The Role of Executive and Motivational Laboratory Tasks in the Assessment of Externalizing and Internalizing Problems in ADHD-C and Non-ADHD-C Youth

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science

In

Psychology

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April 28, 2006

Blacksburg, VA

Keywords: ADHD, Laboratory Tasks, Executive, Motivational, Externalizing, Internalizing

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(ABSTRACT)

The current study utilized laboratory tasks (Conners' Continuous Performance Test, CPT; Behavioral Inhibition Task, BIT) to examine the relationships among motivation, executive functioning, and parent and teacher-reported attention, internalizing, and externalizing problems in a clinical sample of 132 children with or without Attention-Deficit/Hyperactivity Disorder, Combined Type (ADHD-C; 69% male, mean age = 9.88). Specificity was examined through total, unique, and interactive effects via hierarchical regression. Higher CPT scores (i.e., executive disinhibition) were related to greater externalizing problems in total and unique effect analyses, while a relationship between lower CPT scores (i.e., executive inhibition) and greater internalizing problems was found only in unique effect analyses. No significant effects were found for motivational inhibition (i.e., low BIT) or disinhibition (i.e., high BIT). ADHD-C was associated with greater attention and externalizing problems in total effect analyses, but only externalizing problems showed a significant relationship in unique effect analyses. Interactive effects were found for ADHD-C and executive functioning, as lower levels of CPT (i.e., executive inhibition) coupled with ADHD-C resulted in greater parent-reported attention problems. In addition, higher CPT scores (i.e., executive disinhibition) were associated with greater parent-reported externalizing problems in Non-ADHD-C children. Although some main effects were predicted, the interactive effects were somewhat surprising, particularly in relation to ADHD-C, executive inhibition, and parent-reported attention problems. Exploratory analyses revealed that this effect may have been due to greater internalizing problems in ADHD-C children at lower levels of CPT (i.e., executive inhibition). Results are discussed in relation to past studies and laboratory task validity.

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Introduction

In the fields of clinical child psychology and psychiatry, Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most controversial childhood disorders (Diller, 1998), although strong evidence supports the validity of the diagnosis (Barkley, 1998; Hinshaw & Park, 1999; Lahey & Willcutt, 2002) and its subtypes (Lahey et al., 1994, 1998). At the same time, this skepticism may be warranted, as the etiological processes underlying ADHD are not well understood. Research has demonstrated that ADHD has a strong neurobiological basis (Faraone & Biederman, 1998), but the core of these neurobiological deficits remains unclear. ADHD has been viewed at varying times as a disorder of motivation (Quay, 1988), self-regulation (Douglas, 1988, 1989), response inhibition (Barkley, 1997), arousal (Sergeant, Oosterlaan, & van der Meere, 1999), and more recently, disinhibition (Nigg, 2001). Although studies have found group differences (e.g., ADHD vs. controls) for each of these neuropsychological deficits, these findings can be misleading, since not all children with ADHD exhibit deficits in these areas. Indeed, heterogeneity in neuropsychological functioning in ADHD children has been the rule, in opposition to the historical hypothesis of a universal deficit. Given the heterogeneous nature of ADHD, it may be that a universal deficit does not exist and that an ADHD profile may involve deficits in a single area or a combination of areas. For example, in a review of executive functioning deficits in ADHD children, Nigg, Willcutt, Doyle, & Sonuga-Barke (2005) found that only 35% - 50% of cases with ADHD, Combined Type (ADHD-C) have response inhibition deficits (one aspect of executive functioning).

This heterogeneity in neuropsychological profiles is also compounded by significant differences in comorbidity or co-occurring symptomatology. For example, 42% - 93% of ADHD children also meet criteria for another externalizing disorder (e.g., Oppositional Defiant Disorder (ODD) or Conduct Disorder (CD)), and 13% to 50% of ADHD children also meet criteria for an internalizing disorder (Jensen, Martin, & Cantwell, 1997). In addition, comorbidity rates in clinical samples are often higher than those in the general population. Such a finding may be due to referral biases such as Berksonian bias or clinical selection bias (Lilienfeld, 2003), but at the same time, substantive reasons for the comorbidities cannot be ignored, such as one disorder causing a second disorder or overlap between etiological or diagnostic features (American Psychiatric Association, 1994).

In addressing the effect of comorbidity, recent analyses from the Multimodal Treatment Study of Children with ADHD (MTA) have found that comorbid subtypes of ADHD-C may be sufficiently distinct to warrant classification as different from “pure” ADHD (Jensen et al., 2001). Jensen et al. (2001) have proposed the following subtypes as distinct enough to warrant classification as different from “pure” ADHD: ADHD co-occurring with internalizing disorders but without disruptive disorders, ADHD co-occurring with ODD/CD but no anxiety, and ADHD co-occurring with ODD/CD and anxiety. It should be noted, though, that such classifications are only beginning to emerge and future research will need to determine whether these subtypes are etiologically distinct enough to warrant separate diagnoses (e.g., ADHD-C vs. ADHD, Inattentive Type (ADHD-I)). Until then, it is clear that these different profiles exist and that future research will be needed to explore relevant etiological differences in each of these types.

Given the differences in both neuropsychological performance and symptomatology, it is difficult to determine how one should proceed in the study of ADHD. As noted by Nigg et al. (2005), studies to date have relied primarily on exploring performance between groups. It may be that predicting symptomatology from performance would allow for a better understanding of how neuropsychological functioning relates to symptomatology. Such an approach would still require a theory to guide predictions. Although the various theories of ADHD each offer a unique perspective, the most recent theory of disinhibition (Nigg, 2001) seems to offer a valuable and conceptually sound approach. This theoretical view emphasizes disinhibition in two domains in ADHD: Executive functioning and motivation. Although there is evidence for deficits in both executive functioning (Barkley, 1997) and motivation (Quay, 1988) in ADHD, not all children with ADHD exhibit deficits in these domains (Daugherty, Quay, & Ramos, 1993; Nigg et al., 2005). At the same time, these areas have been extensively researched in both ADHD and other domains (e.g., temperament research), making them an ideal place to start in exploring the heterogeneity in ADHD neuropsychological functioning. In addition, these two areas appear to play key roles in disorders other than ADHD. For example, temperament researchers have emphasized that particular combinations of reactivity (i.e., motivational influences) and effortful control (i.e., executive functioning) may account for other childhood disorders (e.g., Conduct Disorder, Anxiety) as well as the complex comorbid profiles found in many children (Derryberry & Reed, 1994). Although the temperament literature and ADHD literature have evolved seemingly independently, the integration of these areas may prove invaluable in understanding the multiple developmental pathways that exist for ADHD children (Nigg, Goldsmith, & Sachek, 2004).

Utilizing the current theory of disinhibition in ADHD, the following sections will review the evidence for motivational and executive deficits. In addition, literature that has attempted to integrate these two neuropsychological processes will be reviewed. Finally, the current study will be presented as an attempt to test hypotheses stemming from an integrative view of executive functioning and motivation.

<u>ADHD and Motivation</u>

In one of the most highly regarded models of motivational behavior, Gray (1982) has proposed that three distinct motivational systems interact to influence behavior. The most widely studied of these systems are the Behavioral Approach System (BAS) and the Behavioral Inhibition System (BIS). According to the theory, the BAS is a reward or approach system that is activated by positive incentives (e.g., internal or external cues associated with reward) that, in turn, activate approach behavior. In contrast, the BIS is an avoidance system that is activated by fear or punishment and results in avoidance behavior.

Although this theory was not originally applied to child psychopathology, Quay (1988) became a proponent of using these systems to explain various risks for child psychopathology. Specifically, Quay proposed that the relative influences of these systems interact to predispose an individual to different forms of psychopathology. In relation to ADHD, Quay argued that the fundamental deficit in ADHD is an underactive BIS. Conversely, others have proposed that an overactive BAS may account for the inhibition failure (Frick, Lilienfeld, Ellis, Loney, & Silverthorn, 1999). Motivational inhibition (BIS > BAS) can be defined as the cessation of response or behavior that is driven substantially by anxiety, uncertainty, signals of punishment, or fear (e.g., inhibition of a motor response due to anxiety or the threat of harm), whereas motivational disinhibition (BAS > BIS) can be defined as the perseveration of a response driven by cues of reward or incentive (Gray, 1982).

In response to Gray's theory, a number of laboratory tasks have been developed to measure motivation in children with psychopathology. In particular, reward dominance tasks have been studied in children with diverse psychopathologies. In a review of these tasks, Frick and Loney (2000) evaluated tasks that have been used in the assessment of aggressive and noncompliant children. Although some of the tasks reviewed are more specific to children with conduct problems, reward dominance tasks have been examined in children with ADHD and anxiety as well. One of the more popular reward dominance tasks is a card playing or door opening task known as the Behavioral Inhibition Task (BIT; O'Brien & Frick, 1996; Quay, 1988; Shapiro, Quay, Hogan, & Schwartz, 1988). Past studies of this task have shown that children with Conduct Disorder (CD) typically play longer (i.e., show greater reward dominance) than CD children with anxiety, ADHD children, anxious children, and normal controls (O'Brien & Frick, 1996). In addition, anxious children have been shown to play fewer trials than the other clinical groups (O'Brien & Frick, 1996; O'Brien, Frick & Lyman, 1994). These data support Gray's theory, as children with anxiety show greater motivational inhibition (i.e., BIS > BAS) than normal controls, while children with CD show greater motivational disinhibition (i.e., BAS > BIS).

In relation to Quay's conceptualization of ADHD (Quay, 1988), the data only partially support the prediction of an underactive BIS. For example, in one study, Daugherty et al. (1993) examined the following five groups: CD, ADHD, CD + ADHD, anxious-withdrawn, and control children. Although findings showed that children with CD exhibited greater motivational disinhibition as predicted, the non-conduct ADHD group did not differ from the control group of children. These findings fail to support Quay's model in as much as the supposedly underactive BIS of ADHD children should theoretically result in greater motivational disinhibition in the pure ADHD group in comparison to normal controls. In another study, CD/ADHD boys played more trials than CD alone boys, and CD alone boys played more trials than normal controls (Matthys, Van Goozen, de Vries., Cohen-Kettenis, & van Engeland, 1998). Interestingly, Quay's theory is supported by these data, since the combination of an underactive BIS

(ADHD characteristic) and an overactive BAS (CD characteristic) seemingly interact and potentiate task performance. These mixed results may suggest that other processes interact with motivation (e.g., executive functioning) to affect laboratory task performance in ADHD children. For example, executive disinhibition in combination with motivational disinhibition may allow greater expression of these motivational characteristics (e.g., CD + ADHD playing more trials than CD). At the same time, this finding may also be due to heterogeneity in motivational functioning in ADHD children.

ADHD and Executive Functioning

In addition to motivation, executive functioning has been studied in children with ADHD. The definition of executive function has been referred to as the regulation of a response to fit its context and the maintenance of behavior towards a specified goal (Pennington & Ozonoff, 1996). Posner, Early, Reiman, Pardo, and Dhawan (1998) have proposed that executive control occurs during the active suppression of a competing response and during novel tasks. In addition, the system is less active during tasks that are well practiced or over-rehearsed. Overall, the system controls the suppression of goal-irrelevant behavior, presumably without influences operative at the subcortical level (e.g., motivational influences such as fear), although this assumption may be problematic given that executive functioning and motivation are thought to have a reciprocal and dynamic interaction. In defining executive functioning in relation to inhibition, executive inhibition refers to the deliberate suppression of a cognition or response to achieve a later, internally represented goal (e.g., inhibiting a prepotent response to achieve a goal), whereas executive disinhibition refers to the failure to inhibit a cognition or response in pursuit of a goal (Nigg, 2001).

In a review of executive functioning deficits in ADHD children, Nigg (2001) concluded that the findings support an executive motor inhibition deficit in ADHD-C. Moreover, the findings on interference control (e.g., Stroop task) were mixed, suggesting that the data are too limited to draw firm conclusions about ADHD and cognitive inhibition or interference. This conclusion is consistent with a recent meta-analysis (van Mourik, Oosterlaan, & Sergeant, 2004) which found that the Stroop Color-Word Task does not provide strong evidence for a deficit in interference control in ADHD children. Finally, Nigg (2001) noted that there is mixed evidence for executive functioning deficits that differentiate the combined and inattentive subtypes, although it was speculated that the inattentive subtype may have greater cognitive deficits than motor response deficits. Overall, these findings suggest that there are executive functioning deficits in the combined type of ADHD, particularly related to executive motor inhibition, but future research is needed to characterize the specific aspects of executive functioning that are compromised in the inattentive and combined subtypes of this disorder.

In order to examine attentional deficits in ADHD children, researchers have developed a class of laboratory tasks known as continuous performance tests (CPTs). The CPT is based on research examining human vigilance, but the test has been applied productively to the study of ADHD as well. Until 1970, little attention was paid to the specific demands of the attentional test, but researchers have increasingly recognized that different tests place different demands on information-processing abilities and neuropsychological processes. Although CPTs serve as a class of laboratory tasks, one of the most studied of the CPTs is the Conners' Continuous Performance Test (Conners, 1994). In all CPTs, the respondent must press a key in response to a target. In this particular version of the CPT, the respondent must respond to single letters presented consecutively on a computer screen, except for the letter "X." This particular task places an emphasis on response inhibition (an executive function), as the nontarget (letter X) is relatively infrequent (i.e., 10% of trials). Although all CPT tasks tap into attentional processes, the Conner's CPT specifically includes an executive inhibition component, as the respondent is required to inhibit a prepotent response (i.e., not hitting the response button on a minority of trials). Finally, much like the laboratory tasks assessing motivation, the CPT may be affected by motivation (e.g., fatigue from length of task, boredom), but it is not hypothesized that the task primarily activates the motivational system, as it lacks an explicit reward or punishment component.

Integration of Motivation and Executive Functioning

In an integrative view of motivation and executive functioning, researchers in the field of temperament have differentiated between reactive and controlled regulatory processes suggesting that action selection can be based on a reactive process such as motivation (e.g., response to reward or fear) or a controlled process such as executive functioning or effortful control. The theory also emphasizes the interconnectedness of these processes, as Derryberry and Rothbart (1997) have argued that cortical and subcortical processes operate in a reciprocal fashion to influence behavior. More specifically, the neurobiological substrates of this system likely include connections between the basal ganglia and the prefrontal cortex. In relation to childhood disorders in general, Derryberry and Rothbart (1997) have noted that too little effortful control coupled with high approach (i.e., BAS > BIS) is likely to lead to externalizing problems and impulsivity, while too little effortful control coupled with high avoidance (i.e., BIS > BAS) is likely to lead to internalizing problems. Support for this idea has come from research studies showing that children with low effortful control exhibit internalizing behaviors (Calkins & Fox, 2002) and externalizing behaviors such as aggression and hyperactivity (Olson, Schilling, & Bates, 1999).

Although the temperament literature emphasizes the terms “effortful control” and “reactivity,” these processes are analogous to executive functioning and motivation. Rothbart and Bates (1998) define effortful control as the ability to inhibit a dominant response and activate a subdominant response. It is also thought to involve attentional control (e.g., the ability to focus and shift attention as needed) and inhibitory control (e.g., the ability to inhibit behavior appropriately). This definition of effortful control maps on to the Pennington and Ozonoff (1996) definition of executive functioning presented earlier for inhibition of a dominant response and behavior. In addition, the task used in the current study (i.e., Conners’ CPT) emphasizes attentional control and executive functioning, suggesting that the current operational definition of executive functioning maps on to the definition of effortful control.

Reactivity has also been emphasized in temperament research. This construct has often been measured in relation to traits such as Neuroticism/Negative Affectivity and Positive Affectivity/Surgency, which fit well with Gray’s theory of reactive motivational systems involving both avoidance and approach (Lonigan, Vasey, Phillips, & Hazen, 2004). Although most studies have examined reactivity using questionnaire methods, the laboratory tasks utilized in the motivational literature (e.g., BIT) can also serve as measures of these reactive motivational systems, since both the laboratory tasks and questionnaires are grounded in Gray’s motivational theory.

As noted earlier, the temperament approach has historically coexisted independently from ADHD research, but the approach may be particularly applicable in understanding the comorbidities and neuropsychological heterogeneities associated with ADHD. Nigg et al. (2004) have outlined a multiple pathway model for the development of ADHD. In this model, Nigg and colleagues note that the early onset of ADHD and the noted effects of early temperament on the development of attention regulation indicate the importance of temperament research in understanding multiple pathways in the development of ADHD. Within this model, the overarching principles are that ADHD evolves from the interaction of reactive and regulatory processes. Finally, Nigg and colleagues suggest that some children with ADHD may be impaired from reactive processes (e.g., motivation disinhibition), regulatory processes (e.g., executive disinhibition), or their combination.

Measurement of Motivation and Executive Functioning

As noted earlier, many of the temperament research studies have explored executive functioning and motivation using questionnaire measures of these constructs. Although this method has its advantages, laboratory task performance may also be useful in measuring these dimensions, particularly since such tasks serve as a more objective measure of performance. In relation to laboratory tasks in the ADHD literature, Nigg (2001) categorized the tasks used in the assessment of ADHD into executive and motivational tasks. In Nigg's discussion of executive functioning tasks used in ADHD research, the CPT was noted as a key task in the assessment of ADHD but was excluded due to concern over the interpretation of fast and slow commission errors and their relationship to disinhibition (Halperin, Wolf, Greenblatt, & Young, 1991). Although this concern is valid, it should be noted that the Conners' CPT places greater emphasis on executive inhibition, and would fit within the executive task category of "suppression of a primary (but activated or prepotent) response" (Nigg, 2001). Within the motivational task category, the card playing or door opening tasks (e.g., BIT) were also noted as tasks relevant to the assessment of ADHD. As noted earlier, the general conclusion of the review was that ADHD is unlikely to be due solely to motivational inhibitory control deficits, although suggestions were made for additional studies that could qualify this conclusion. Finally, further work to integrate the strength of impulse with the strength of inhibitory process was recommended for generating integrative accounts of ADHD.

Although laboratory tasks may involve both executive and motivational processes, these processes can be isolated due to the relative contribution of one process over the other in the various laboratory tasks. In addition, the reciprocal and dynamic influences described in the temperament literature would result in greater interactive effects, which are the primary interest in the current study. Overall, findings suggest that executive functioning may be primary in ADHD and that motivational processes may determine the particular ADHD profile. For example, if deficits in a controlled process (i.e., executive disinhibition) are coupled with a reactive process (e.g., motivational disinhibition), the combination may yield a child with attentional problems and conduct problems. While researchers have explored individual task performance in separate disorders, motivational and executive task performance and their interaction effects have not been utilized in the prediction of symptomatology.

Present Study

The current study attempts to address both the individual contributions of motivational impulse and executive functioning as well as the combined effect of these influences on behavior ratings. The dimensions of executive functioning and motivation were measured using laboratory tasks, while measures of parent and teacher-reported attention, internalizing, and externalizing problems were obtained as measures of behavior. In the context of disinhibition, internalizing problems were conceptualized as representing behavioral inhibition and externalizing problems were conceptualized as representing behavioral disinhibition. Although temperament researchers would emphasize that deficits in these processes would result in symptomatology in all children, the focus of this study was on the combination of these influences in children diagnosed with ADHD-C. In order to examine both types of children, the study compared task performance in a clinic-referred sample of both ADHD-C and Non-ADHD-C children. It is important to note that children with ADHD-I were placed within the Non-ADHD-C group along with other clinic-referred children who either did not have a diagnosis or had a diagnosis other than ADHD-C.

Thus, the present study sought to explore the relationships among motivational inhibition/disinhibition, executive inhibition/disinhibition, and behavioral inhibition/disinhibition in children with and without ADHD-C. The hypotheses for the study were as follows:

Hypothesis 1: There will be a main effect for laboratory-based motivational inhibition/disinhibition on behaviors related to motivation, such as externalizing and internalizing problems. Specifically, there will be a main effect for motivational disinhibition (i.e., higher BIT scores) on externalizing problems and a main effect for motivational inhibition (i.e., lower BIT scores) on internalizing problems. In addition, it is hypothesized that there will be a main effect for executive disinhibition (i.e., higher CPT scores) on ratings of attentional problems.

Hypothesis 2: The presence of ADHD-C will be associated with greater attention problems.

Hypothesis 3: The effect of motivation on internalizing and externalizing behaviors will be moderated by the effect of executive functioning. More specifically, executive disinhibition (i.e., high CPT) coupled with motivational disinhibition (i.e., high BIT) will be associated with greater externalizing problems, while executive disinhibition (i.e., high CPT) coupled with motivational inhibition (i.e., low BIT) will be associated with greater internalizing problems.

Since it is unclear whether the relationships between these processes and behavior ratings will be moderated by the presence of ADHD-C, no specific hypothesis is set forth regarding the effect of this variable (i.e., ADHD-C vs. Non-ADHD-C). Finally, although specific hypotheses related to age, gender, and IQ are not put forth, these effects will be controlled for in the analyses due to their potential influence on laboratory task performance and other predictors.

Method

Participants

This study utilized an existing data set collected at the Child Study Center of Virginia Tech. Participants included clinic-referred outpatient children and their parent(s) who were referred primarily by community pediatricians, family practitioners, schools, and mental health professionals. The children for this study were drawn from a larger sample of approximately 370 children referred to the clinic over the past several years. Only children who completed both of the laboratory-based measures and the parent and teacher-report measures were selected for this study. In addition, only children with DSM-IV diagnoses were included in the study. It should be noted that only maternal report was selected for this study, since the vast majority of primary parents are mothers in the current data set. In addition, children with an IQ < 80 (n = 42) and children with diagnoses of either Pervasive Developmental Disorder (n = 23) or Schizophrenia (n = 0) were excluded from the study. It should also be noted that all families were asked to discontinue stimulant medication use on the days of assessment.

Participant Characteristics

Based on the criteria indicated above, 132 children were examined: 69% of the children were male. Approximately 92% of the children were Caucasian, 4% African-American, 2% Hispanic, and the remaining 2% of some other ethnicity. Mean age of the sample was 9.88 (SD = 2.43, range = 6 – 17). Average family income was approximately $52,000 (SD = $37,000). Nine per cent of mothers did not complete high school, 22% completed high school, 26% attended college, 23% completed college, and 20% received some graduate training.

Procedure

Children and their parents presented at the clinic for a comprehensive psychoeducational assessment of the child and his or her family. In all cases, parental consent forms were completed prior to the assessment. Two clinicians were assigned to each case. One clinician interviewed the parent(s) and administered the parent and family measures, while the other clinician separately and independently completed the child assessment protocol. The full assessment typically involved three visits to the clinic for three-hour testing sessions. Clinical diagnoses (DSM-IV) were reached through a consensus assessment team meeting, utilizing a multi-informant and multi-method approach to assessment (see Grills & Ollendick, 2003, for details). The consensus meeting was chaired by a clinical child psychologist with 35 years of clinical experience, as well as the child and parent clinicians who conducted the assessment. After reaching consensus diagnoses, participants were divided based on whether a diagnosis of ADHD-C was reached. Only children meeting criteria for the combined type were categorized as "ADHD" in this study, since the research on executive and motivational functioning in ADHD stems largely from research on children with ADHD-C. As noted earlier, children meeting criteria for ADHD-I were included in the Non-ADHD-C clinical control group. This group also included those children without diagnoses and those with diagnoses different from ADHD-C. Diagnoses for both groups are presented in Table 2.

Measures

Behavioral Inhibition Task (BIT; O'Brien & Frick, 1996). As previously mentioned, reward dominance tasks have often been used to evaluate Gray's theory of motivational behavior (Daugherty & Quay, 1991; O'Brien et al., 1994). In the BIT, participants' sensitivity to punishment cues during a reward-oriented paradigm is assessed using a computerized task. Participants are told that they are competing for a prize prior to the start of the task, which purportedly serves to engage the motivational system. The exact prize depends on the number of points earned during the task. During the task, a stimulus (e.g., a playing card) appears on the screen, and the child is asked to choose whether or not to press a key to view the other side of the stimulus (e.g., a face) or to press a key to stop the game. There is a successful outcome (e.g., a happy face) or an unsuccessful outcome (e.g., a sad face) on the other side of the stimulus card. Each child begins with 50 points and a point is either added or taken away depending on the outcome of each trial. The child receives feedback about their current number of points from the number of cards shown in the upper left-hand corner of the screen. The proportion of successful outcomes across each successive 10 trials decreases from 90% to 0% over 100 trials. The optimal number of trials played is 50, and the total number of trials played serves as an index of persistent responding despite an increased ratio of punished trials (loss of point) to rewarded trials (gain of point).

Motivational inhibition/disinhibition was assessed by performance on this task, which corresponded to the total number of trials played. A higher number of trials played corresponds to higher motivational disinhibition (i.e., BAS > BIS). A fewer number of trials played corresponds to higher motivational inhibition (i.e. BIS > BAS). Since negative feedback is not given until after the first 10 trials, all subjects who completed fewer than 10 trials were removed from the current analyses (n = 5).

Conners' Continuous Performance Test (Conners, 1994). This is a 14-minute laboratory test involving the child's continuous responding to letters presented on a computer screen with 10% of the stimuli consisting of a non-target letter ('X'). This high density of target stimuli has the effect of placing more demands upon response inhibition than do traditional CPTs which typically place more demands on signal detection. The test has been used in children as young as 4 years of age, so the age range in the current study was appropriate (i.e., 6 – 17). The test has shown to be a reliable task in the assessment of ADHD, using the criteria of at least three independent investigators finding significant between-group (i.e., ADHD vs. control) differences in at least 75% of studies (Rapport, Chung, Shore, Denney, & Isaacs, 2000).

Executive functioning was assessed by CPT performance and quantified by the overall index score. The overall index score indicates attention problems derived from a weighted regression equation of variables relevant to reaction time, omission errors, and variability of responses. An overall index score greater than 11 is considered the cutoff for attention problems, so children who score higher than 11 are considered to have "failed" the CPT (Conners, 1994). For this study, higher overall index scores correspond to higher levels of executive disinhibition whereas lower scores correspond to greater executive inhibition. It should be noted that examiners either stayed in the room or watched the child's performance from the observation room. If a child started to get off task, the examiner redirected the child and if necessary went into the room to facilitate maximal performance.

Child Behavior Checklist (CBCL; Achenbach, 1991a). The CBCL is a 113-item paper and pencil questionnaire designed to be completed by parents. Parents are asked to indicate how often the behavior described in each item is true of their child using a three-point scale (often/always true, sometimes true, and not true). Additional sections allow parents to provide information regarding children's activities and friendships. The CBCL yields the following eight factors: Aggressive Behavior, Anxious/Depressed, Attention Problems, Delinquent Rule-Breaking Behavior, Social Problems, Somatic Complaints, Thought Problems, Withdrawn, and the composite scores of Externalizing, Internalizing, Total Problems, and DSM-oriented scales. Achenbach (1991a) reports test-retest reliability over a 1-week interval to be .99 for the competence scales and .95 for the problem items. Measures of behavior included in the current study were the Attention, Internalizing and Externalizing Problems subscale T-scores.

Teacher's Report Form (TRF; Achenbach, 1991b). The teacher's report form is a questionnaire that also includes 113 items to which the teacher is asked to indicate if each behavior/characteristic is often/always true, not true, or sometimes true of the student being assessed. In addition, two sections ask the teacher to provide information about the child with reference to his/her peers, one in relation to academic performance, and a second more general four-item section tapping behavior, accomplishment, and happiness in the classroom. Further, 10 additional items allow the teacher to provide information about any special classes/programs the child is involved in, length of time acquainted with the child, etc., as well as providing room for open-ended questions regarding teachers concerns/student strengths. This measure yields the same factors as the CBCL (see above). Test-retest reliability over a 15-day period is .90 for adaptive behavior scales and .95 for problem behavior scales. Measures of behavior included in the current study were the Attention, Internalizing, and Externalizing Problems subscale T-scores.

Wechsler Intelligence Scale for Children (WISC; Wechsler, 1991, 2003). The WISC is an individually administered clinical instrument for assessing the intellectual ability of children aged 6 years through 16 years and 11 months. The mean score for the Full Scale IQ (FSIQ) is 100 with a standard deviation of 15. Evidence for adequate reliability and validity of the WISC has been documented

(Wechsler, 1991; Prifitera, Saklofske, & Weiss, 2005). Given the timeframe of the study which extended over several years, the WISC-III (1991) and WISC-IV (2003) were used to assess intellectual ability.

Data Analysis

Data were initially screened for outliers with z-scores greater than 3. These variables were then converted substituting the highest score below 3 SDs and adding 1 unit to the value (Field, 2005). Hierarchical regression analyses, following Holmbeck's (1997) guidelines, were used to examine the main and interactive effects of the laboratory tasks on behavior. As recommended by Holmbeck (2002), the continuous main effect variables were centered before entering them into the model. Centering involves subtracting the sample mean from each individual score on the variable, which results in a new sample mean of zero. This procedure reduces multicollinearity between the two predictors and the interaction term between them and facilitates the testing of simple slopes (Holmbeck, 2002). It should be noted that this procedure does not alter the significance of the interaction or the values of the simple slopes.

In the analyses, age, sex, and IQ were entered in the first step, main effects in second step, the two-way interactions in the third step, and the three-way interaction in the fourth step. The analyses were conducted separately for the six dependent variables (Attention Problems T-scores [parent and teacher], Internalizing Problems T-scores [parent and teacher], and Externalizing Problems T-scores [parent and teacher]). Following Holmbeck's (1997) guidelines, moderation was deemed present if a significant interaction was found after main effects were controlled. Post-hoc probing guidelines were used to explore moderation (see Aiken & West, 1991; Holmbeck, 2002). Significant interactions found in the full model were run again in a reduced model including only the main effect variables and the interaction terms. Simple slopes were then calculated for conditional moderators by manipulating the zero-point of the variables (see Holmbeck, 2002). These slopes were then evaluated to see whether they were significantly different from zero. Only slopes significantly different from zero are reported. All analyses in the study were two-tailed and statistical significance was defined at the .05 level and the .01 level (if applicable). Given the exploratory nature of the study, it was decided to not include a correction for multiple tests.

Results

Means and standard deviations are presented in Table 1 for the full sample, the ADHD-C group, and the Non-ADHD-C group. Table 2 presents differences in diagnoses in the two groups. Bivariate correlations are reported in Table 3. The results of the hierarchical regression analyses are presented in Tables 4 – 7 and Figures 1 - 2.

ADHD-C vs. Non-ADHD-C Group Differences

One-way ANOVAs and chi-square analyses were used to compare the ADHD-C and Non-ADHD-C groups (See Tables 1 and 2). In relation to the outcome variables in the study, the ADHD-C group showed significantly higher levels of parent-reported Attention and Externalizing Problems as well as teacher-reported Attention, Internalizing, and Externalizing Problems. The ADHD-C group was also significantly younger, had lower IQs, and exhibited more difficulty on the CPT. In order to examine the percentage of each group scoring in the clinical range for the CPT, each group was divided based on CPT scores above and below 11, the clinical cutoff for the task. 63% of children in the ADHD-C group had scores in the clinical range, while 32% of Non-ADHD-C children had scores in the clinical range. BIT performance was also explored in relation to scores above and below the optimal performance point (i.e., 50 trials) as well as for those who played all trials (i.e., 100 trials). 79% of children in the ADHD-C group played more than 50 trials, while 72% of children in the Non-ADHD-C group played more than 50 trials. 18% of children in the ADHD-C group played all trials, while 23% of children in the Non-ADHD-C group played all trials. No significant between group differences were found for the BIT.

Differences in the diagnostic composition of the two groups were also explored (See Table 2). Chi-square analyses revealed significantly greater diagnoses of Dysthymia and Adjustment Disorder in the Non-ADHD-C group and greater diagnosis of ODD in the ADHD-C group.

Total Effects of Predictors on Parent-Reported Symptomatology

In the analyses presented in Table 4, age, gender (0 = male, 1 = female), and full scale IQ were examined in the first block, main effects of ADHD-C status (i.e., 0 = Non-ADHD-C, 1 = ADHD-C), CPT, and BIT variables in the second block, two-way interactions (i.e., ADHD-C x CPT, ADHD-C x BIT, and BIT x CPT) in the third block, and the three-way interaction (i.e., ADHD-C x CPT x BIT) in the fourth block.

In the prediction of CBCL dimensions, gender and ADHD-C both showed significant main effects on Attention Problems, as female gender and the presence of ADHD-C were both positively associated with Attention Problems. No main effects were noted in the prediction of Internalizing Problems. Finally, ADHD-C status and CPT performance were significantly associated with Externalizing Problems, as children with ADHD-C and children who exhibited a higher overall index score on the CPT showed greater externalizing problems.

Total Effects of Predictors on Teacher-Reported Symptomatology

In the prediction of the TRF dimensions (Table 5), the same sequence of variables was used for the regression analyses. IQ and ADHD-C both showed significant main effects on Attention Problems, as IQ was negatively associated with Attention Problems, while the presence of ADHD-C revealed a positive association. Main effects were also noted for Internalizing Problems, as the presence of ADHD-C showed a significant positive relationship. Finally, ADHD-C status and CPT performance were significantly associated with Externalizing Problems, as children with ADHD-C and children who exhibited a higher overall index score on the CPT showed greater Externalizing Problems.

Overall, both the parent-report and teacher-report data showed a somewhat consistent pattern, as the presence of ADHD-C resulted in greater Attention and Externalizing Problems. In addition, higher CPT scores were also consistently associated with greater Externalizing Problems. At the same time, some variability was noted in covariates such as gender and IQ, and only the teacher-report revealed a significant relationship between the presence of ADHD-C and Internalizing Problems. Finally, it is interesting to note that BIT performance was not significantly associated with any of the outcome variables.

Interactive Effects of Predictors on Parent-Reported Symptomatology

In order to examine the interactive effects of predictors, all two and three-way interaction terms were examined (ADHD-C x CPT, ADHD-C x BIT, BIT x CPT, and ADHD-C x CPT x BIT). Table 4 presents the interactive effects of predictors on the CBCL dimensions. In the prediction of Attention Problems, the ADHD-C x CPT term revealed a significant interactive effect. Figure 1 presents this two-way interaction. Post-hoc probing revealed that when low levels of CPT were coupled with ADHD-C, parents reported greater Attention Problems. Such a difference was not found for children without ADHD-C. No interactive effects were noted in the prediction of Internalizing Problems. Finally, the ADHD-C x CPT term was also significantly associated with Externalizing Problems. Figure 2 presents this interaction. Post-hoc probing revealed that higher CPT scores coupled with the absence of ADHD-C resulted in greater Externalizing Problems. Such a difference was not found for children with ADHD-C.

Interactive Effects of Predictors on Teacher-Reported Symptomatology

Table 5 presents the interactive effects of predictors on the TRF dimensions. In the prediction of the TRF Attention Problems, the ADHD-C x CPT x BIT term revealed a significant 3-way interactive effect. Post-hoc probing revealed that none of the slopes was significantly different from zero, so these slopes were not examined. Finally, the ADHD-C x BIT term was significantly associated with Externalizing Problems, but this term was not significant in a reduced model including the main effects and the interaction term, so post-hoc probing was not pursued for this interaction.

Overall, both analyses revealed unexpected effects, as a better CPT performance (i.e., a lower score) coupled with ADHD-C resulted in greater Attention Problems on the CBCL. At the same time, a somewhat expected effect was found for CBCL, as Non-ADHD-C children who exhibited higher scores on the CPT showed greater Externalizing Problems.

Unique Effects of Predictors on Parent-Reported Symptomatology

In order to examine the unique effects of the predictors on each behavior dimension, effects were examined by controlling for the indirect relations between the parent and teacher-report scores and the outcome variable of interest (e.g., controlling for CBCL Internalizing and Externalizing Problems in the prediction of CBCL Attention Problems).

In the analyses presented in Table 6, age, gender, and full scale IQ were examined in the first block, main effects of ADHD-C status, the other two CBCL variables, CPT, and BIT variables in the second block, two-way interactions in the third block (i.e., ADHD-C x CPT, ADHD-C x BIT, and BIT x CPT), and the three-way interaction (i.e., ADHD-C x CPT x BIT) in the fourth block.

It should first be noted that the CBCL predictors that were controlled for were significant in all analyses which was not surprising given the high correlations between the three CBCL dimensions (See Tables 3). Although some findings remained consistent with the previous set of analyses, some changes were noted. In the prediction of CBCL Attention Problems, the presence of ADHD-C was no longer significant and IQ became significant, suggesting that the presence of ADHD-C shares significant variance with the Internalizing and Externalizing Problems dimensions. Parent-reported Internalizing Problems also revealed a new significant main effect, as CPT was negatively associated with Internalizing Problems. Finally, only one change was noted for Externalizing Problems, as the ADHD-C x CPT term was no longer significant.

<u>Unique Effects of Predictors on Teacher-Reported Symptomatology</u>

Analyses for unique effects on the TRF are presented in Table 7. Much like the CBCL analyses, both of the TRF dimensions that were controlled for in each analysis were significant. In the prediction of Attention Problems, the presence of ADHD-C was no longer significant, suggesting again that the presence of ADHD-C shares significant variance with the Internalizing and Externalizing Problems dimensions. For Internalizing Problems, the presence of ADHD-C became nonsignificant and the CPT became significantly and negatively associated with Internalizing Problems (similar to CBCL findings). In addition, a significant BIT x CPT interaction emerged. Post-hoc probing revealed that neither slope was significantly different from zero. Finally, the analyses conducted on Externalizing Problems revealed the same pattern as the previous analyses, except that gender became significant (greater Externalizing Problems for males) and the ADHD-C x BIT interaction was nonsignificant.

Some general patterns emerged from the unique effect analyses. ADHD-C became nonsignificant for both parent and teacher-reports of Attention and Internalizing Problems, suggesting a strong relationship between the CBCL/TRF variables and ADHD-C for these two dimensions. CPT performance also showed a new relationship, as lower CPT scores became significantly related to Internalizing Problems. The findings showed that lower CPT scores were associated with greater Internalizing Problems. Such a finding could explain the unexpected finding that lower CPT scores in ADHD-C children were associated with greater Attention Problems. In addition, demographic variables could also explain the differences. A series of exploratory analyses were undertaken to explore this potential effect.

Exploratory Analyses

The first analysis predicted parent-reported Attention Problems, since it showed an unexpected effect. The same main effects and interaction terms used earlier were involved in the analyses, but the new variable of Internalizing Problems was used in order to understand the relationship presented in Figure 1. Age, gender, and full scale IQ were examined in the first block, main effects of ADHD-C status, Internalizing Problems, and CPT variables in the second block, two-way interactions in the third block (i.e., ADHD-C x CPT, ADHD-C x Internalizing, and CPT x Internalizing), and the three-way interaction (i.e., ADHD-C x CPT x Internalizing) in the fourth block. In addition, these analyses were run twice, as parent and teacher-reported Internalizing Problems were controlled in separate analyses for the same outcome variable (e.g., parent-reported Internalizing Problems controlled for in one analysis of parent-reported Attention Problems, and teacher-reported Internalizing Problems controlled for in the other analysis of parent-reported Attention Problems). No significant interaction effects were found in these analyses. This analytic approach was also used to explore age, gender, and IQ interactions. Once again, no interactions were found to be significant.

The second analysis compared mean levels (via one-way ANOVA) of parent and teacher-reported Internalizing and Externalizing Problems for the Low CPT/ADHD-C group (i.e., 1 SD below the CPT mean for ADHD-C children) vs. High CPT/ADHD-C group (i.e., 1 SD below the CPT mean for ADHD-C children) in the interaction (i.e., ADHD-C x CPT for CBCL Attention Problems, Figure 1). The results revealed no significant differences. It should be noted that the Low CPT/ADHD-C group revealed nonsignificantly higher levels of Internalizing Problems than the High CPT/ADHD-C group at nonsignificant levels for both parent and teacher reports. Although again non-significant, Attention Problems were also higher for the teacher report for the Low CPT/ADHD-C group in comparison to the High CPT/ADHD-C group, suggesting that this finding of greater Attention Problems in the Low CPT/ADHD-C group was consistent across reporters.

Discussion

The present study utilized laboratory tasks to examine the relationship between motivation and executive functioning in predicting parent and teacher-reported behavior problems. Although similar examinations have occurred in both clinical and non-clinical samples using questionnaire methods, this study is the first to explore the relationships between motivation and executive functioning using laboratory tasks in ADHD-C and Non-ADHD-C children in a clinical sample.

Overall, the results present a mixed picture in relation to predicted relationships. The pattern of main effects was generally consistent with the predicted relationships. While ADHD-C was predicted to have a significant relationship with attention problems, the significant relationships with internalizing and externalizing problems were not predicted. At the same time, this finding is not that surprising, as 13% to 51% of children with ADHD also meet criteria for an internalizing disorder and 42 % - 93% of ADHD children also meet criteria for another externalizing disorder (Jensen et al., 1997). The CPT findings also fit somewhat with the hypotheses, as children with externalizing problems (i.e., behavioral disinhibition) showed significantly more difficulty on the CPT (i.e., executive disinhibition). It should be noted that this finding differs from a study that found no relationship between the Conners' CPT overall index score and CBCL and TRF reports of internalizing and externalizing problems (McGee, Clark, & Symons, 2000). It may be that the current sample includes more externalizing children in the ADHD-C group than in the former study. In fact, Tables 1 and 2 show that this group exhibited significantly more externalizing problems than the Non-ADHD-C group based on both parent and teacher-reports and greater diagnosis of ODD. A negative relationship between CPT and internalizing Problems was also found, although it was not predicted. This finding does fit with some past research showing less impulsivity on the CPT in ADHD children with anxiety (Pliszka, 1992). Anxiety should be an important factor in the future study of CPTs, as one study suggested that physiological anxiety has an inhibitory effect on performance during the Conners' CPT, while cognitive anxiety has a disinhibitory effect (Epstein, Goldberg, Conners, & March, 1997). It is unclear what types of anxiety children were experiencing in this study, but heightened physiological anxiety could have accounted for the negative relationship between the CPT and internalizing problems.

Although the current study sought to explore main effects in the clinical sample, the main purpose of the study was to explore the interactive effects between motivation and executive functioning for ADHD-C and Non-ADHD-C children (i.e., the BIT x CPT and ADHD-C x CPT x BIT interaction terms). Examination of the two and three-way interaction terms revealed some interesting and, for the most part, unexpected patterns. One of the strongest interaction effects was the ADHD-C x CPT term for both attention and externalizing problems. This interaction term was only significant for parent-reported dimensions, and in addition, the effect was nonsignificant in the unique effects analysis for externalizing problems. In turn, it seems that the effect may be stronger for parent-reported attention problems. Figure 1 reveals that lower CPT scores (i.e., executive inhibition) coupled with the presence of ADHD-C resulted in greater attention problems than higher CPT scores (i.e., executive disinhibition) coupled with the presence of ADHD-C. This effect was unexpected, since it was predicted that ADHD-C children would show more attentional problems when executive disinhibition (i.e., high CPT) was present. Interestingly, Table 1 shows that ADHD-C children have significantly higher scores on the CPT than the Non-ADHD-C group in general. It seems that the presence of ADHD-C coupled with a lower CPT score is a special case of ADHD-C that may result in greater attentional problems. One possible explanation for this finding is that ADHD-C children with lower CPT scores exhibit greater internalizing problems, which would potentially serve to exacerbate attentional problems. Exploratory analyses addressing this possibility did not show a significant trend for greater internalizing problems at lower levels of CPT in ADHD-C children. Finally, age, gender, and IQ were also examined in order to understand this interaction, but no significant interaction among ADHD-C, CPT, and the demographic variable of interest was found. Analyses of groups at 1 SD above and below the mean CPT score in ADHD-C children revealed nonsignificantly higher internalizing problems at the low level of CPT (i.e., 1 SD below the mean) compared to the high level of CPT (i.e., 1 SD above the mean).

Overall, the pattern of main effects presented in this study was somewhat consistent with the predicted effects, although exploration of the interaction terms revealed that many of the main effects were moderated by other variables. In addition, these moderational relationships were often unexpected. The predicted relationships between reactive (i.e., motivation) and regulatory (i.e., executive functioning) processes and internalizing and externalizing problems have been found using questionnaires (Eisenberg et al., 2001; Lonigan et al., 2004) but findings related to significant interaction terms have been mixed (Muris, De Jong, & Engelen, 2004). In this study, a main effect for executive disinhibition was found for parent and teacher-reported externalizing problems, but an opposite effect was found for internalizing problems (i.e., greater executive inhibition). No main effects were found for motivational inhibition/disinhibition and no significant interaction effects were found at the level of simple slopes. The lack of replicability in this study is surprising, but it may be that laboratory tasks lack the specificity and sensitivity to measure dimensions of executive functioning/effortful control and motivation/reactivity. Although laboratory tasks have been considered valuable in the assessment of psychopathology, a review of the clinical utility of such tasks revealed that current laboratory tasks lack the sensitivity, specificity, and incremental validity to make diagnostic decisions alone or in combination with standard clinical procedures (Frick, 2000). The special section led by Frick also included an assessment of laboratory tasks and ADHD. Rapport et al. (2000) categorized only five tasks as reliable in the assessment of ADHD: Continuous Performance Tests (CPTs), Stop Signal tasks, WISC-R Arithmetic, WISC-R Coding, and Visual Recall (Miscellaneous). More specifically, the review categorized reliable instruments as those studied by at least three independent investigators that yielded statistically significant between-group differences (i.e., ADHD vs. normal controls) in at least 75% of studies. Overall, visual CPTs were found to show significant group differences in 86% of the studies surveyed. Although this strong group effect has been replicated across studies, little attention has been paid to within group differences. For example, data in Table 1 show that only 63% percent of children in the current study were impaired on the CPT (scores > 11) and the effect size for ADHD-C vs. Non-ADHD-C was in the medium range at .11. In comparison, a study by Nigg et al. (2005) showed that between 16% and 37% of ADHD children scored beyond the control group at the 90th percentile. In addition, the CPT effect size varied from .01 - .11 (η^2). While the current study showed a CPT effect size of .11 for ADHD-C vs. Non-ADHD-C, analyses at high and low levels of CPT showed that parent-reported attention problems were higher for ADHD-C children at lower levels of CPT. Interestingly, this finding did not apply to Non-ADHD-C children. As noted earlier, this difference could possibly be explained by differences in internalizing problems (i.e., greater internalizing problems at lower levels of CPT in ADHD-C children).

Only one study to date has examined “false negatives” on a CPT. Using the Gordon Diagnostic System (GDS) Vigilance Task (VT), Fisher, Newby, and Gordon (1995) compared ADHD children who scored above the 93rd percentile on the CPT to those who scored below this point. Overall, the authors found that the “normal” CPT group showed less inattention and more conduct and psychosomatic problems according to the Conners’ Parent and Teacher Rating Scales, but it should be noted that no differences were found on the CBCL (Internalizing and Externalizing) or the CBCL-T (precursor to TRF) Internalizing, Externalizing, and Inattentive factors. Although this study provides some information about within ADHD CPT differences, the CPT task in the Fisher et al. study differs from that used in the current study, as it used a task that relies less on response inhibition. Future studies will need to explore ADHD children who score at lower levels on the CPT.

In relation to the BIT, it was surprising that no main effect relationships were found for this task, although BIT x CPT and ADHD x CPT x BIT relationships were noted. In relation to the interactional hypotheses of the study, no support was found for the hypothesis proposed by Derryberry and Reed (1994), which proposes that too little effortful control coupled with high approach (i.e., BAS > BIS) is likely to lead to externalizing problems and impulsivity, while too little effortful control coupled with high avoidance (i.e., BIS > BAS) is likely to lead to internalizing problems. There are potentially a number of reasons why these relationships were not found, but the major reason seems to be whether laboratory task performance adequately maps onto the constructs of executive functioning/effortful control and reactivity/motivation. In the current study, CPT performance was negatively associated with internalizing problems, suggesting that lower scores on the CPT are associated with greater internalizing problems. It may be that CPT performance is not clearly tapping effortful control, since the CPT may not serve as a strong enough stimulus to evoke the level of anxiety necessary for effortful control to be measured. In turn, anxiety may simply work to facilitate task performance through enhanced vigilance. This hypothesis is consistent with findings from Epstein et al. (1997) who found that children who reported physiological anxiety reported less impulsivity on the task. At the same time, this study also found that children who reported cognitive anxiety were more disinhibited and impulsive on this task. It may be that effortful control would be more adequately measured in the latter case more than the former. When faced with a task that evokes cognitive anxiety (e.g., worrying about performance), this anxiety may be stronger and more cognitively taxing, which would have greater implications for effortful control. As noted earlier, it is unclear what type of anxiety children experienced in this study, but it will be important for future laboratory-based measures to take into the account the influence of anxiety and whether anxiety is evoked in the experimental procedure. Measures could include child-reported state and trait anxiety ratings.

The validity of the BIT has also been questioned, as noted in the mixed data presented in the introduction. Some statistics from the current study suggest that the BIT may be unusual in the current sample. A number of past studies have reported the mean level of trials played as well as the percentage of children who played all trials. In the study by Daugherty et al. (1993), for example, 50% of CD children played all trials, while 18% of all other groups played all trials. In the current study, 18% of the ADHD-C children played all trials and 23% on Non-ADHD-C children played all trials. Since ADHD was included in “all other groups” in the Daugherty et al. (1993) study, this statistic seems comparable. Differences do seem to emerge more at the mean level of trials. Shapiro et al. (1988) found a mean of 78.3 for CD children and 47.5 for the comparison group with sub-clinical CD T-scores from the Revised

Behavior Problem Checklist (RBPC). It should be noted, though, that all children were selected from a group of “seriously emotionally disturbed students.” In the Matthys et al. (1998) study, CD children played 71.2 trials, while the normal control group played 57.9 trials and the CD/ADHD group played 93.6 trials. In the current study, the ADHD-C group played 75.65 trials and the Non-ADHD-C group played 69.44 trials. These levels are close to the levels for CD children reported in the other studies. Since our sample includes only one child with a diagnosis of CD, these data raise concerns about the BIT used in the current study and whether the motivational system was activated in the same way as in previous studies.

Limitations of the current study include a local and clinical sample that included only a small percentage of minority families and females. Another potential confound is the fact that the CPT was used as one of the sources of information in making diagnostic decisions during consensus team meetings. Such a strategy may have resulted in an overestimate of the relationship between ADHD diagnosis and CPT performance. Finally, the overall index score was used as a measure of executive disinhibition. It is unclear whether other CPT indices would be more valuable in measuring this construct.

Future studies should work to more clearly understand executive functioning/effortful control and reactivity/motivation. Although these terms are described as analogous in the literature, it is unclear as to how similarly they are conceptualized by the various research fields. It will be important to further clarify these constructs and develop tasks that clearly measure these constructs. Although laboratory tasks are often thought to measure theoretical constructs, it is clear that additional processes affect task performance (e.g., anxiety during the CPT, response inhibition or IQ deficits on the BIT). Although the current study did not find the predicted relationships between task performance and symptomatology, the temperament framework is only beginning to be applied to ADHD research. Future research will hopefully yield more fruitful results when more carefully designed laboratory tasks are developed to measure reactive and regulatory processes in ADHD children. A final challenge for this marriage between temperament and ADHD will be to understand the processes involved in ADHD children who exhibit both internalizing and externalizing problems. Motivational reactivity is often described in approach/avoidance terms, but it clear that these internalizing and externalizing children are experiencing both types of reactivity often in concert with executive disinhibition. Future studies will need to work to more clearly understand this highly complex group.

References

Achenbach, T. M. (1991a). *Manual for the Child Behavior Checklist 4-18 and 1991 profile.* Burlington, VT: University of Vermont, Department of Psychiatry.

Achenbach, T. M. (1991b). *Manual for the Teacher's Report Form and 1991 profile.* Burlington, VT: University of Vermont, Department of Psychiatry.

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Press.

Barkley, R.A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*, 65-94.

Barkley, R.A. (1998). *Attention-deficit/hyperactivity disorder: A handbook for diagnosis and treatment* (2nd ed.). New York: Guilford Press.

Calkins, S.D., & Fox, N.A. (2002). Self-regulatory processes in early personality development: A multilevel approach to the study of childhood social withdrawal and aggression. *Development and Psychopathology, 14,* 477 – 498.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Conners, C. K. (1994). *The Conners Continuous Performance Test.* Toronto, Canada: Multi-Health Systems.

Daugherty, T. K., & Quay, H. C. (1991). Response perseveration and delayed responding in childhood behavior disorders. *Journal of Child Psychology & Psychiatry, 32,* 453-461.

Daugherty, T. K., Quay, H. C., & Ramos, L. (1993). Response perseveration, inhibitory control, and central dopaminergic activity in childhood behavior disorders. *Journal of Genetic Psychology, 154,* 177-188.

Derryberry, D., & Reed, M. A., (1994). Temperament and the self-organization of personality. *Development and Psychopathology, 6*, 653-676.

Derryberry, D., & Rothbart, M. K. (1997). Reactive and effortful processes in the organization of temperament. *Development and Psychopathology, 9*, 633 – 652.

Diller, L. H. (1998). *Running on Ritalin.* New York: Bantam Books.

Douglas, V. I. (1988). Cognitive deficits in children with attention deficit disorder with hyperactivity. In L. M. Bloomingdale & J. Sergeant (Eds.), *Attention deficit disorder: Criteria, cognition, and intervention* (pp. 65–81). New York: Pergamon Press.

Douglas, V. I. (1989). Can Skinnerian theory explain attention deficit disorder? A reply to Barkley. In L. M. Bloomingdale & J. Swanson (Eds.), *Attention deficit disorder: Current concepts and emerging trends in attentional and behavioral disorders of childhood* (pp. 235 – 254). New York: Pergamon Press.

Eisenberg, N., Cumberland, A., Spinrad, T.L., Fabes, R.A., Shepard, S.A., Reiser, M., Murphy, B.C., Losoya, S.H., & Guthrie, I.K. (2001). The relations of regulation and emotionality to children's externalizing and internalizing behavior problems. *Child Development, 72*, 1112 – 1134.

Epstein, J.N., Goldberg, N.A., Conners, C.K., & March, J.S. (1997). The effects of anxiety on continuous performance test functioning in an ADHD clinic sample. *Journal of Attention Disorders, 2,* 45 – 52.

Faraone, S. V., Biederman, J. (1998). Neurobiology of attention deficit hyperactivity disorder. *Biological Psychiatry, 44*, 951-958.

Field, A. (2005). *Discovering statistics using SPSS* (2nd edition). London: Sage.

Fisher, M., Newby, R., & Gordon, M. (1995). Who are the false negatives on Continuous Performance Tests? *Journal of Clinical Child Psychology, 24,* 427-433.

Frick, P. J., Lilienfeld, S. O., Ellis, M., Loney, B., & Silverthorn, P. (1999). The association between anxiety and psychopathy dimensions in children. *Journal of Abnormal Child Psychology, 27,* 383-392.

Frick, P.J. (2000). Laboratory and performance-based measures of childhood disorders: Introduction to special section. *Journal of Clinical Child Psychology, 29*, 475-478.

Frick, P. J., & Loney, B. R. (2000). The use of laboratory and performance-based measures in the assessment of children and adolescents with conduct disorders. *Journal of Clinical Child Psychology, 29*, 540-554.

Gray, J. A. (1982). *The neuropsychology of anxiety: An enquiry into the function of the septo-hippocampal system.* Oxford: Oxford University Press.

Grills, A.E., & Ollendick, T.H. (2003). Multiple informant agreement and the Anxiety Disorders Interview Schedule for Parents and Children. *Journal of the American Academy of Child and Adolescent Psychiatry, 42,* 30-40.

Halperin, J. M., Wolf, L. E., Greenblatt, E. R., & Young, G. (1991). Subtype analysis of commission errors on the continuous performance test in children. *Developmental Neuropsychology, 7*, 207 – 217.

Hinshaw, S. P., & Park, T. (1999). Research issues and problems: Toward a more definitive science of disruptive behavior disorders. In H. C. Quay & A. E. Hogan (Eds.), *Handbook of disruptive behavior disorders* (pp. 593-620). New York: Plenum Press.

Holmbeck, G. N. (1997). Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures. *Journal of Consulting and Clinical Psychology. 65*, 599-610.

Holmbeck, G. N. (2002). Post-hoc probing of significant moderational and mediational effects in studies of pediatric populations. *Journal of Pediatric Psychology, 27*, 87-96.

Jensen, P. S., Hinshaw, S.P., Kraemer, H.C., Lenora, N., Newcorn, J.H., Abikoff, H.B., et al. (2001). ADHD comorbidity findings from the MTA study: Comparing comorbid subgroups. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 147-158.

Jensen, P. S., Martin, D., & Cantwell, D. P. (1997). Comorbidity in ADHD: Implications for research, practice, and DSM-IV. *Journal of American Academy of Child and Adolescent*

Psychiatry, 36, 1065 – 1079.

Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., et al. (1994). DSM-IV field trails for attention deficit/hyperactivity disorder in children and adolescents. *American Journal of Psychiatry, 151*, 1673-1685.

Lahey, B. B., Pelham, W. E., Stein, M. A., Loney, J., Trapani, C., Nugent, K., et al. (1998). Validity of DSM-IV attention-deficit/hyperactivity disorder for younger children. *Journal of the American Academy of Child and Adolescent Psychiatry, 37*, 695-702.

Lahey, B. B., & Willcutt, E. (2002). The validity of attention-deficit/hyperactivity disorder among children and adolescents. In P. S. Jensen & J. R. Cooper (Eds.), *Diagnosis and treatment of attention deficit hyperactivity disorder: An evidence-based approach* (pp. 1–23) New York: Civic Research Institute.

Lilienfeld, S. O. (2003). Comorbidity between and within childhood externalizing and internalizing disorders: Reflections and directions. *Journal of Abnormal Child Psychology, 31,* 285-291.

Lonigan, C. J., Vasey, M. W., Phillips, B. M., & Hazen, R. A. (2004). Temperament, anxiety, and the processing of threat-relevant stimuli. *Journal of Clinical Child & Adolescent Psychology, 33,* 8-20.

Matthys, W., Van Goozen, S. H. M., de Vries, H., Cohen-Kettenis, P. T., & van Engeland, H. (1998). The dominance of behavioural activation over behavioural inhibition in conduct disordered boys with or without attention deficit hyperactivity disorder. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39*, 643 – 651.

McGee, Clark, & Symons (2000). Does the Conners' Continuous Performance Test aid in ADHD diagnosis? *Journal of Abnormal Child Psychology, 28,* 415 – 424.

Muris, P., De Jong, P.J., & Engelen, S. (2004). Relationships between neuroticism, attentional control, and anxiety disorders symptoms in non-clinical children. *Personality and Individual Differences, 37,* 789 – 797.

Nigg, J. T. (2001). Is ADHD a disinhibitory disorder? *Psychological Bulletin, 127*, 571-598.

Nigg, J. T., Goldsmith, H. H., & Sachek, J. (2004). Temperament and attention deficit hyperactivity disorder: The development of a multiple pathway model. *Journal of Clinical Child and Adolescent Psychology, 33,* 42-53.

Nigg, J. T., Willcutt, E.G., Doyle, A.E., & Sonuga-Barke, E. J. S. (2005). Causal heterogeneity in attention-deficit/hyperactivity disorder: Do we need neuropsychologically impaired subtypes? *Biological Psychiatry, 57,* 1224-1230.

O'Brien, B. S., & Frick, P. J. (1996). Reward dominance: Associations with anxiety, conduct problems, and psychopathy in children. *Journal of Abnormal Child Psychology, 24,* 223-240.

O'Brien, B. S., Frick, P. J., & Lyman, R. D. (1994). Reward dominance among children with disruptive behavior disorders. *Journal of Psychopathology & Behavioral Assessment, 16,* 131-145.

Olson, S.L., Schilling, E.M., & Bates, J.E. (1999). Measurement of impulsivity: Construct coherence, longitudinal stability, and relationship with externalizing problems in middle childhood and adolescence. *Journal of Abnormal Child Psychology, 27,* 151 – 165.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*, 51–87.

Pliszka, S.R. (1989). Effect of anxiety on cognition, behavior, and stimulant response in ADHD. *Journal of the American Academy of Child and Adolescent Psychiatry, 28,* 882- 887.

Posner, M. I., Early, T. S., Reiman, E., Pardo, P. J., & Dhawan, M. (1988). Asymmetries in hemispheric control of attention in schizophrenia. *Archives of General Psychiatry, 45*, 814 - 821.

Prifitera, A., Saklofske, D. H., & Weiss, G. (2005). *WISC-IV: Clinical use and interpretation*. New York: Elsevier Science.

Quay, H.C. (1988). Attention-deficit disorder and the behavioral inhibition system: The relevance of the neuropsychological theory of Jeffrey A. Gray. In L. M. Bloomingdale &

J. Sergeant (Eds.), *Attention-deficit disorder: Criteria, cognition, and intervention* (pp. 117–126). New York: Pergamon Press.

Rapport, M. D., Chung, K. M., Shore, G., Denney, C. B., Isaacs, P. (2000). Upgrading the science and technology of assessment and diagnosis: Laboratory and clinic-based assessment of children with ADHD. *Journal of Clinical Child Psychology, 29,* 555-568.

Rothbart, M.K. & Bates, J.E. (1998). Temperament. In N. Eisenberg & W. Damon (Eds.), *Handbook of child psychology: Volume 3. Social, emotional, and personality development* (pp. 105 – 176). New York: Wiley.

Sergeant, J. A., Oosterlaan, J., & van der Meere, J. (1999). Information processing and energetic factors in attention-deficit/hyperactivity disorder. In H. C. Quay & A. E. Hogan (Eds.), *Handbook of disruptive behavior disorders* (pp. 75 – 104). New York: Plenum.

Shapiro, S. K., Quay, H. C., Hogan, A. E., & Schwartz, K. P. (1988). Response perseveration and delayed responding in undersocialized aggressive conduct disorder. *Journal of Abnormal Psychology, 97*, 371-373.

van Mourik, R., Oosterlaan, J., Sergeant, J. A. (2005). The Stroop revisited: a meta-analysis of interference control in AD/HD. *Journal of Child Psychology and Psychiatry, 46*, 150 – 165.

Wechsler, D. (1991). *Manual for the Wechsler Intelligence Scale for Children* (3rd edition). San Antonio, TX: The Psychological Corporation.

Wechsler, D. (2003). *Manual for the Wechsler Intelligence Scale for Children* (3rd edition). San Antonio, TX: The Psychological Corporation.

Table 1. Mean/Count and Standard Deviation/Percent for Full Sample, ADHD-C Children, and Non-ADHD-C children

Measures	Full Sample (N = 132)	ADHD-C (N = 57)	Non-ADHD-C (N = 75)	Effect Size (η^2)
Age	9.88(2.43)	8.95(1.82)**	10.59(2.60)	.11
Gender (male)	91 (69%)	41 (72%)	50 (67%)	-
Full Scale IQ	104.20(12.54)	101.25(13.09)*	106.45(11.70)	.04
Overall Index (CPT)	10.65(7.35)	13.49(6.69)**	8.49(7.13)	.11
Total Trials (BIT)	72.12(27.67)	75.65(25.14)	69.44(29.33)	.01
CBCL Attention	68.06(9.44)	70.65(9.10)**	66.09 (9.28)	.06
CBCL Internalizing	61.21(11.78)	62.89(10.26)	59.93(12.73)	.08
CBCL Externalizing	60.30(10.63)	63.72(8.56)**	57.69(11.34)	.08
TRF Attention	62.45(9.07)	65.89(9.44)**	59.84(7.89)	.11
TRF Internalizing	55.81(10.69)	58.91(10.36)**	53.45(10.40)	.06
TRF Externalizing	57.53(9.11)	61.77(8.85)**	54.31(7.96)	.17
Overall Index > 11	60(46%)	36(63%)	24(32%)	-
BIT Trials > 50	97(74%)	45(79%)	52(70%)	-
BIT Trials = 100	27(21%)	10(18%)	17(23%)	-

* Significant difference between ADHD-C and Non-ADHD-C ($p < .05$)

** Significant difference between ADHD-C and Non-ADHD-C ($p < .01$)

Note: Cohen (1988) recommends the following interpretation of η^2: small = .01 to .05, medium = .06 to .13, large = .15 or greater.

Table 2. Diagnoses for children in the ADHD-C and Non-ADHD-C Groups

Diagnoses	ADHD-C	Non-ADHD-C
ADHD-I	0**	24
ADHD-H	0	2
GAD	13	23
Social Phobia	8	13
OCD	4	4
Specific Phobia	16	11
PTSD	2	2
Agoraphobia	0	1
MDD	2	2
Dysthymia	0*	8
Bipolar	1	0
ODD	17*	9
CD	1	0
LD	20	28
Sleep Terror Disorder	2	1
Enuresis	3	4
Encopresis	1	1
Adjustment Disorder	2*	11

* Significant difference between ADHD-C and Non-ADHD-C ($p < .05$)

** Significant difference between ADHD-C and Non-ADHD-C ($p < .01$)

Table 3. Pearson Correlations Among Age, Gender, Full Scale IQ, Computer Tasks, and CBCL/TRF Factors (TRF above diagonal and CBCL below)

Measure	1	2	3	4	5	6	7	8	9
Age	1	.135	.096	-.336**	-.059	-.201*	-.215*	-.102	-.117
Gender	.135	1	-.049	-.056	-.007	.076	.022	-.034	-.160
IQ	.096	-.049	1	-.206*	-.136	-.069	-.294**	-.094	-.143
ADHD-C	-.336**	-.056	-.206*	1	.338**	.112	.332**	.254**	.407**
CPT	-.059	-.007	-.136	.338**	1	-.088	.033	-.031	.301**
BIT	-.201*	.076	-.069	.112	-.088	1	.160	-.004	-.104
Att	-.095	.191*	-.204*	.240**	-.022	.023	1	.352**	.517**
Int	-.076	-.030	-.032	.125	-.114	.040	.502**	1	.350**
Ext	-.043	.040	-.018	.282**	.172*	-.098	.501**	.506**	1

Note: Gender = Male (0) or Female (1), ADHD = Consensus diagnosis of ADHD-C (1) or no diagnosis of ADHD-C (0), CPT = Conners' Continuous Performance Test (overall index score), BIT = Behavioral Inhibition Task (number of trials), Att = Attention Problems T-score of the Child Behavior Checklist (CBCL)/Teacher's Report Form (TRF), Int = Internalizing Problems T-score of the Child Behavior Checklist (CBCL)/Teacher's Report Form (TRF), Ext = Externalizing Problems T-score of the Child Behavior Checklist (CBCL)/Teacher's Report Form (TRF).

*Correlation is significant at the .05 level (2-tailed).

**Correlation is significant at the .01 level (2-tailed).

Table 4. Predicting Parent-Reported Symptomatology

DV	*df* Error	Effect	β	ΔR^2	Total R^2
ATT	121	Age	-.100		
		Gender	.241**		
		IQ	-.148	.085*	
		ADHD-C	.270**		
		BIT	-.185		
		CPT	.117	.054	
		ADHD-C x CPT	-.375**		
		ADHD-C x BIT	.148		
		BIT x CPT	-.001	.098**	
		ADHD-C x CPT x BIT	.004	.000	.238**
INT	121	Age	-.049		
		Gender	-.011		
		IQ	-.010	.007	
		ADHD-C	.165		
		BIT	-.032		
		CPT	-.106	.038	
		ADHD-C x CPT	-.092		
		ADHD-C x BIT	.066		
		BIT x CPT	.088	.012	
		ADHD-C x CPT x BIT	-.065	.001	.058
EXT	121	Age	-.003		
		Gender	.088		
		IQ	.045	.004	
		ADHD-C	.337**		
		BIT	-.159		
		CPT	.251*	.103**	
		ADHD-C x CPT	-.307*		
		ADHD-C x BIT	-.036		
		BIT x CPT	.023		
		ADHD-C x CPT x BIT	.059	.045	.154*

Table 5. Predicting Teacher-Reported Symptomatology

DV	*df* Error	Effect	β	ΔR^2	Total R^2
ATT	121	Age	-.071		
		Gender	.029		
		IQ	-.248**	.123**	
		ADHD-C	.379**		
		BIT	.105		
		CPT	-.043	.068*	
		ADHD-C x CPT	-.175		
		ADHD-C x BIT	-.253		
		BIT x CPT	-.095	.008	
		ADHD-C x CPT x BIT	.309*	.034*	.233**
INT	121	Age	-.041		
		Gender	-.034		
		IQ	-.036	.018	
		ADHD-C	.292**		
		BIT	-.099		
		CPT	-.197	.067*	
		ADHD-C x CPT	.089		
		ADHD-C x BIT	.058		
		BIT x CPT	.200	.052	
		ADHD-C x CPT x BIT	-.003	.000	.138*
EXT	121	Age	.039		
		Gender	-.130		
		IQ	-.083	.055	
		ADHD-C	.438**		
		BIT	-.022		
		CPT	.233*	.178**	
		ADHD-C x CPT	-.200		
		ADHD-C x BIT	-.305*		
		BIT x CPT	.019	.029	
		ADHD-C x CPT x BIT	.158	.009	.271**

Table 6. Predicting Parent-Reported Symptomatology, Unique Effects

DV	*df* Error	Effect	β	ΔR^2	Total R^2
ATT	119	Age	-.084		
		Gender	.221**		
		IQ	-.156*	.085*	
		ADHD-C	.130		
		Int	.322**		
		Ext	.260**		
		BIT	-.134		
		CPT	.086	.334**	
		ADHD-C x CPT	-.265*		
		ADHD-C x BIT	.137		
		BIT x CPT	-.036	.052*	
		ADHD-C x CPT x BIT	.010	.000	.471**
INT	119	Age	-.011		
		Gender	-.134		
		IQ	-.027	.007	
		ADHD-C	-.067		
		Att	.366**		
		Ext	.394**		
		BIT	.098		
		CPT	-.248*	.377**	
		ADHD-C x CPT	.166		
		ADHD-C x BIT	.026		
		BIT x CPT	.079	.012	
		ADHD-C x CPT x BIT	-.090	.003	.399**
EXT	119	Age	.043		
		Gender	.025		
		IQ	.090	.004	
		ADHD-C	.200*		
		Att	.279**		
		Int	.372**		
		BIT	-.095		
		CPT	.258**	.415**	
		ADHD-C x CPT	-.169		
		ADHD-C x BIT	-.102		
		BIT x CPT	-.009	.011	
		ADHD-C x CPT x BIT	.082	.002	.432**

Table 7. Predicting Teacher-Reported Symptomatology, Unique Effects

DV	*df* Error	Effect	β	ΔR^2	Total R^2
ATT	119	Age	-.082		
		Gender	.093		
		IQ	-.205**	.123**	
		ADHD-C	.136		
		Int	.160*		
		Ext	.448**		
		BIT	.131		
		CPT	-.116	.294**	
		ADHD-C x CPT	-.100		
		ADHD-C x BIT	-.126		
		BIT x CPT	-.135	.002	
		ADHD-C x CPT x BIT	.239*	.020*	.439**
INT	119	Age	-.036		
		Gender	-.006		
		IQ	.038	.018	
		ADHD-C	.098		
		Att	.210*		
		Ext	.262*		
		BIT	-.115		
		CPT	-.249*	.176**	
		ADHD-C x CPT	.178		
		ADHD-C x BIT	.191		
		BIT x CPT	.215*	.064*	
		ADHD-C x CPT x BIT	-.110	.004	.262**
EXT	119	Age	.077		
		Gender	-.136*		
		IQ	.027	.055	
		ADHD-C	.225*		
		Att	.419**		
		Int	.186*		
		BIT	-.047		
		CPT	.287**	.399**	
		ADHD-C x CPT	-.143		
		ADHD-C x BIT	-.209		
		BIT x CPT	.021	.022	
		ADHD-C x CPT x BIT	.029	.000	.476**

Figure 1. Parent-Reported Attention Problems as a Function of CPT Performance and ADHD-C Status

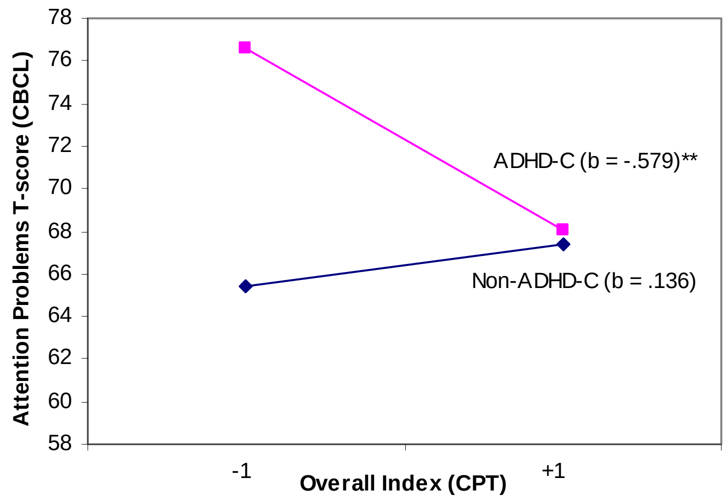

Figure 2. Parent-Reported Externalizing Problems as a Function of CPT Performance and ADHD-C Status