. However, age 6 inattention did not predict age 9 ADD status.

Similar to the three studies discussed above, the current study also examines whether behavioral inhibition and/or inattention in preschool-aged children predict later ADHD symptoms. However, this study provides the unique opportunity to examine that relationship in more detail across three time points using multiple measures in a large community sample of girls and boys, thereby allowing for greater generalizability of the results. In addition, this study uses multiple measures of behavioral inhibition, which allows us to assess behavioral inhibition as an executive function (CPT commission errors) and as a motivational strategy (delay of gratification). Furthermore, by controlling early ADHD symptoms when examining the predictive relationship between preschool behavioral inhibition, inattention, and later ADHD symptoms, we will determine whether early behavioral inhibition and/or inattention predict later ADHD symptoms above and beyond the temporal stability in symptoms. Finally, these questions are also examined as a function of ADHD symptom level. In summary, this study aims to answer the following questions:

1. Are ADHD symptoms stable, despite different reporters, that is, teachers, from 54 months to third grade (age 9)?
2. Are behavioral inhibition and attention deficits associated both concurrently and longitudinally with ADHD symptom ratings?
3. Do behavioral inhibition deficits and inattention at 54 months predict ADHD symptoms in first and third grades, even after controlling for ADHD symptoms at 54 months?
4. Is the relationship between ADHD symptoms at preschool age and at first and third grades stronger among participants who exhibit deficits in behavioral inhibition or attention at preschool age? That is, does preschool behavioral inhibition and/or inattention moderate the association between symptoms of ADHD assessed at preschool age and later ADHD symptoms?
5. Are the relationships described in questions 1 and 3 still significant when examined as a function of ADHD symptom level, that is, within a sample of children exhibiting ADHD symptoms in the "at risk" range between 54 months and third grade?

Overall, this study provides the rare opportunity to examine these questions with empirically validated measures and multiple reporters in a large, diverse community-based sample using a prospective longitudinal design.

2. Method

2.1. Participants

The analyses for this study are based on data from 776 children, who are a subset of those participating in an ongoing, multisite study, the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD

SECCYD). Children participating in this study were born between 1990 and 1991 in hospitals at 10 data collection sites across the United States: Little Rock, AR; Irvine, CA; Lawrence and Topeka, KS; Boston, MA; Philadelphia, PA; Pittsburgh, PA; Charlottesville, VA; Morganton and Hickory, NC; Seattle, WA; and Madison, WI. These children and their families were followed from birth through third grade. Details of sample recruitment may be found at the study Web site (<http://secc.rti.org/>).

The 776 children included in the present study had relevant data available at 54 months. Table 1 summarizes demographic and descriptive characteristics of the sample used for this study.

Attrition analyses, comparing study families who were not included in the analyses due to missing measures or because their child did not attend preschool at 54 months ($N = 588$) with those families who met the above criteria ($N = 776$), revealed significant differences between the groups. Based on the 1-month home visit, mothers of children included in this study ($M = 14.68$, $SD = 2.44$) were more educated than mothers of children who were excluded ($M = 13.64$, $SD = 2.48$), $t(1361) = 7.72$, $p < .001$. On the basis of the income-to-needs ratios averaged across 6, 15, 24, 36, and 54 months, included families had more financial resources ($M = 4.03$, $SD = 2.91$) than families who were not included ($M = 2.97$, $SD = 2.63$), $t(1200) = 6.81$, $p < .001$. These analyses indicate that the sample for the current study is biased toward families with more financial and academic resources.

2.2. Procedure

Inhibition and inattention were assessed in the laboratory at 54 months of age. As part of a longer laboratory visit, children were administered age-appropriate versions of the CPT, a DGT, and the Stroop Test. In preschool or child care at 54 months and in first and third grades, symptoms of ADHD were measured using the Teacher Report Form (Achenbach, 1991). In third grade, teachers also completed the Disruptive Behaviors Disorder Rating Scale (Pelham, Gnagny, Greenslade, & Milich, 1992).

Demographic information was obtained during interviews administered to mothers at regular intervals when children were between 1 and 54 months of age. Mothers reported on their education level and total annual family income (the family's income-to-needs ratio was calculated by dividing total income by the poverty threshold for the family's size).

2.3. Measures

2.3.1. Predictor Measures

2.3.1.1. Continuous Performance Task: At 54 months, children were individually administered the CPT toward the end of a 2-hour laboratory visit. The child was seated in front of a 2-inch-square screen and a red button. Dot-matrix pictures of familiar objects, such as butterflies, fish, and flowers, were generated by a computer and presented consecutively on the screen. The child was instructed to press the red button each time a previously identified target stimulus (a chair) appeared on the screen.

Once the test session began, the stimuli were presented in 22 blocks. Each block contained 10 stimuli, resulting in a total display of 220 stimuli over the course of the test. The stimulus was flashed on the screen for 500 milliseconds, and the interstimulus interval (ISI) lasted 1500 milliseconds before the next stimulus appeared. Within each block of stimuli, the target stimulus was presented twice at random. The entire test lasted approximately 7 minutes and 20 seconds. The computer automatically provided scores on the number of times the child responded to a nontarget stimulus, that is, errors of commission, which are traditionally considered to represent impulsive responses or deficient behavioral inhibition

(Barkley & Grodzinsky, 1994; Epstein et al., 2003). Information was also provided on the number of times the child failed to respond to a target stimulus, that is, errors of omission, which are commonly used as a measure of inattention (Halperin et al., 1991).

2.3.1.2. Delay of gratification task: On the DGT, behavioral inhibition is operationalized by the ability to resist choosing an immediate smaller reward in lieu of a larger delayed reward. The DGT was administered during the 54-month laboratory visit and was modeled on Mischel's self-imposed waiting task (Mischel, Shoda, & Rodriguez, 1989).

Before the DGT was administered, the visit coordinator (VC) issued four sets of instructions to the child. First, the child was taught how to ring the bell, and the VC explained that she or he was going to leave the room and could be summoned back when the child rang the bell. This procedure was practiced before the experiment began. Second, the VC established which food, that is, M&Ms, animal crackers, or pretzels, the child would like to have as a reward. Third, the VC determined whether the child preferred to have a small amount or a larger amount of his or her favorite food for a reward. Finally, after the VC determined that the child preferred a larger quantity of his or her chosen food, the VC provided the following explanation of how to play the "waiting game." The VC told the child that she or he would play the waiting game while the VC was out of the room for a few minutes doing some work. Two plates were left in the room with the child, one holding a small pile of food and the other holding a larger pile of food. The VC told the child that she or he would be able to eat the larger amount of the desired food, if she or he was able to wait until the VC returned to the room, without the child summoning her back. In the event that he or she was unable to wait for the return of the VC, the child was told that he or she could ring the bell and the VC would return. However, the child was warned that if she or he summoned the VC back into the room by ringing the bell, she or he would receive the smaller amount of food. The child was also told to remain seated in his or her chair while the VC was out of the room and not to eat any of the food until the VC returned.

After delivering these instructions the VC left the room and entered an observation booth to watch the child. If the child successfully waited for 7 minutes, the VC returned, praised the child, and rewarded him or her with the larger pile of food. If the child did not use the bell but proceeded to eat any of the food, the amount of elapsed time was recorded, and the VC returned to the room and gave the child the smaller pile of food. If the child spontaneously ate the food, but also did not display convincing evidence that she or he comprehended the waiting rules to begin with, this child's data were treated as "missing" (i.e., no waiting time was entered on the scoring sheet, $N = 72$). The amount of time the child waited after the VC left the room was used to operationalize behavioral inhibition in the current study.

2.3.1.3. Day-night Stroop Test: The original Stroop test presents subjects with the names of colors printed in incongruent colors. Subjects are asked to name the color in which the word is written rather than the color the word denotes. Behavioral inhibition must be employed to follow these directions successfully; that is, subjects must inhibit an overlearned, therefore dominant, response to comply with the instructions. Gerstadt, Hong, and Diamond (1994) adapted the original Stroop Test into a version for preschool children. The test consists of 18 cards; 9 of the cards are black with a yellow moon and several stars, and 9 are white with a bright sun. The test cards were placed face down in front of the study child in a predetermined order. First, the child was shown a night card and instructed to identify it as "day" and then shown a day card and instructed to identify it as "night." If the child understood the directions and answered correctly on the first set of practice trials, the instructions were not repeated again and the test trials were initiated. However, if the child made a mistake on either of the first two practice trials, the instructions were repeated again and a new set of practice trials were begun. For the data to be counted, the child had to

answer correctly on both day and night in one of the two sets of practice trials. Fourteen trials were administered to the child during the actual test. The percentage incorrect out of the total number of non-missing responses was used to operationalize interference or lack of inhibition in the current study. The items used to create this variable had moderate internal reliability (Cronbach's $\alpha = 0.79$).

2.3.2. Outcome measures

2.3.2.1. Teacher Report Form (TRF): At first and third grades, teachers were asked to complete the TRF, the teacher version of the Child Behavior Checklist 4–18 (CBCL) (Achenbach, 1991). The 20 items making up the Attention Problems scale are of interest in the current study.

2.3.2.2. Disruptive Behaviors Disorder Rating Scale (DBD): At third grade, teachers were asked to rate the nine symptoms of inattention and nine symptoms of hyperactivity–impulsivity derived from the DSM-IV (American Psychiatric Association, 1994). This measure is an adaptation of the original Disruptive Behavior Disorders Rating Scale (DBD) (Pelham et al., 1992). Each behavior was rated on a 4-point scale: 0 = not at all, 1 = just a little, 2 = pretty much, and 3 = very much a problem. The total score was obtained by summing the 18 ADHD symptoms, which were found to have high internal reliability (Cronbach's $\alpha = 0.95$). In addition, children who received ratings of “pretty much” (2) or “very much” (3) on six symptoms of inattention and/or six symptoms of hyperactivity–impulsivity were considered to meet symptomatic criteria for ADHD at third grade according to teachers.

2.3.3. Control measures

2.3.3.1. Maternal education: At the 1-month interview, mothers reported on the number of years of school completed, and this was used as an index of maternal education.

2.3.3.2. Income-to-needs ratio: When study children were 6, 15, 24, 36, and 54 months old, information about family income and family size was collected. The income-to-needs ratio measures the total family income divided by the poverty threshold (U.S. Department of Labor, 1994) according to size of family. The average score across measurement periods was used as a control for family income disparities.

2.3.3.3. Teacher Report Form: Teachers were asked to complete the TRF when the study child was 54 months old. The Attention Problems subscale (see above) was used as a measure of ADHD symptoms at 54 months.

3. Results

Means, standard deviations, and sample sizes for all control, predictor, and outcome measures are provided in Table 2. For the sake of brevity, behavioral inhibition and inattention measures are referred to as predictors, except in the analyses examining their roles as moderators. The CPT variables were square root transformed due to their skewed distribution. Inspection of the other variables revealed distributions adequate for analyses assuming normalcy.

3.1. Analytic Plan

First, preliminary correlational analyses were conducted on demographic, predictor, and outcome variables. Second, two sets of regression analyses were run, one to examine whether behavioral inhibition or inattention at 54 months predicts ADHD symptoms in first and third grades, and the second to test whether behavioral inhibition deficits or inattention

exacerbates the relationship between ADHD symptoms at 54 months and at first and third grades. Finally, the data were examined categorically to investigate these questions as a function of ADHD symptom *levels*.

Prior to the main analyses, continuous predictor variables were centered by subtracting the group mean from individual scores, to reduce nonessential multicollinearity. In addition, variance inflation factors, direct indices of the impact of multicollinearity on estimation, were examined. None of the regression models had variance inflation factors (VIFs) greater than 10 (highest VIF = 2.151); however, zero-order correlations among the predictors are presented to facilitate interpretation of the results (see Table 3).

3.1.1. Correlations between demographics, predictors, and outcome—Table 3 provides the matrix of zero-order correlations among demographic (education and income), predictor, moderator, and outcome variables. Maternal education and income were both significantly correlated with the predictors (ADHD symptoms, behavioral inhibition, and inattention at 54 months), as well as the outcome variables (ADHD symptoms at first and third grades). Overall, higher maternal educational achievement was related to teacher-reported ADHD symptoms, behavioral inhibition, and inattention in the expected directions. Children with more highly educated mothers displayed lower levels of inattention at 54 months and of ADHD symptoms at 54 months, first grade, and third grade. Higher levels of maternal education were also significantly associated with higher levels of behavioral inhibition in children at 54 months. Because maternal education was related to both the predictor and outcome variables, it was controlled in all regression analyses. Because the average income-to-needs ratio was correlated with the same predictor and outcome variables as the maternal education variable, and it was moderately correlated with maternal education ($r = .54, p < .001$), only the maternal education variable was controlled in the regression analyses.

3.1.2. Sex differences—Sex differences in the predictor variables were examined using independent-sample *t* tests. Analyses indicated that girls ($M = 9.08$) made significantly fewer errors of commission on the CPT at 54 months than boys ($M = 15.85$), $t(601) = 4.75, p < .001$. Subsequently, sex was controlled in all regression analyses involving this variable, and interaction effects were examined as well. No other inhibition or inattention measure showed sex differences.

3.1.3. Correlations among behavioral inhibition measures—Because only modest correlations were found between the three preschool behavioral inhibition measures (see Table 3), they were treated separately in all further analyses.

3.2. Question 1: Do ADHD Symptoms Remain Stable from 54 Months to Third Grade?

As noted above, Pearson product moment correlations were performed between ADHD symptom ratings at 54 months, first grade, and third grade. Symptoms across these three time points were found to be moderately correlated (see Table 3). Therefore, we can conclude that ADHD symptoms remain somewhat stable from preschool into early elementary school.

3.3. Question 2: Are Behavioral Inhibition Deficits or Inattention Associated with Concurrent and Longitudinal Symptoms of ADHD?

Similarly, the association between behavioral inhibition and inattention and concurrent and longitudinal symptoms of ADHD was examined using correlational analyses. Behavioral inhibition deficits and inattention at 54 months (as measured by CPT commission errors, DGT task, and CPT omission errors) were found to be modestly associated with concurrent

symptoms of ADHD and later symptoms of ADHD, in both first and third grades (see Table 3).

3.4. Question 3: Does Behavioral Inhibition or Inattention at 54 Months Predict ADHD Symptoms During First and Third Grades Above and Beyond ADHD Symptoms at 54 Months?

Four hierarchical regression analyses were conducted to test whether behavioral inhibition or inattention at 54 months predicted symptoms of ADHD as measured by the TRF in first and third grades, as well as the DBD in third grade, while controlling for these same teacher-rated behavior problems at 54 months. Maternal education was entered first as a control variable, followed by ratings of ADHD symptoms at 54 months, and then by one of the behavioral inhibition or inattention measures. Analyses examining CPT commission errors also included sex in Step 1 and the interaction term (CPT commission errors $\times$ sex) in Step 4. Results are summarized in Table 4.

Behavioral inhibition at 54 months, as measured by CPT commission errors and the DGT, predicted ADHD symptoms at first grade over and above stability in symptoms. First grade ADHD symptoms were also predicted by inattention at 54 months, operationalized by CPT omission errors. The Stroop Test did not contribute unique variance to teacher ratings of child behavior problems, as was anticipated from the nonsignificant correlations in Table 3.

Third grade ADHD symptoms, as measured by both the TRF (see Table 5) and the DBD (see Table 6), were also predicted by CPT commission errors and the DGT, but not by either the Stroop Test or CPT omission errors. Again, these links were evident despite controls for earlier (54-month) ADHD symptoms.

Furthermore, a significant interaction was found between CPT commission errors and sex in relation to third grade ADHD symptoms (see Table 5). Consequently, post hoc analyses were performed, which indicated that the longitudinal predictive relationship between 54-month CPT commission errors and third grade TRF ADHD symptoms was significant for girls, but not boys (see Figure 1).

3.5. Question 4: Does Behavioral Inhibition or Inattention at 54 Months Moderate the Association Between ADHD Symptoms at 54 Months and at First and Third Grades?

Hierarchical regressions were used to test whether or not behavioral inhibition or inattention at 54 months moderated the relationship between ADHD symptoms as reported by teachers at 54 months and at first and third grades. The Attention Problems subscale of the TRF at first and third grades, as well as the ADHD score from the DBD, were separately regressed on maternal education in Step 1. One of the behavioral inhibition or inattention measures (CPT commission errors, DGT, or CPT omission errors) was added in Step 2, followed by ADHD symptoms at 54 months in Step 3, and finally the corresponding interaction term (attention problems $\times$ behavioral inhibition or inattention) in Step 4. As CPT commission errors had been found to predict TRF attention problems in third grade for girls only, moderation analyses for this relationship were performed on girls alone. None of these interactions was significant.

3.6. Exploratory Analyses

Three additional hierarchical regression analyses were conducted to test whether the three behavioral inhibition measures accounted for unique variance when entered together to predict ADHD symptoms in first and third grades. After controlling for maternal education in Step 1 and gender and 54-month ADHD symptoms in Step 2, the two behavioral inhibition measures were entered in Step 3. Results indicated that CPT commission errors

and DGT each accounted for unique variance in TRF ADHD symptoms in first grade (CPT: $\beta = .14$, $\Delta R^2 = .02$; DGT: $\beta = -.12$, $\Delta R^2 = .01$; $p < .01$) and third grade (CPT: $\beta = .09$, $\Delta R^2 = .01$; DGT: $\beta = -.14$, $\Delta R^2 = .02$; $p < .05$), as well as in DBD ADHD symptoms in third grade (CPT: $\beta = .18$, $\Delta R^2 = .03$; DGT: $\beta = -.11$, $\Delta R^2 = .01$; $p < .01$).

3.7. Categorical Analyses

3.7.1. Question 1: Do ADHD symptoms at “at risk” levels at 54 months remain stable to first and third grades?—To examine the longitudinal stability of ADHD symptoms as a function of symptom level, an “at risk” group was identified at each time point. These groups included participants who scored in the “at risk” range: a *T* score of 60 or above on the TRF at 54 months ($N = 133$, boys = 70), first grade ($N = 109$, boys = 43), and third grade ($N = 115$, boys = 56).

Logistic regressions were used to test whether “at risk” status at 54 months predicted future “at risk” status at either first or third grade. After controlling for maternal education, elevated levels of ADHD symptoms at preschool, that is, “at risk” status, was found to predict “at risk” status significantly in first grade (odds ratio, $e^{\beta} = 0.231$, $p < 0.01$) and third grade ($e^{\beta} = 0.292$, $p < 0.01$).

3.7.2. Question 3: Do behavioral inhibition and inattention at 54 months predict “persistently at risk” levels of ADHD symptoms at first and third grades?—To answer this question, two extreme groups were formed from the overall sample. The “persistently at risk” group ($N = 106$, boys = 52) included children who demonstrated high levels of ADHD symptoms at two or more time points between 54 months and third grade. High levels of ADHD symptoms were operationalized as a borderline or clinical score ($T \geq 60$) on the TRF, or meeting symptom criteria on the DBD). The “normative” group ($N = 503$, boys = 239) comprised children who received ADHD symptom ratings within the normal range at all three time points. Children whose scores fell between these extremes were not included in the following analysis.

A logistic regression analysis was conducted to test whether behavioral inhibition or inattention at 54 months predicted extreme group status. After controlling for maternal education in Step 1, the 54-month behavioral inhibition and inattention measures were added in Step 2. Results indicated that behavioral inhibition, as measured by CPT commission errors ($e^{\beta} = 1.285$, $p < 0.01$) and the DGT ($e^{\beta} = 0.883$, $p < 0.05$), but not inattention, significantly and independently predicted extreme group status.

4. Discussion

4.1. Summary of Results

The overarching goal of this study was to examine the early emergence and developmental course of ADHD symptoms in early childhood. More specifically, we first examined whether ADHD symptoms demonstrate temporal stability from 54 months to third grade in this community sample. Next, in line with current theory and research, we investigated whether behavioral inhibition deficits and inattention in preschool children predicted school-age ADHD symptoms directly. Furthermore, we tested this relationship controlling for stability in ADHD symptoms. In addition, we examined whether the longitudinal stability of ADHD symptoms at preschool and first and third grades was moderated by deficits in preschool behavioral inhibition or attention, that is, whether the occurrence of both early ADHD symptoms and inhibition or attention deficits exacerbated the level of later ADHD symptoms. Overall, after controlling for the stability in symptoms from preschool, we found that inhibition and attention deficits in preschool predicted ADHD symptoms in first grade,

whereas inhibition deficits alone predicted ADHD symptoms in third grade (β ranged from $-.85$ to $-.62$, $p < .01$). However, the predictive relationship between CPT commission errors and third grade TRF attention problems was significant only for girls and not for boys. Furthermore, exploratory analyses revealed that two of the three behavioral inhibition measures accounted for unique variance in first and third grade symptoms of ADHD (β ranged from 1.11 to $-.50$, $p < .05$). Finally, we did not find any evidence that preschool measures of behavioral inhibition or inattention moderated the relationship between symptoms of ADHD in preschool and in first and third grades.

In addition, motivated by our desire to understand ADHD, we examined the stability of, and potential early markers of, ADHD symptoms as a function of elevated symptom levels. Using this categorical approach, we found that elevated symptoms of ADHD, that is, "at risk" status, at 54 months predicted "at risk" status at both first and third grades. Furthermore, behavioral inhibition deficits, but not inattention, at 54 months were found to predict "persistent at risk" status, that is, elevated levels of ADHD symptoms from preschool to elementary school.

Regarding the development of ADHD symptoms, we found that teacher-rated attention problems are significantly associated across time, from 54 months to first and third grades, despite the difference in settings and reporters. Caregiver ratings of attention problems in child care settings when the participants were 54 months old significantly predicted teacher-reported attention problems when the children were in first and third grades. These results are consistent with the findings reported by Lahey and colleagues (2005) and Pierce et al. (1999), which provide evidence of modest stability in ADHD symptoms over time even at this early age.

Consistent with the literature (Berlin et al., 2003; Campbell et al., 1994; Marakovitz & Campbell, 1998), two of the behavioral inhibition measures (CPT commission errors and DGT) were found to predict ADHD symptoms at first and third grades, and inattention was found to predict ADHD symptoms at first grade. However, as far as we know, the current study is the first to examine and find these effects even after controlling for the longitudinal stability in ADHD symptoms. This relationship between preschool behavioral inhibition as measured by CPT commission errors and third grade TRF attention problems (symptoms of ADHD) was found to be significant only for girls. Behavioral inhibition deficits in girls at 54 months may be less developmentally normative than impulsivity evidenced by boys at the same age. Therefore, when girls show impulsive behavior in preschool, they may be at higher risk of later regulatory problems, as reflected in ADHD symptoms. Finally, behavioral inhibition was also related to concurrent measures of ADHD symptoms at 54 months. These findings indicate that behavioral inhibition deficits, as measured by laboratory tasks, in preschool children are associated with ADHD symptomatology, as rated by teachers, both concurrently and longitudinally.

The preschool behavioral inhibition measures account for about 1–4 % of the variance in ADHD symptoms at school age, after controlling for preschool ADHD symptoms. In comparison, in the study by Berlin and colleagues' (2003), the "go/no-go" task accounted for between 6 and 17% of the variance in their sample's school-age ADHD symptoms, whereas Campbell and colleagues (1994) reported that their inhibition task predicted 4% of the variance in school-age behavioral symptoms. Thus, our findings converge with others in supporting a link between early deficits in behavioral inhibition and later ratings of ADHD symptoms, despite differences in measures, reporters, and samples.

The current study is unique in that it alone controlled for preschool ADHD symptoms when predicting later ADHD symptoms from preschool measures of behavioral inhibition and

inattention. This may explain why the inhibition measures in the current study accounted for a modest percentage of the variance in ADHD symptoms at first and third grades. Neither Campbell et al. (1994) nor Berlin and colleagues (2003) controlled for potential stability of ADHD symptoms from preschool to school age.

One of the behavioral inhibition measures we used, the day–night Stroop Test, was not related to either 54-month or later ADHD symptoms, even though it was moderately correlated with the other measures of inhibition. The day–night Stroop Test was created more recently by Gerstadt et al. (1994) as a preschool version of the Stroop task. As a result, it has not been commonly used in research and, therefore, has not accumulated a large number of studies reporting on its reliability and construct validity. In contrast, the original Stroop Test has a long history in the research literature, its validity has been established, and it has also been found to be related to ADHD symptoms (Homack & Riccio, 2004). Therefore, the day–night Stroop test was included in the current study based primarily on its face validity as a preschool adaptation of the original Stroop measure. The null findings reported in this study suggest that the day–night Stroop task is not capturing behavioral inhibition as manifested in preschoolers. Alternatively, the preschool version of the Stroop may be capturing an aspect, or aspects, of behavioral inhibition that either may not be related to ADHD symptoms or may not be a primary engine leading to the development of ADHD.

The leading theoretical models of ADHD and the research literature suffer from a lack of precision regarding the nature and definition of behavioral inhibition, as discussed by Nigg (2001). In an attempt at clarification, Nigg has proposed a binary division. He suggests that two general types of inhibition exist: inhibition that is under executive control (which includes the motor domain), and inhibition that is under motivational control. This distinction, in fact, mirrors a division found in the theoretical literature. For instance, Sonuga-Barke et al. (1994) in the Delay Aversion Hypothesis conceptualizes behavioral inhibition deficits exhibited by children with ADHD as behavioral strategies, which are, in turn, generated by their primary motivation to escape or avoid delay. In contrast, Barkley (1999) and Quay (1988) hypothesize that executive function deficits in inhibition are responsible for the behavioral inhibition deficits evidenced in children with ADHD.

In line with Barkley (1999) and Quay (1988), Nigg (2001) argues that ADHD is due to a deficit in an executive motor inhibition process rather than a motivational inhibitory control deficit. If this definitional division is indeed theoretically significant, then the measure used to operationalize behavioral inhibition becomes highly pertinent. The current study used behavioral inhibition measures that are related to both executive function (CPT) and motivation (DGT). As previously reported, preschool behavioral inhibition deficits as captured by both of these measures were found to significantly and *independently* predict school-age ADHD symptoms. These results suggest that both motivational and regulatory aspects of behavioral inhibition are involved in the development of ADHD. This conclusion is in line with the Cognitive-Energetic Model proposed by Sergeant (2000), which states that deficits in *both* executive and motivationally controlled behavioral inhibition contribute to ADHD.

On the basis of past research and our findings that behavioral inhibition, inattention, and ADHD symptoms assessed at preschool age predict symptoms of ADHD at first and third grades, it would be intuitive to assume that the interaction between these variables would predict later ADHD symptoms. Common sense suggests that higher levels of behavioral inhibition or attention deficits would exacerbate the development of ADHD symptoms, especially in children showing early behavioral symptoms, and that lower levels of behavioral inhibition or attention deficits at 54 months might act as a buffer against the

future persistence of behavior problems. However, our results did not support this hypothesis. The fact that ADHD symptoms, inattention, and behavioral inhibition are all found to be independent predictors of later ADHD symptoms suggests that, even though these measures are related, their associations with later behavioral problems are independent of one another. These findings suggest that the laboratory measures of behavioral inhibition and inattention are capturing different facets of impulsive and inattentive behavior than the teacher ratings of symptoms.

In summary, our findings provide evidence for the temporal stability of ADHD symptoms from preschool to early school age. Preschool behavioral inhibition and inattention were found to be associated with school-age symptoms even after controlling for preschool ADHD symptoms. This relationship was found using both the CPT and the DGT, indicating that deficits in both executive and motivationally controlled inhibition precede, indeed predict, the development of ADHD symptomatology. Finally, these findings support the Cognitive-Energetic Model of ADHD (Sergeant, 2000), which incorporates both motivational and executive controlled behavioral inhibition.

4.2. Limitations and Future Directions

One limitation of the current study involves the somewhat biased nature of the sample. For instance, the children included in this study were primarily Caucasian, and their families were characterized by more parental education and higher average income-to-needs ratios than the population at large. As a result, the findings of this study may not generalize to samples with greater ethnic diversity and higher socioeconomic risk. Future studies examining the early development of ADHD symptoms should employ a sample with greater ethnic and socioeconomic diversity to ensure the generalizability of results.

Measurement limitations are also apparent in the current study. Although the day–night Stroop Test possesses face validity, in that it appears to be similar to the adult Stroop Test, based on our results it does not appear to have adequate construct validity. The current interest in executive function deficits, including behavioral inhibition, in preschool children has spurred increased interest in executive function measures appropriate for preschool-aged children. Future research should employ a range of preschool behavioral inhibition measures that have been empirically validated. Furthermore, we acknowledge the clinical limitations of the measures we have employed: none of the measures used in the current study can be used to make a clinical diagnosis of ADHD. Fortunately, as we are investigating *symptoms* of ADHD in the current study, this latter limitation does not directly affect our results.

The ambiguous definition of behavioral inhibition poses yet another constraint on this area of research, including the current study. Behavioral inhibition is defined and measured in numerous ways in the literature. Even though the various definitions of behavioral inhibition can be categorized as variations on the same theme, their existence underlines the fact that the exact nature of behavioral inhibition and its constituent aspects have not been fully clarified. Unfortunately, the current poorly defined nature of behavioral inhibition hinders true clarity regarding the role of behavioral inhibition in the development of ADHD.

In summary, future research should include younger and more diverse samples to ensure the generalizability of the findings and help to clarify the early development of ADHD symptoms and the roles played by behavioral inhibition and inattention. Future research also should try to use more precise measures of behavioral inhibition. The growing brain imaging literature may help to achieve this end. Finally, brain imaging techniques should also be employed to elucidate how ADHD develops and what role executive functions, such as behavioral inhibition and inattention, play in its development.

5. Conclusions

We can conclude, based on our findings, that behavioral inhibition and inattention at 54 months (operationally defined by the DGT, CPT commission errors and CPT omission errors) predict ADHD symptoms at first and third grades. Furthermore, these findings suggest that behavioral inhibition and inattention at preschool can be used as independent markers of developing ADHD symptoms. These markers, if used in tandem with other early indicators, could be used to create a risk index to help identify children at risk for ADHD who could then be targeted for early intervention.

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Figure 1. Third grade Teacher Report Form (TRF) attention problems as a function of sex and Continuous Performance Task (CPT) Commission errors (1 *SD* above or below the mean).

Table 1

Demographic Characteristics of the Study Sample

Demographic variable	Descriptive statistics	
	<i>n</i>	%
Child gender		
Boys	383	49
Girls	393	51
Child Ethnicity		
Caucasian	654	84
African-American	75	10
Other	47	6
Maternal education (1 month)		
<12 years	48	6
High school or GED	144	19
Some college	253	33
Bachelor's degree	188	24
Postgraduate work	143	18
Income-to-needs ratio (average, 1 month to first grade)		
<2.0 (poor)	173	22
≥2.0 (not poor)	602	78

Table 2

Sample Descriptive Characteristics for Control, Predictor, and Outcome Variables (Total N = 776)

Variable	<i>M</i>	<i>SD</i>	<i>n</i>
Control variables			
Maternal education (1 month)	14.68	2.44	776
Mean income-to-needs (6–54 months)	4.03	2.91	775
Predictor variables (54 months)			
CPT commission errors	12.39	19.14	711
CPT omission errors	8.79	7.34	711
Delay of gratification task	4.79	2.91	681
Stroop Test	25.20	20.65	610
TRF attention problems	54.41	6.05	776
Outcome variables (first grade)			
TRF attention problems	53.46	5.73	730
Outcome variables (third grade)			
TRF attention problems	54.40	7.033	675
DBD ADHD score	9.71	10.70	673

Note. CPT = Continuous Performance Task, TRF = Teacher Report Form, DBD = Disruptive Behaviors Disorder Rating Scale, ADHD = attention deficit/hyperactivity disorder.

Table 3

Zero-Order Correlations of Control, Predictor, and Outcome Variables

Variable	1	2	3	4	5	6	7	8	9	10
Control variables										
1. Maternal education (1 month)	—	0.54**	-0.20**	0.22**	-0.11**	-0.14**	-0.21**	-0.24**	-0.24**	-0.24**
2. Income-to-needs (6-54 months)		—	-0.09*	0.21**	-0.12**	-0.08*	-0.15**	-0.21**	-0.21**	-0.21**
Predictor variables (54 months)										
3. CPT commission errors			—	-0.27**	0.15**	0.22**	0.21**	0.21**	0.16**	0.25**
4. Delay of gratification task				—	-0.10*	-0.21**	-0.16**	-0.23**	-0.24**	-0.24**
5. Stroop Test					—	0.04	0.08	0.06	-0.02	0.00
6. CPT omission errors						—	0.15**	0.21**	0.13**	0.08
7. TRF attention problems							—	0.37**	0.31**	0.33**
Outcome variables (first grade)										
8. TRF attention problems								—	0.44**	0.44**
Outcome variables (third grade)										
9. TRF attention problems									—	0.79**
10. DBD ADHD score										—

Note. CPT = Continuous Performance Task, TRF = Teacher Report Form, DBD = Disruptive Behaviors Disorder Rating Scale, ADHD = attention deficit/hyperactivity disorder.

**
p < .01.

*
p < .05.

Table 4

Hierarchical Regression: Predicting Teacher Report Form (TRF) Attention Problems at First Grade from Behavioral Inhibition and Inattention at 54 Months

Predictor	β	SE β	β
<i>CPT commission errors</i>			
Step 1			
Maternal education	-0.55	0.09	-0.24**
Sex	0.64	0.42	0.06
$R^2 = 0.06^{**}$			
Step 2			
Maternal education	-0.41	0.08	-0.18**
Sex	0.79	0.40	0.07*
ADHD symptoms 54 months	0.30	0.04	0.03**
$\Delta R^2 = 0.10^{**}$			
Step 3			
Maternal education	-0.34	0.08	-0.15**
Sex	1.20	0.40	0.11**
ADHD symptoms 54 months	0.27	0.04	0.28**
CPT commission errors	0.47	0.10	0.18**
$\Delta R^2 = 0.03^{**}$			
Step 4			
Maternal education	-0.34	0.08	-0.15**
Sex	1.37	0.41	0.12**
ADHD symptoms 54 months	0.26	0.04	0.27**
CPT commission errors	0.33	0.13	0.12*
Sex $\times$ CPT commission errors	0.32	0.19	0.08
$\Delta R^2 = 0.003$			
<i>Delay of gratification task</i>			
Step 1			
Maternal education	-0.59	0.09	-0.25**
$R^2 = 0.06^{**}$			
Step 2			
Maternal education	-0.45	0.09	-0.19**
ADHD symptoms 54 months	0.35	0.04	0.35**
$\Delta R^2 = 0.12^{**}$			
Step 3			
Maternal education	-0.38	0.09	-0.16**
ADHD symptoms 54 months	0.33	0.04	0.33**

Predictor	β	SE β	β
Delay of gratification	-0.28	0.07	-0.14**
$\Delta R^2 = 0.02^{**}$			
<i>CPT omission errors</i>			
Step 1			
Maternal education	-0.55	0.09	-0.24**
$R^2 = 0.06^{**}$			
Step 2			
Maternal education	-0.41	0.08	-0.18**
ADHD symptoms 54 months	0.30	0.04	0.31**
$\Delta R^2 = 0.09^{**}$			
Step 3			
Maternal education	-0.37	0.08	-0.16**
ADHD symptoms 54 months	0.28	0.03	0.29**
CPT omission errors	0.11	0.03	0.14**
$\Delta R^2 = 0.02^{**}$			

Note. CPT = Continuous Performance Task, DBD = Disruptive Behaviors Disorder Rating.

**
 $p < .01$.

*
 $p < .05$.

Table 5

Hierarchical Regression: Predicting Teacher Report Form (TRF) Attention Problems at Third Grade from Behavioral Inhibition at 54 Months

Predictor	β	SE β	β
<i>CPT commission errors</i>			
Step 1			
Maternal education	-0.73	0.12	-0.25**
Sex	0.20	0.54	0.01
$R^2 = 0.06^{**}$			
Step 2			
Maternal education	-0.56	0.11	-0.19**
Sex	0.40	0.53	0.03
Attention problems 54 months	0.32	0.05	0.26**
$\Delta R^2 = 0.07^{**}$			
Step 3			
Maternal education	-0.50	0.11	-0.17**
Sex	0.74	0.53	0.05
Attention problems 54 months	0.29	0.05	0.24**
CPT commission errors	0.42	0.13	0.13**
$\Delta R^2 = 0.01^{**}$			
Step 4			
Maternal education	-0.50	0.11	-0.17**
Sex	1.15	0.55	0.08*
Attention problems 54 months	0.27	0.05	0.22**
CPT commission errors	0.07	0.18	0.02
Sex $\times$ CPT commission errors	0.78	0.26	0.17**
$\Delta R^2 = 0.01^{**}$			
<i>Delay of gratification task</i>			
Step 1			
Maternal education	-0.70	.12	-0.23**
$R^2 = 0.06^{**}$			
Step 2			
Maternal education	-0.56	0.12	-0.19**
Attention problems 54 months	0.33	0.05	0.26**
$\Delta R^2 = 0.07^{**}$			
Step 3			
Maternal education	-0.47	0.12	-0.16**
Attention problems 54 months	0.31	0.05	0.24**

Predictor	β	$SE \beta$	β
Delay of gratification task	-0.41	0.10	-0.17**
$\Delta R^2 = 0.03^{**}$			

Note. CPT = Continuous Performance Task, ADHD = attention deficit/hyperactivity disorder.

**
 $p < .01$.

**
 $p < .05$.

Table 6

Hierarchical Regression: Predicting DBD ADHD Score at Third Grade from Behavioral Inhibition at 54 Months

Predictor	β	SE β	β
<i>CPT commission errors</i>			
Step 1			
Maternal education	-1.03	0.17	-0.23**
Sex	-4.12	0.82	-0.19**
$R^2 = 0.09^{**}$			
Step 3			
Maternal education	-0.77	0.17	-0.17**
Sex	-3.82	0.79	-0.18
Attention problems 54 months	0.49	0.07	0.27**
$\Delta R^2 = 0.07^{**}$			
Step 4			
Maternal education	-0.61	0.17	-0.14**
Sex	-2.96	0.79	-0.14
Attention problems 54 months	0.42	0.70	0.23**
CPT commission errors	1.04	0.20	0.20**
$\Delta R^2 = 0.04^{**}$			
Step 5			
Maternal education	-0.61	0.17	-0.14**
Sex	-2.74	0.81	-0.13**
Attentional problems 54 months	0.41	0.07	0.22**
CPT commission errors	0.85	0.26	0.17**
Sex $\times$ CPT commission errors	0.42	0.38	0.06
$\Delta R^2 = 0.002$			
<i>Delay of gratification task</i>			
Step 1			
Maternal education	-0.98	0.18	-0.22**
$R^2 = 0.05^{**}$			
Step 2			
Maternal education	-0.75	0.18	-0.17**
Attention problems 54 months	0.55	0.07	0.29**
$\Delta R^2 = 0.08^{**}$			
Step 3			
Maternal education	-0.61	0.18	-0.14**
Attention problems 54 months	0.52	0.07	0.27**

Predictor	β	$SE \beta$	β
Delay of gratification task	-0.62	0.14	-0.17**
$\Delta R^2 = 0.03^{**}$			

Note. CPT = Continuous Performance Task.

**
 $p < .01$.