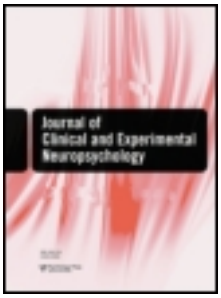

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Neuropsychological Assessment of Response Inhibition in Adults With ADHD

Jeffery N. Epstein, Diane E. Johnson, Indira M. Varia, and C. Keith Conners
Duke University Medical Center, Durham, NC, USA

ABSTRACT

Several theoretical models suggest that the core deficit of ADHD is a deficiency in response inhibition. While neuropsychological deficits in response inhibition are well documented in ADHD children, research on these deficits in adult ADHD populations is minimal. Twenty-five adult ADHD patients, 15 anxiety-disordered adult patients, and 30 normal adults completed three neuropsychological tests of response inhibition: the Continuous Performance Test, Posner Visual Orienting Test, and the Stop Signal Task. ADHD adults demonstrated response inhibition performance deficits when compared to both normal adults and anxiety disordered adults only on the Continuous Performance Test. A similar pattern of differences was not observed on the other two neuropsychological tests. Differing results between tasks may be due to differences in test reliability, task parameters, or the targeted area of brain functioning assessed by each test.

Attention-Deficit Hyperactivity Disorder (ADHD) is a prevalent childhood psychiatric disorder that frequently persists into adulthood (NIH, 1998). The disorder is defined by a list of cognitive/behavioral symptoms across three behavioral domains: inattention, hyperactivity, and impulsivity (APA, 1994). Poor sustained attention (Douglas, 1972; Douglas, & Peters, 1979), poor motivation (Rosenthal, & Allen, 1978), inability to respond to behavioral consequences (Beninger, 1989; Sergeant, 1988), and deficient response inhibition (Barkley, 1997; Quay, 1997) are most often proposed as core areas of deficit in ADHD. While a consensus decision regarding which deficit is primary does not exist, recent theories focus on response inhibition (Barkley, 1997; Quay, 1997; Schachar, Tannock, & Logan, 1993).

Quay (1997) has proposed that an underresponsive behavioral inhibition system (BIS) located in the septo-hippocampal system of the brain, having connections to the frontal cortex, is responsible for ADHD. According to Quay, an underresponsive BIS makes inhibiting behaviors difficult and results in impulsive, hyperactive, and some inattentive behaviors. Barkley (1997) has expanded Quay's theory. Barkley concurs that the core ADHD deficit is attributable to poor inhibition. Barkley builds on and enforces the theory by linking poor inhibitory functioning to the inability to prioritize and execute four critical executive functions: (1) nonverbal working memory, (2) internalization of self-directed speech, (3) self-regulation of mood, motivation and level of arousal, and (4) reconstitution or the ability to break down observed behaviors into component parts. According to Barkley, the inability to perform these executive functions leads to ADHD behaviors.

Numerous neuropsychological studies support the hypothesis that ADHD children have inhibitory deficits. ADHD children demonstrate performance deficits on a variety of putative tests of response inhibition. These measures include the Matching Familiar Figures Test (DuPaul, Anasto-

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Please address all correspondence to Jeff Epstein, Ph.D., Box 3431, Duke University Medical Center, Durham, NC 27710; Fax: 919-286-7081; email: epste002@mc.duke.edu
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polous, Shelton, Guevremont, & Metevia, 1992), Continuous Performance Tasks (see Corkum & Siegel, 1993 for review), and delayed response tasks (Solanto, 1990), among others.

One methodologically sophisticated approach to researching response inhibition is the stop paradigm (Logan & Cowan, 1984; Logan, Cowan, & Davis, 1984). The stop paradigm is based on the race model where response execution races with the inhibitory process to determine whether a response is inhibited (see Logan, 1994). As an individual begins executing a response, an inhibitory process begins when stimuli signal it is time to stop. The stop paradigm measures the minimal time required between the onset of the inhibitory process and stopping of a response (called the Stop Signal Reaction Time [SSRT]). The longer the SSRT, the poorer an individual's response inhibition. Several studies demonstrate that ADHD children have longer SSRTs than control populations (see Oosterlaan, Logan, & Sergeant, 1998 for review), but there is no research to date using this paradigm in adults with ADHD.

The present study compares the performance of adults diagnosed with ADHD to a normal group using three measures of response inhibition. While comparisons to normal adults are critical for documenting neuropsychological deficits, it is also important to demonstrate that the neuropsychological deficit is specific to the disorder in question. Comparison to a psychiatric control group is useful to demonstrate this specificity. Thus, in addition to comparing adults with ADHD to normal controls, patients with anxiety disorders served as a patient comparison group. Anxiety-disordered adults provide an interesting comparison group as theories of response inhibition (Gray, 1982; Quay, 1997) suggest that anxiety disordered patients have an overactive behavioral inhibition system (BIS) and should demonstrate increased response inhibition and a behavioral pattern opposite to that of patients with ADHD.

METHOD

Participants

Adults (aged 18–65 years) with ADHD or anxiety symptomatology (ANX) were recruited using clinic referrals from local mental health professionals and newspaper advertisements asking for ''adults diagnosed with ADHD or an anxiety disorder to participate in a research study''. Normal controls (NORM) were recruited through newspaper advertisements asking for ''normal adults to participate in a research study''. Recruited participants for all groups were asked to complete a questionnaire about ADHD symptoms and a questionnaire about anxiety symptoms. Participants had to meet pre-defined questionnaire criteria as outlined in Table 1. Additional exclusion criteria included any history of closed head injury or neurological disorders. If questionnaire criteria were met, participants came to the Duke University Medical Center ADHD Clinic for study participation. Study participants then were administered a clinician-administered interview to assess ADHD symptomatology followed by a computerized interview to assess anxiety sympto-

Table 1. Group Criteria.

Measure	Group		
	ADHD	Anxiety	Normal
CAARS–Inattention, Hyperactivity, Impulsivity, Index Scale Scores	Any scale t score > 60	All scale t scores < 65	All scale t scores < 65
STAI–Trait Score	t score < 65	t score > 60	t score < 65
CHAMPS–DSM-IV Diagnosis	Present	Absent	Absent
SCID–Anxiety Diagnosis	Absent	Present	Absent

Note: ADHD = Attention Deficit Hyperactivity Disorder; CAARS = Conners Adult ADHD Rating Scale; STAI = Speilberger State – Trait Anxiety Inventory; CHAMPS = Schedule for the Assessment of Conduct, Hyperactivity, Anxiety, Mood and Psychoactive Substances; SCID = Semi-structured Clinical Interview for DSM-IV.

matology. In order to meet study inclusion criteria, participants were required to meet a second set of pre-determined criteria as defined in Table 1 based on the clinical interviews.

Thirty normal controls, 25 ADHD adults, and 15 anxiety disordered controls met study criteria and completed the study. Gender, age, and educational level for the participants in the three groups are presented in Table 2. Groups did not differ on any of these demographic variables. Of the 25 ADHD participants, 10 met DSM-IV diagnostic criteria for ADHD, Combined Type, 14 met diagnostic criteria for ADHD, Predominantly Inattentive Type, and 1 met diagnostic criteria for ADHD, Predominantly Hyperactive/Impulsive Type. Of the 15 anxiety disordered participants, 13 met DSM-IV diagnostic criteria for agoraphobia, four for obsessive-compulsive disorder, eight for generalized anxiety disorder, five for panic disorder, four for posttraumatic stress disorder, and two met criteria for anxiety disorder due to general medical condition. Eleven of the 15 anxiety disordered patients met diagnostic criteria for multiple anxiety disorders. The rates of comorbid diagnoses across all three groups are presented in Table 3. Learning disabilities were not assessed among the patient groups.

All participants were unmedicated at the time of study participation. If ADHD patients were currently taking psychostimulant medications, they were required to abstain from ingesting those medications on the day of their clinic visit. The vast majority of the anxiety disordered subjects were recruited at intake to local anxiety disorder clinics and thus had not yet been prescribed anxiolytic medication.

Table 2. Demographic Characteristics.

Group	N	% Male	Age	Education*
ADHD	25	40%	33.6	4.4
Anxiety	15	40%	37.7	4.6
Normal	30	50%	33.4	4.7

*Scale = 1 to 7 (4 = some college experience and 5 = university graduate).

Clinical Measures

Conners Adult ADHD Rating Scale (CAARS)

The Conners Adult ADHD Rating Scale (CAARS; Conners, Erhardt, & Sparrow, 1999) was used to assess adult symptomatology. The scale consists of 66-items that are rated using a 4-point Likert scale (ranging from "0" for "not at all true" to "3" for "very much true"). Four factors emerge from this 66-item scale: Inattention/Cognitive Problems, Hyperactivity/Restlessness, Impulsivity/Emotional Lability, and Problems with Self-Concept (Conners et al., in press). An ADHD index score comprised of 12 CAARS items can also be derived that is highly related to ADHD diagnosis. Sensitivity and specificity of the ADHD Index score are 71% and 75% respectively (Conners et al., 1999). The reliability and validity of the CAARS factors are satisfactory; internal reliability of the factor scales ranged between .86 and .92; test-retest reliabilities ranged between .88 and .91 (Erhardt, Epstein, Conners, Parker, & Sitarenios, in press).

Spielberger Trait Anxiety Inventory (STAI)

The STAI (Spielberger, 1983) is a standardized instrument on which participants rated their feelings of apprehension, tension, nervousness, and worry using a 4-point Likert-type scale (ranging from "1" for "not at all" to "4" for "very much so"). Test-retest reliability (range = .71–.75) and internal consistency (median = .90) of the trait scale are adequate. The validity of the scale has been established using group contrasts and correlations with similar scales (Spielberger, 1983).

Table 3. Comorbid Diagnoses in Each Group as Determined By Self-Report Computerized SCID.

	Group					
	ADHD (n = 25)		Anxiety (n = 15)		Normal (n = 30)	
DSM-IV Disorder	N	%	N	%	N	%
Major Depressive Disorder	2	8%	3	20%	0	0%
Manic/Hypomanic Episode	2	8%	1	7%	0	0%
Alcohol Abuse/Dependence	5	20%	4	27%	6	20%
Other Drug Abuse/Dependence	1	4%	1	7%	1	3%

Note: SCID = Semi-structured Clinical Interview for DSM-IV.

Schedule for the Assessment of Conduct, Hyperactivity, Anxiety, Mood and Psychoactive Substances (CHAMPS)

The CHAMPS (Mannuzza & Klein, 1987) is a clinician-administered semi-structured interview that assesses DSM-IV ADHD symptoms. The interview determines the presence of ADHD symptoms in childhood and adulthood, age of onset for each symptom, environments where the symptom is present, and ascertains severity of each symptom. Answers to the interview items are utilized to derive a DSM-IV ADHD diagnosis.

Semi-Structured Clinical Interview for DSM-IV (SCID)

Participants self-administered a computerized version of the SCID interview (First, Gibbon, Williams, & Spitzer, 1997). They answered questions about the presence or absence of DSM-IV symptoms over the course of the past year. The following anxiety disorders were assessed via this interview: agoraphobia, obsessive-compulsive disorder, generalized anxiety disorder, panic disorder, posttraumatic stress disorder, specific phobia, social phobia, and anxiety disorder due to general medical condition.

Neuropsychological Tests

Continuous Performance Test (CPT)

The CPT (Conners, 1992) was completed on an IBM-compatible desktop computer. Three hundred sixty (360) letters (approximately 1'' in size) appeared on the computer screen, one at a time, for approximately 250 milliseconds. The 360 trials were presented in 18 consecutive blocks of 20 trials. The 18 blocks consisted of a separate ISI (1, 2, or 4 secs). The ISIs were block randomized across the 18 blocks so that all three ISI conditions would occur every 3 blocks. Therefore, the entire CPT was divisible into six consecutive time blocks with each time block containing all three ISI conditions. Participants were required to depress the spacebar when any letter except the letter ''X'' appeared on the screen. The event rate, or percentage of trials when letters other than ''X'' appeared, was 90% and this percentage was constant across ISI and time blocks. Errors of commission occurred when participants depressed the spacebar on trials when the letter ''X'' was presented. The total CPT task took approximately 14 minutes for the participant to complete.

Posner Visual Orienting Task (PVOT)

All participants were administered the PVOT (Posner, Inhoff, Friedrich, & Cohen, 1987) on an IBM-compatible desktop computer. Participants were seated at a desk with their head secured by a chin rest 33 cm from the computer screen. Two boxes (each 2 cm wide $\times$ 1.5 cm high) appeared approximately 13° right and left of a central fixation point on the computer screen. These boxes and a cross (+) in the center of the screen were present throughout this entire task. An asterisk was presented in either one of the boxes for each trial. Participants were instructed to depress the space bar on the keyboard as soon as they observed the asterisk. After the response, the asterisk was removed from the screen for a 1000 ms intertrial interval in which only the cross and boxes remained on the screen. Two hundred forty (240) trials were presented in five blocks of 48 trials. Participants were allowed to rest for as long as they wished between each block of trials.

Half of the target stimuli were presented in the right visual field and half were presented in the left visual field. Before each trial, the participant received a visual cue in the form of a second box appearing in one or both of the target boxes. This was perceived by the participants as a brightening of the boxes. On 160 of the 240 trials (67%), the box in which the asterisk was to appear was cued. These trials constituted the valid cue condition. On another 40 trials, the incorrect box was cued; this was the invalid condition. On another 40 trials, both boxes were cued, thus cueing provided no directional information regarding target location; these trials constituted the null condition. The delay between the cue and onset of the target stimulus was either 100 ms or 800 ms. Each delay condition occurred evenly across the different cueing conditions.

One outcome measure on the task was the percentage of trials in which the participant responded impulsively. An impulsive response occurred when the participant responded after the presentation of the cue but before the presentation of the asterisk. Only trials with an 800 ms delay were used for assessing impulsive responding since participants were unable to respond before presentation of the target with only a 100 ms delay. Across the 800 ms trials, 50 trials were cued with a right visual cue, 50 trials with a left visual cue, and 20 trials with a null dual cue.

Stop-Signal Task (SST)

The SST (Logan et al., 1984) was performed on an IBM-compatible desktop computer. Participants were first presented with a fixation point ''+'' sign in the middle of the screen for 500 ms, then either an ''X'' or an ''O'' appeared for 1000 ms. The presentation of the letter was followed by a 1000 ms blank screen. Participants were instructed to respond to the letter as quickly as possible without making

errors, by pressing the ''enter'' key if the letter was an ''X'' and the ''0'' key if the letter was an ''O''. Participants were simultaneously presented with 1000 Hz tones played through the computer speaker that indicated to the participant to inhibit their response on that trial. The delay between presentation of the letter and the stop signal began at 250 ms and was varied according to the participant's performance so that the participant was able to inhibit on approximately half of the trials on which the tone was presented.

Five-hundred twelve (512) trials were administered in eight 64-trial blocks. The first block was split into two blocks of 32 trials each and was used for practice. During the first 32 trials, participants were instructed to respond only to the ''X'' and ''O'' and to ignore the audible tones. During the second block of 32 trials, the participants were instructed to continue responding as during the first block except they were to inhibit their responses when they heard the tone. Only the responses from the last seven blocks were used as data. The participant was given a break after every 32 trials. Presentation of the ''X'' and ''O'' stimuli were equal in each block. Stop signals were presented on 25% of all trials in each block.

Stop-signal reaction time (SSRT) is the most widely used dependent measure on this task. SSRT is the difference between the point at which the stop signal was presented and the point at which the stopping process finished (Schachar et al., 1993). The higher the SSRT, the slower the inhibitory process, the harder it becomes to inhibit responding.

Procedure

Research participants signed informed consent and then completed the CHAMPS, SCID, CPT, PVOT, and SST in the stated order. Participants were not given feedback on their neuropsychological test performance. All participants were compensated monetarily for their study participation.

RESULTS

CPT

A 3 (group) × 6 (block) × 3 (ISI) ANOVA was conducted to examine between-group differences on errors of commission and to examine for any interactions with CPT task parameters (time block or ISI). Results from this analysis revealed significant main effects of group ($F(2,67) = 4.68$, $p < .05$) and block ($F(5,335) = 5.49$, $p < .0001$). Post-hoc Newman-Keuls tests revealed that the ADHD group had a significantly higher rate of commission errors than both the ANX and Normal groups (both p's $< .05$). No differences were observed between the anxiety disordered and normal control groups. Table 4 displays group means and effect sizes for the three groups. The

Table 4. Means, SDs, and Between Group Comparison Results on Measures of Response Inhibition on Three Neuropsychological Tests.

Task/Dependent Variable	Group			Effect Sizes		
	ADHD (n = 25)	Anxiety Disorder (n = 15)	Normal Controls (n = 30)	ADHD vs. Normal *d**	ADHD vs. Anxiety *d**	Anxiety vs. Normal *d**
CPT/ Percentage commission errors	13.36 (8.28)	7.80 (5.65)	8.27 (6.15)	.71	.75	.08
PVOT/ Percentage impulsive responses	4.35 (4.68)	3.26 (3.43)	2.63 (2.05)	.49	.26	.25
SST/ Stop signal reaction time	251.90 (97.22)	228.42 (37.45)	209.89 (42.30)	.58	.29	.45

Note: *d is effect size using pooled error. CPT = Continuous Performance Test; PVOT = Posner Visual Orienting Task; SST = Stop Signal Task.

time block main effect was a result of a decreasing percentage of commission errors as the task progressed across all three groups. There was no interaction effects of time block with either group or ISI nor were there any other interaction effects (all p's > .10).

PVOT

Table 4 shows the mean percentage of PVOT impulsive errors for the three groups and effect sizes for between-group comparisons. A one-way between-groups ANOVA was conducted to test for any group differences in percentage of impulsive errors. While there was a clear trend for the ADHD group to have increased numbers of impulsive errors compared to the normal group (ADHD mean = 4.35, Normal mean = 2.63), the main effect of group was not statistically significant ($F(2,67) = 1.68$, $p > .05$). In case inclusion of the ANX group in the ANOVA analysis was influencing the group effect, a post-hoc comparison was conducted to look at differences between groups. Newman-Keuls post-hoc comparisons revealed no differences between any of the 3 groups (all p's > .05).

SST

While the CPT and PVOT tasks both assessed the rates of impulsive responding across the three groups, the SST was designed to assess the individual participant's speed of inhibiting a response. Longer SSRTs denote that participants are less proficient at stopping a response once it has begun which is likely to manifest itself in impulsive response patterns. A repeated measures 3 (group) × 7 (time block) ANOVA was conducted using the mean SSRT per block as the dependent measure. The group main effect was non-significant ($F2,67) = 2.70$, $p > .05$). Group means are displayed in Table 4. Again, post-hoc Newman-Keuls group comparisons were all non-significant (all p's > .05). There was a main effect of time block with SSRT decreasing over time ($F(6,402) = 6.51$, $p < .0001$). This effect occurred mainly because of a jump in SSRT from block 1 (mean SSRT = 270.13) to block 2 (mean SSRT = 224.61) after which it stayed mostly stable. This pattern was evident across both groups as there was no interaction between time block and group status ($F(12,402) = .80$, $p > .05$).

Secondary Analyses

According to DSM-IV, three distinct subtypes of ADHD exist. Within the ADHD group in this sample, there was representation among all three subtypes. Given the amount of within-group variability in the ADHD group on the response inhibition measures, differential performance among ADHD subtypes was a distinct possibility. One-way ANOVA analyses were conducted comparing response inhibition measures across the three subtypes. None of the comparisons approached significance (all p's > .05).

While the primary hypotheses in this paper relate to response inhibition deficits in ADHD adults, the tests utilized to measure response inhibition yield measures of other neuropsychological constructs including inattention, orienting, disengagement of attention, etc. In order to comprehensively report neuropsychological performance across tests and across groups, Table 5 presents group means and reports statistical differences for additional CPT and SST performance indices. Typical analysis of PVOT responses is more complex and less amenable to table presentation. A textual description of the PVOT results is presented below.

The two visual fields (left and right), three cueing conditions (valid, invalid, and null), and two delay conditions (100 ms and 800 ms) produced 12 repeated measures combinations of conditions. Mean reaction times were computed for each of these 12 conditions based upon the median reaction times from each of the five blocks. A 4-way mixed design ANOVA was conducted. Group status was the only between-subjects factor. Repeated measures factors included Visual Field (Right or Left), Cue (Valid, Invalid, or Null), and Delay (100 ms or 800 ms). Results from this ANOVA did not reveal any main effect of group ($F(2,67) = 1.70$, $p > .05$) nor any interactions of group status with any of the independent variables (all p's > .10).

DISCUSSION

Adults diagnosed with ADHD, anxiety-disorders, and a group of normals all completed three neuro-

Table 5. Means, *SD*s, and Main Effects on Secondary Neuropsychological Performance Measures.

	Group								
Task/Dependent Variable	ADHD (n = 25)		Anxiety Disorder (n = 15)		Normal Controls (n = 30)		Group Main Effect		Post-hoc Comparisons[1]
	M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*F*	*p*	
CPT									
Reaction Time[2]	362.19	(57.48)	373.23	(46.34)	373.21	(64.59)	.28	.75	
Reaction Time SE[3]	6.65	(2.64)	5.00	(1.39)	4.98	(1.57)	5.57	.006	ADHD > ANX**; ADHD > Normals*
Ommission errors %	.87	(1.04)	.60	(.34)	.62	(1.24)	.48	.62	
SST									
Reaction Time[4]	691.89	(204.82)	633.13	(241.98)	571.90	(151.48)	2.65	.07	
Reaction Time SD[5]	167.52	(70.34)	133.88	(62.96)	117.22	(44.87)	5.03	.009	ADHD > Normals*
Accuracy[6]	96.39	(3.89)	97.89	(1.56)	98.28	(1.67)	3.59	.03	None Significant

Note: [1]Newman-Keuls Post-hoc Comparisons; [2]Mean reaction time on successful target trials; [3]Mean standard error on successful target trials; [4]Mean reaction time on non-inhibited trials; [5]Standard deviation of reaction time on non-inhibited trials; [6]Percentage of non-inhibited trials with correct keyed response; *p < .05; **p < .01; CPT = Continuous Performance Test; SST = Stop Signal Task; SE = Standard Error; *SD* = Standard Deviation.

psychological tasks assessing response inhibition. Results from this study indicate that the hypothesized pattern of results indicating poorer response inhibition and specificity of these response inhibition deficits was limited to only one of the neuropsychological tests (i.e., CPT). Several CPT task parameters were assessed to determine whether they influenced response inhibition across the groups. Neither the time on task nor rate of stimuli presentation interacted with response inhibition across the groups. The CPT results of this study corroborate previous neuropsychological research conducted with ADHD adults. A few studies have demonstrated that ADHD adults make more commission errors on CPT tasks than normal controls (Barkley, Murphy, & Kwasnik, 1996; Epstein, Conners, Sitarenios, & Erhardt, 1998). The present study expands upon those results by demonstrating that ADHD performance deficits may be specific to ADHD populations and not to other psychiatric control groups (e.g. adults with anxiety disorders). This demonstration of deficit specificity is often neglected in neuropsychological research with ADHD populations. Yet demonstration of such specificity is heuristically essential in specifying the areas of deficit common to a specific disordered group.

The present CPT findings are consistent with similar research conducted with child populations. In a recent meta-analysis of CPT research comparing ADHD and normal children, an effect size of .73 was reported for commission errors (Losier, McGrath, & Klein, 1996). The effect size for this same comparison in the present study was .71 suggesting comparable magnitudes of deficit across child and adult samples. The present study also suggests that performance differences between ADHD and anxiety-disordered children may be similar in magnitude (effect size = .75). In the only published study comparing ADHD and purely anxiety-disordered children on a CPT task, Halperin et al. (1993) also found significant performance differences on CPT measures of impulsivity between ADHD and anxiety disordered children. As in the present study, no performance differences existed between the normal and anxiety disordered groups.

While the present study's CPT results are consistent with prior research in children and adults, a criticism levied on many neuropsychological tests measuring impulsivity is that the tests may be too global in nature, measuring other constructs besides impulsivity, such as IQ (Halperin, McKay, Matier, & Sharma, 1994; Schachar & Logan, 1990). The SST was developed to address this concern (Oosterlaan, 1996) and was included in this study's protocol to further our understanding of impulsive response patterns in adult ADHD populations. Unfortunately, between-group differences did not emerge on this test. The same

was true for between-group differences on the PVOT. Since the PVOT was not specifically designed to assess impulsive responding nor has it been utilized for this specific purpose, null results are less surprising. However, the SST is a well-researched neuropsychological test utilized with ADHD children that has consistently found between group differences between ADHD and normal samples and occasionally between ADHD and anxiety disordered samples (e.g., Oosterlaan & Sergeant, 1998).

Null results on the SST may be due to a variety of reasons. The group sample sizes may have been too small to have sufficient power to detect between-group differences on this test. The ADHD-Normal post-hoc comparison did approach significance ($p = .11$) and might have reached statistical significance with larger group sample sizes. The effect size found in the present study for this comparison ($d = .58$) compares favorably with that reported in a recent meta-analysis ($d = .64$; Oosterlaan et al., 1998). However, the ADHD-anxiety group comparison does not appear to be due to the possibility of Type II error. Had the sample sizes of both the ADHD and anxiety groups been increased to 30, similar means and sd's would have produced similar non-significant results for the ADHD-anxiety comparison.

Differences in results across the three tests may imply that the CPT is measuring response inhibition differently than the other two tests. Correlations between the CPT and each of the other two tests (SST $r = .43$; PVOT $r = .62$) were high but clearly suggest unique variance to each task. Indeed the CPT is unique in that is has variable ISIs and often rapid pace which may prime impulsive response patterns among participants, thus making it more sensitive to differences across groups. Another explanation for differing results across tests is that CPT measurement error may be lower than the other two tests thus providing more power to detect group differences.

Limitations of the present study mainly concern power and diagnostic issues. Sample sizes for this study were determined using effect sizes from the childhood literature. A smaller anxiety-disordered sample was recruited than targeted largely due to the high rate of self-reported inattentive symptoms among this population. If 6 or more DSM-IV ADHD inattentive symptoms were reported, anxiety-disordered participants were excluded from the study. The large amount of comorbid symptoms in the anxiety group made recruitment of these participants difficult and led to a smaller sample size in this group.

There also may be concerns about the diagnostic procedure used to diagnose anxiety disorders. Rather than using a clinician-administered diagnostic interview, a computerized diagnostic interview was employed. While this interview contains the same diagnostic questions and diagnostic tree as a traditional clinician-administered SCID interview, the psychometric properties of this interview when self-administered via a computer are not known. Given the diagnostic profile of the anxious subjects, there appears to be a bias towards producing multiple anxiety diagnoses. However, the multiple gating procedure by which anxiety-disordered participants were recruited including referrals from clinics/responding to an advertisement for adults with anxiety disorders, scoring high on anxiety questionnaires, and then completion of the SCID interview likely selected a diagnostic group of anxiety controls.

A deficit in response inhibition is a critical feature of several theoretical models of ADHD (Quay, 1997; Barkley, 1997). Both Quay and Barkley suggest that an underlying deficit in response inhibition is responsible for ADHD behavioral symptomatology. These theories would predict that response inhibition deficits documented in children should persist in adults with the same cognitive and behavioral symptomatology. Further, response inhibition deficits should be specific to ADHD and should not necessarily represent general psychopathology. The present study partially supports this prediction by finding a concordant pattern of CPT results as has been demonstrated in children. Further, this study provides some evidence supporting the specificity of these deficits to ADHD. Of concern is the fact that deficits in response inhibition were not observed across the multiple measures. More neuropsychological research needs to be conducted to determine how different tasks, with differing task demands, may assess different brain functioning related to response inhibition.

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