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Neuropsychological Functioning in College Students With and Without ADHD

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Abstract

Increasing numbers of students with attention-deficit/hyperactivity disorder (ADHD) are attending college; however, little empirical information is available concerning the functional impairment experienced by these students. Although preliminary studies suggest that college students with ADHD are more likely to experience a variety of psychosocial and academic difficulties compared to their peers without the disorder, findings regarding neuropsychological functioning have been inconsistent with some studies reporting that college students with ADHD perform more poorly on various cognitive and neuropsychological tasks whereas others report no differences compared to non-ADHD peers. The purpose of the present study was to: a) examine the performance of 436 first-year college students with and without ADHD (51.6% female) on measures of executive function (EF) and intelligence; and b) investigate the association of self-reported use of stimulant medication with neuropsychological performance in students with ADHD. Participant data from their first year of involvement in the Trajectories Related to ADHD in College (TRAC) project, a longitudinal study following the 4-year outcomes of college students with and without ADHD, were analyzed. Participants with ADHD performed more poorly on task-based and self-report executive function measures relative to the comparison group. In contrast, no significant group differences in intellectual performance were found. Within the ADHD group, receipt of stimulant medication was associated with improved performance on some neuropsychological tasks, but not for intellectual functioning. Additional analyses also revealed significant group differences in EF based on clinical diagnostic status. Implications of these findings and suggestions for future research are advanced.

Neuropsychological Functioning In College Students with and without ADHD

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by hyperactivity, impulsivity, and/or inattention (American Psychiatric Association, 2013). Symptoms begin early in life, are chronic in nature, and are associated with clinically significant impairment across multiple areas of functioning, including academic, psychological, social, and occupational functioning. A number of theories exist regarding the underlying pathophysiology of ADHD including neurological and genetic theories (Franke et al., 2012; Wasserstein & Stefanatos, 2016, Weyandt 2006), theories of response inhibition (Barkley, 2014), and theories that emphasize underlying deficits in executive functions (Nigg et al., 2005). Executive functions include a wide array of cognitive processes such as strategic planning, response inhibition, fluency, and working memory. Recent physiological findings using evoked potentials (ERP) and other techniques suggest that processes that impact executive function performance i.e., orienting attention to cues, cognitive preparation, and inhibitory processing may present early in life and remain developmentally stable into adulthood (e.g., Cheung et al., 2015; McLoughlin et al., 2010). Furthermore, numerous studies have found that children, adolescents, and adults with ADHD tend to perform more poorly on executive function tasks relative to control participants (Biederman et al., 2004; Clark, Prior, & Kinsella, 2000; Nigg et al., 2005; Toplak, Bucciarelli, Jain, & Tannock, 2008; Wiegand et al., 2016); however, it is important to note that executive function deficits are not uniquely characteristic of ADHD (Craig et al., 2016; Weyandt, 2009).

ADHD was primarily considered a childhood disorder (Biederman et al., 1993); however, longitudinal studies have substantiated that the majority of individuals diagnosed with ADHD continue to exhibit symptoms into adulthood (Barkley, 2014; Biederman, Petty, Clarke, Lomedico, & Faraone, 2011; Cheung et al., 2015; Fischer, Barkley, Smallish, & Fletcher, 2005). A substantial body of research has found that adults with ADHD, compared to their same-age peers, are at greater risk for neuropsychological deficits, comorbid psychiatric diagnoses, vehicular accidents, criminal offenses, and psychosocial problems (Barkley, Murphy, DuPaul, & Bush, 2002; Kessler et al., 2006; Mostert et al., 2015). Recent research has begun to focus on a subsample of adults with ADHD, namely college students, as increasing numbers of high school students with ADHD are attending college (Weyandt & DuPaul, 2012; Wolf, Simkowitz, & Carlson, 2009). Relative to the child and adult populations, little empirical information is currently available concerning the performance of these students with respect to cognitive and neuropsychological functioning, and the studies that are available have produced inconsistent findings. Some studies have found, for example, that college students with ADHD perform poorly on working memory tasks (Gropper, Gotlieb, Kronitz, & Tannock, 2014; Kim, Liu, Glizer, Tannock, & Woltering, 2014) and continuous performance tasks (Jarrett, Rapport, Rondon, & Becker, 2014; McLoughlin et al., 2010; Weyandt, Mitzlaff, & Thomas, 2002) as well as various domains of self-reported executive function (Gray et al., 2014; Weyandt et al., 2013). Others, however, have found that college students with ADHD perform similar to non-diagnosed peers on verbal learning tasks (Semrud-Clikeman & Harder, 2011; Weyandt et al., 2013), measures of intelligence (Advokat, Martino, Hill, & Gouvier, 2007; Weyandt, Mitzlaff, Thomas, 2002), self-reported grade point average (Gray et al., 2015), continuous performance task measures (Weyandt et al., 2013), and visual search tasks (Dehili, Prevatt, & Coffman, 2013).

Factors likely contributing to the disparate findings across studies have been identified by Weyandt and DuPaul (2008) and largely relate to methodological variability and shortcomings. For example, most studies consist of small sample sizes and are characterized by low statistical power. Diagnostic rigor varies among the studies, as do the psychometric properties and intra-subject variability on the neuropsychological tasks employed (Klein, Wendling, Huettner, Ruder, & Peper, 2006). In addition, many studies rely on students with ADHD who self-refer to counseling or disability services offices; yet, these students are estimated to comprise only one third of college students with the disorder (Advokat, Lane, & Luo, 2011). It is also possible that medications used to treat ADHD obfuscate neuropsychological differences among college students, a hypothesis that has remained virtually unexplored in the literature. A psychopharmacological review of the effects of stimulants with adults in general, conducted by Smith and Farah (2011), suggested that the only area of neuropsychological functioning with considerable evidence for an enhancement effect was long-term declarative memory, although effect sizes varied according to the specific task and study. Other areas of functioning (i.e., working memory and cognitive control), however, were not enhanced following ingestion of a prescription stimulant (Smith & Farah, 2011). Additional research is needed to clarify whether stimulant medication can enhance cognitive functions other than long-term declarative memory among individuals with ADHD. Notably, DuPaul and colleagues (2012) conducted a randomized, double-blind, placebo-controlled trial in a sample of college students with ADHD and found that prescription stimulants (lisdexamfetamine dimesylate) were associated with improvements in self-reported as well as task-based measures of executive functioning compared to a placebo, among college students with ADHD.

The present study addressed the methodological limitations of previous studies and further explored the neuropsychological performance of college students with ADHD compared to those without the disorder. To that end, the present study used a large, multi-site sample as well as rigorous diagnostic and assessment procedures. Specifically, the present study examined the performance of college students with and without ADHD on self-reported and laboratory measures of neuropsychological functioning including executive functioning, and investigated the association between self-reported stimulant medication use and neuropsychological performance among students with ADHD. It was hypothesized that: a) college students with ADHD would perform more poorly relative to those without the disorder on measures of intelligence and executive function; and b) participants with ADHD who self-reported being medicated with prescription stimulants at the time of assessment would perform better on measures of executive function and intelligence than participants with ADHD who were not taking prescription stimulant medication.

Method

Participants

A total of 527 first-year college students were initially screened to determine their eligibility for a 4-year multi-site longitudinal investigation, the Trajectories Related to ADHD in College (TRAC) project. A total of 456 (i.e., ADHD = 228; Comparison = 228) met study eligibility requirements; however, 13 withdrew from the project before completing the second of a four-stage assessment process, and 7 did not have complete data for the present analyses. Therefore, the total sample for the current study comprised 436 participants (ADHD = 216; Controls = 220) who had complete first-year data for the present analyses. The present study included 211 males (48.4%) and 225 females (51.6%) ranging in age from 18 to 22 years (*M* = 18.2; *SD* = 0.02). The racial/ethnic composition of the present sample was 28.7% from racially diverse, non-Caucasian backgrounds, and 11.3% from Hispanic/Latino backgrounds. Overall racial/ethnic diversity (i.e., students who endorsed being of Hispanic/Latino ethnicity and/or non-Caucasian racial backgrounds) was 32.1% (28.3% in the ADHD group; 35.9% in the

Comparison group). The overall rate of having one current non-ADHD psychiatric or learning disability diagnosis was significantly higher for the ADHD group (55%) versus the Comparison group (11%).

To be eligible for the ADHD group, participants were required to meet DSM-5 criteria (American Psychiatric Association, 2013). ADHD and non-ADHD comparison group status was determined via a four-stage multi-method assessment procedure that included expert panel review. The first stage of this assessment included the completion of a self-report ADHD Rating Scale (DuPaul, Power, Anastopoulos, & Reid, 1998), which was modified to address current and past ADHD symptoms, in addition to medication status. If a participant's self-report or parent-report indicated frequent displays of 4 or more symptoms of either inattention or hyperactivity-impulsivity during both childhood and the past 6 months, a semi-structured interview for adult ADHD was then administered to address full DSM-5 criteria for ADHD, which included the requirement of 5 or more symptoms of either inattention or hyperactivity-impulsivity being present. This same interview was administered to potential Comparison participants whose self- and parent-reported responses to the ADHD Rating Scale indicated the presence of 3 or fewer symptoms for both inattention and hyperactivity-impulsivity during childhood and during the past 6 months. Participants whose interview responses continued to suggest the presence of 3 or fewer symptoms from both symptom lists were deemed eligible for the Comparison group. All potentially eligible cases were then reviewed by a panel of four ADHD experts (i.e., the three principal investigators and a nationally recognized adult ADHD consultant). Unanimous panel agreement was required for final determination of ADHD and Comparison group status, as well as for determination of non-ADHD psychiatric and learning disability comorbidity status. For detailed information regarding ADHD diagnostic results (e.g., ADHD Rating Scale, Semi-

Structured Interview for ADHD) as well as the prevalence and nature of comorbidities within the present sample, the reader is referred to a related publication by our team (Anastopoulos et al., 2016).

Measures

Eligibility Determination Measures

Background information. All participants completed a one-page information form regarding demographic and contact information. Participants also underwent a background interview to provide information about their K-12 school history, family of origin demographics, and personal and family histories of mental health difficulties.

ADHD Rating Scale, Self-Report Version (ADHD RS-SRV). The ADHD RS-SRV, developed specifically for the purposes of this study, is a modified version of the ADHD RS-IV (DuPaul et al., 1998). Like its predecessor, the ADHD RS-SRV lists the inattention (IN) and hyperactive-impulsive (HI) symptoms in alternating fashion, and the frequency of occurrence for each symptom can be rated as: 0 (*never or rarely present*), 1 (*sometimes present*), 2 (*often present*), or 3 (*very often present*). Summing the number of items scored 2 or 3 yields symptom frequency counts for both IN and HI, which were used for eligibility screening purposes. Unlike the ADHD RS-IV, the ADHD RS-SRV addresses ADHD symptoms both during childhood and during the past 6 months, while also taking into account medication status. In the current study coefficient alphas were very good (.74) to excellent (.94) for the childhood and past 6 months reports of both IN and HI symptoms, regardless of medication status. There was also evidence of concurrent validity, with correlations between the IN and HI scores and their respective Conners' Adult ADHD Rating Scale, Self-Report, Long Form (CAARS-S:L) dimensions ranging from .27 to .92 (all p values $< .01$).

ADHD Rating Scale, Parent-Report Version. The ADHD RS-PRV is a modified version of the ADHD RS-IV (DuPaul et al., 1998) that requires parents to rate their child's IN and HI symptoms both during childhood and during the past 6 months. For parents of participants with histories of taking medication for managing ADHD, instructions were given to provide ratings based on the participant's status when not taking medication. The format and scoring of the ADHD RS-PRV are similar to that of the ADHD RS-SRV. In the current study, the ADHD RS-PRV demonstrated excellent psychometric properties, with very good to excellent internal consistency (.89 to .94), and correlations between the IN and HI scores and corresponding CAARS-S:L dimensions ranging from .49 to .61 (all p values < .001).

Semi-Structured Interview for Adult ADHD. The Semi-Structured Interview for Adult ADHD was developed specifically for this study to provide an assessment of functional impairment at the ADHD symptom level, while also taking into account medication status. The nine IN symptoms are presented first, followed by the nine HI symptoms. For each symptom endorsed as being present "most of the time," additional questioning takes place to determine that symptoms impact school, social, and other areas of daily functioning. Upon completing a review of all nine IN symptoms, further questioning is conducted to address duration, age of onset, and other DSM-5 criteria for ADHD. Similar questioning follows the review of the nine HI symptoms. As needed, follow-up questioning is conducted for participants whose initial responses were based on their functioning while taking medication. More specifically, participants are asked to rate symptoms at times when not taking medication. In the current study coefficient alphas for both the IN and HI portions of the interview were excellent (.90 and .85, respectively), and both symptom dimensions were highly correlated with their respective CAARS-SL dimensions (.78 and .84, respectively).

Structured Clinical Interview for DSM Disorders (SCID-I). The SCID-I (First, Gibbon, Spitzer, & Williams, 1996) is a psychometrically sound, clinician-administered, semi-structured interview that has been used widely in clinical research to identify categorical psychiatric disorders. The SCID-I Mood and Anxiety Disorders modules were administered to all participants. Other SCID-I modules were given whenever participants reported a personal or family history of psychiatric disorders during the background interview. Because DSM-5 criteria for many non-ADHD conditions had not yet been finalized at the time these first year data were collected, DSM-IV-TR (American Psychiatric Association, 2000) guidelines were used to assess these non-ADHD conditions. Diagnoses generated from the SCID-I served to identify mental health conditions that might rule out ADHD, be comorbid with ADHD, or be present among Comparison participants.

Present Study: Measures of Primary Interest

Conners' Continuous Performance Test II. The Conners' Continuous Performance Test II (CPT II; Conners & MHS Staff, 2000) was administered to measure sustained attention, behavioral inhibition, and vigilance. During administration, respondents were required to press the spacebar whenever any letter except the letter "X" appears on the computer screen. The administration of the CPT-II takes 14 minutes among individuals 6 years of age and older. The inter-stimulus intervals (ISIs) are 1, 2 and 4 seconds with a display time of 250 milliseconds. The test is structured in 6 blocks, with 3 sub-blocks, each containing 20 trials (i.e. letter presentations), with ISI varying between blocks.

Split-half reliability between trials is shown to be adequate on hit reaction time (i.e., the average speed of correct responses for the entire test; 0.95), errors of commission (i.e., responses given to non-targets, X's; 0.83), errors of omission (i.e., failure to respond to target letters, non-

Xs; 0.94), standard error (i.e., response speed consistency, with greater numbers reflecting greater inconsistency; 0.87), variability (i.e., within respondent, response speed variability over 18 separate segments; 0.66), d prime (i.e., detectability or the difference between the signal (non-X) and noise (X) distributions, with greater scores representing better ability to distinguish and detect X and non-X stimuli; 0.83), and beta (i.e. response style, with higher values of beta reflecting more cautious response styles; 0.73; Conners & MHS Staff, 2000). A measure of perseverations is also included on the CPT, which reflects any reaction time that is less than 100 ms, suggesting either slow responses to a preceding stimuli, a random response, an anticipatory response, or a response repeated with no consideration of the stimuli or task requirements (Conners & MHS Staff, 2000). Furthermore, hit reaction time by block (i.e., hit RT block change, or the change in reaction time across the duration of the test with high values indicating a substantial slowing in reaction times), standard error by block (i.e., hit SE block change, or the changes in response consistency over the duration of the test with high values indicating a substantial loss of consistency over the progression of the test), reaction time by inter-stimulus interval (i.e., hit RT ISI change or the average reaction times at the different ISIs, that is, when letters are presented at 1, 2, or 4 second intervals), and standard error by inter-stimulus interval (i.e., hit SE ISI change, or the change in standard error of reaction times at the different ISIs, that is, when letters are presented at 1, 2, or 4 second intervals) are measured (Conners & MHS Staff, 2000).

Omission errors indicate the number of times the target was presented but the participant did not respond/press the spacebar. High omission rates indicate that the participant was either not paying attention (distractibility) to stimuli or had a sluggish response. Commission errors indicate the number of times the participant responded, but no target was presented. A fast reaction time and high commission error rate point to difficulties with impulsivity, while a slow reaction time with high commission and omission errors indicate general inattention. Norms from a nationally representative sample are available, and T-scores for hit reaction time, omission error, commission error, hit RT standard error, variability, detectability, beta, perseverations, hit RT block change, hit SE block change, hit RT ISI change, and hit SE ISI change were used as dependent variables in the present study.

The procedure included the respondent reading through the instructions on the computer screen, after which the administrator briefly reiterated the instructions for the respondent and then gave the respondent the standard practice trials to be certain the instructions were understood. The administrator was not present in the room while the participant completed the CPT task.

Behavior Rating Inventory of Executive Function- Adult Version. Aspects of executive functioning were assessed using the Behavior Rating Inventory of Executive Function, BRIEF Adult Version (Gioia, Isquith, Guy & Kentworthy, 2000). The BRIEF is a self-report instrument that takes approximately 10 minutes to complete and has adequate psychometric properties. Children and adults with ADHD have been found to perform more poorly on executive function measures including the BRIEF, relative to control participants (Nigg et al., 2005; Toplak et al., 2008). In addition to providing nine specific executive functioning scores, the BRIEF generates three general composite scores - Behavior Regulation Index, Metacognition Index, and General Executive Composite. To complete the BRIEF, participants rate the frequency of 75 problematic behaviors over the past month on a 3-point scale (1 = *never*; 2 = *sometimes*; 3 = *often*). Higher scores indicate greater degrees of executive dysfunction. The nine clinical scales form two broader scales, the Behavioral Regulation Index (BRI) and the

Metacognition Index (MI), as well as an overall summary score, the Global Executive Composite (GEC). The BRI incorporates scores from the Inhibit, Shift, Emotional Control, and Self-Monitor subscales. The MI incorporates scores from the Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials subscales. The scores from all nine subscales are included to form the GEC. The BRIEF-A has demonstrated reliability, validity, and clinical utility as an ecologically sensitive measure of EF in healthy respondents, as well as individuals with a range of psychiatric and neurological conditions (Roth, Isquith, & Gioia, 2005).

Wechsler Abbreviated Scale of Intelligence – Second Edition. The Wechsler Abbreviated Scale of Intelligence – Second Edition (WASI-II; Wechsler & Hsiao-pin, 2011) was implemented to assess participant intellectual functioning. The WASI-II consists of four subtests, two comprise the Verbal Scale (Vocabulary and Similarities) and the remaining two comprise the Performance Scale (Block Design and Matrix Reasoning). The FSIQ-2 scale is an estimate of participants' general cognitive ability, and comprises the Vocabulary and Matrix Reasoning subtests. The WASI was standardized on a large and highly representative sample, and has shown high test-retest reliability, internal consistency, and validity (i.e., high correlation with WISC-III). Participants were administered only Vocabulary and Matrix Reasoning due to time considerations and these two subtest scores, along with a Full Scale IQ estimate, served as dependent variables in the present study.

Services for College Students Interview - Assessment of Stimulant Medication Status. The Services for College Students Interview (SCSI) was developed to assess campus resources and treatment services participants may receive throughout the college years, including assistance from an academic advisor or professor, academic skills assistance, academic tutoring, writing or speaking assistance, career counseling, formal disability service accommodations, medication for attentional, learning, emotional, or behavioral difficulties, and individual or group counseling/therapy. For the present study, medication for attention difficulties (i.e., stimulant medication status) served as a dependent variable.

Procedure

The goal of the TRAC study is to examine multiple functional trajectories (e.g., educational, behavioral, social, vocational) across this early period of emerging adulthood and to identify risk and protective factors that inform clinical assessment and treatment. Three primary sites are involved, including one university in the Southeast and two universities in the Northeast United States. In addition, six colleges and universities near the primary sites served exclusively as recruitment sites. Two cohorts of first-year students were recruited successively across the first two years of the project. A total of 219 participants were recruited in Cohort 1, another 237 participants were recruited in Cohort 2. All participants underwent an annual four-stage assessment process, and earned up to $100 as an incentive for completing all required procedures. Data collected from the first of four planned annual assessments were used in this study.

Participants were recruited from a variety of sources, including summer orientation sessions, disability services, student counseling centers, fliers, and presentations to large first-year classrooms. Participants with and without ADHD, who were entering college for the first time and between the ages of 18 and 25 years were consented into the project and asked to complete the current and childhood self-report versions of the ADHD RS. In addition, their parents were asked to complete the parent version of the ADHD RS, addressing both current and childhood symptoms. Data collected from these self- and parent-report versions of the ADHD RS served as the basis for determining which participants moved on to the next assessment phase, involving the Semi-Structured Interview for Adult ADHD. Information from this interview, in combination with information about non-ADHD conditions derived from the SCID-I, was then used to determine which cases would be forwarded to the expert panel for review and final determination of ADHD or Comparison group classification, as well as psychiatric comorbidity status. Therefore, participants assigned group status (i.e., ADHD or Comparison) were based on the present assessment results and expert panel review. The expert panel consisted of 4 Ph.D. level psychologists all of whom have extensive knowledge of ADHD. Background history data and relevant information collected later in the four-stage assessment process (i.e., self-reported receipt of special education services and IQ-achievement discrepancies) were similarly forwarded to the panel for determination of learning disability (LD) status. For cases lacking unanimous panel agreement, weekly telephone conference calls were conducted for the purpose of resolving these differences of opinion and ultimately reaching a unanimous decision. Of the participants with ADHD, 110 (48.2%) were taking prescription medication at the time they entered the study and due to ethical reasons (i.e., academic performance, exams) students were not asked to refrain from taking their medication while participating in the study. Tables 1 and 2 illustrate the demographic characteristics of the current sample and its subgroups, as well as the percentage of participants meeting criteria for 1 or more comorbid disorders. Demographically, the ADHD and comparison groups were statistically equivalent except with regard to race/ethnicity; however, ADHD symptomatology and comorbidity rates were significantly higher in the ADHD group, as expected.

All data were collected by pre-doctoral and doctoral level staff from clinical psychology and school psychology backgrounds. All staff received extensive training prior to the start of the project, and their adherence to the various assessment protocols was monitored on an ongoing basis to maintain consistency across sites. All study procedures were reviewed on an annual basis and were approved by the Institutional Review Boards at each site.

Data Analysis

Multivariate analyses of variance (MANOVAs) and independent sample *t*-tests were conducted to test the study hypotheses. Additionally, Cohen's *d* effect sizes were computed for all group comparisons (Cohen, 1992).

Given that participants completed the study assessments across three separate sessions, and that not all participants completed all three sessions, sample sizes differ across measures/analyses. For example, the CPT-II was completed during the second assessment session whereas the WASI-II and the BRIEF-A were completed during the third session. Thus, due to attrition, the sample used for the CPT-II analyses is slightly larger than the sample used for the WASI-II and BRIEF-A analyses. Additionally, it should be noted that for analyses pertaining to potential medication effects, only participants from the ADHD group who reported: a) having taken prescription stimulant medication at the time of assessment or b) having taken no medication at all were included. Hence, participants who reported taking a non-stimulant (CPT analyses n = 2; WASI analyses n = 5) or any other medication (CPT analyses n = 6; WASI analyses n = 3), as well as those whose medication status at the time of assessment was unclear or missing (CPT analyses n = 12; WASI analyses n = 22), were excluded from the medication analyses. To decrease the false-positive results rate of the *t*-test findings, the Benjamini-Hochberg method was used (Benjamini & Hochberg, 1995). All *t*-test results that were significant at the .05 level survived the false-positive correction.

Results

MANOVA results revealed a statistically significant difference in CPT-II performance across the two groups (ADHD vs. comparison): $F(12, 423) = 6.83$, $p < 0.001$; Wilks' $\Lambda = 0.838$, Pillai's Trace = 0.162, partial $\eta^2 = 0.162$. With regard to BRIEF-A ratings, MANOVA results also revealed a statistically significant difference across groups (ADHD vs. comparison): $F(12, 407) = 67.20$, $p < 0.001$; Wilks' $\Lambda = 0.335$, Pillai's Trace = 0.665, partial $\eta^2 = 0.665$.

Results further revealed participants with ADHD performed significantly more poorly than participants without ADHD on most CPT-II score indices, including: Omissions %, Commissions %, Hit RT Std. Error, Variability, Detectability (d'), Perseverations %, Hit RT Block Change, Hit SE Block Change, and Hit RT ISI Change (see Table 3). Cohen's *d* effect sizes (Cohen, 1992) ranged from small (e.g., $d = 0.25$ for Hit RT Standard Error) to medium/large (e.g., $d = 0.76$ for Commission percentage). Similarly, participants with ADHD self-reported greater executive dysfunction relative to the comparison group on all subscales and composite scores of the BRIEF-A (see Table 4), with all Cohen's *d* effect sizes in the large range (Cohen, 1992). In contrast, no statistically significant group differences in intellectual performance were found for the Vocabulary, Matrix Reasoning, and FSIQ-2 scores of the WASI-II (see Table 5), which were in the high end of the average range.

Regarding hypothesis 2, mixed results were found, which were dependent on the CPT index assessed. No statistically significant differences in number of CPT-II omission and commission errors were found between participants with ADHD taking stimulant medication at the time of assessment and participants with ADHD who were not taking any medication; however, the Hit Reaction Time Standard Error, Variability, Perseverations, and Hit Reaction

Time ISI Change were significantly lower among those taking stimulant medication at the time of assessment (see Table 6), with Cohen's *d* generally in the medium range (Cohen, 1992).

Contrary to expectations, no significant differences were found in WASI-II Vocabulary, Matrix Reasoning, or FSIQ-2 scores based on stimulant medication status at the time of assessment (see Table 7). Interestingly, group difference in Matrix Reasoning scores approached, but did not reach, statistical significance ($p = 0.07$). The estimated post-hoc power of the present study ranged from a low of 0.23 to a high of 0.99, depending on analysis (Faul, Erdfelder, Buchner, & Lang, 2009).

Additional analyses were conducted to investigate the relationship between having an ADHD diagnosis, having other psychiatric diagnoses (i.e., comorbidity), and executive functioning as measured by the CPT-II and BRIEF-A. MANOVA results revealed a statistically significant difference in a linear combination of CPT-II score indices based on participant ADHD status: $F(12, 421) = 3.49$, $p < 0.001$; Wilks' $\Lambda = 0.909$, Pillai's Trace = 0.091, partial $\eta^2 = 0.091$ as well as other psychiatric diagnostic status (i.e., no other psychiatric diagnosis vs. 1 or more diagnoses): $F(12, 421) = 1.98$, $p = 0.02$; Wilks' $\Lambda = 0.947$, Pillai's Trace = 0.053, partial $\eta^2 = 0.053$, wherein having ADHD and/or 1 or more psychiatric diagnoses was associated with a *poorer* outcome. No statistically significant interaction between ADHD and other psychiatric diagnostic status was found: $F(12, 421) = 0.585$, $p = 0.86$; Wilks' $\Lambda = 0.984$, Pillai's Trace = 0.016, partial $\eta^2 = 0.016$.

With respect to group status and comorbidity, results of additional MANOVA analyses revealed a statistically significant difference in a linear combination of all BRIEF-A score indices based on participant ADHD status: $F(12, 405) = 44.40$, $p < 0.001$; Wilks' $\Lambda = 0.432$, Pillai's Trace = 0.568, partial $\eta^2 = 0.568$ as well as other psychiatric diagnostic status (i.e., no other psychiatric diagnosis vs. 1 or more diagnoses): $F(12, 405) = 4.22$, $p < 0.001$; Wilks' $\Lambda = 0.889$, Pillai's Trace = 0.111, partial $\eta^2 = 0.111$, wherein having ADHD and/or 1 or more psychiatric diagnoses was associated with a *poorer* executive functioning outcome. No statistically significant interaction between ADHD and other psychiatric diagnostic group status was found: $F(12, 405) = 1.918$, $p = 0.03$; Wilks' $\Lambda = 0.946$, Pillai's Trace = 0.054, partial $\eta^2 = 0.054$.

Discussion

The purpose of this study was to investigate the performance of first-year college students with and without well-defined ADHD on measures of neuropsychological functioning including intelligence and executive function, and to explore the relationship between self-reported psychostimulant medication status and neuropsychological performance. Based on previous findings and current theoretical conceptualizations of ADHD, it was hypothesized that college students with ADHD would demonstrate greater executive dysfunction, as measured by a laboratory-based task (i.e., CPT-II) and self-report rating scale (i.e., BRIEF-A) of EF. Indeed, results revealed that college students with ADHD reported greater difficulty with organization, planning, inhibition, working memory, and metacognition as measured by the BRIEF-A, and demonstrated greater difficulty in the areas of attention, sustained attention, vigilance, and impulsivity as measured by the CPT-II.

Self-reported Executive Functioning Outcomes

These findings suggest that first-year college students with ADHD, compared to their non-ADHD counterparts, may require additional support with regard to organizing and planning daily activities. In addition, problems associated with inhibition and impulsivity may impair the ability of college students with ADHD to resist impulses and control their own behavior and may relate to difficulties delaying gratification (e.g., completing homework and/or studying for exams rather than socializing with peers or engaging in other preferred behaviors; Isquith, Roth, Gioia, & PAR Staff, 2006). Difficulties with working memory suggest college students with ADHD have trouble maintaining and manipulating information in their mind (e.g., when performing mathematical calculations and/or following multi-step instructions), and problems with shifting from one task to another can potentially cause difficulty managing multiple demands at once, as is common for college students (e.g., managing demands for multiple classes, attending a job, and taking care of personal needs). Furthermore, inattention, difficulties sustaining attention and vigilance may further impair college students' abilities to attend to important information and manage their coursework and personal life during the college years. A study conducted by our research team (Gormley et al., 2015), using the current dataset, corroborated this pattern; students with ADHD had lower GPAs and self-reported poorer study skills than students without ADHD. Overall, these findings underscore the need for developing interventions to assist college students in developing strategies to cope with these areas of difficulty (Anastopoulos & King, 2015; Fuermaier et al., 2015; Isquith et al., 2006; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Van Ewijk et al., 2014; Weyandt, 2009; Weyandt et al., 2014).

Attention Outcomes

On a laboratory-based neuropsychological measure (CPT-II) of executive functions, college students with ADHD demonstrated poor detectability, significantly more errors of omission and commission, as well as high levels of inconsistency in response speed, suggesting greater levels of inattention compared to the control group. Poor performance on the detectability index is an indicator of inattention, a finding also reported by Epstein and colleagues (1998), who examined the performance of adults with and without ADHD. Furthermore, greater errors of omission and commission suggest college students with ADHD may be more inattentive to stimuli or have a more sluggish response style than students without ADHD, although additional research investigating the external validity of these findings in the academic setting is needed to explore these hypotheses. The higher rate of omission and commission errors on continuous performance tasks by college students with ADHD are generally consistent with previous research conducted with adults with ADHD (Epstein, Conners, Sitarenios, & Erhardt, 1998; Hervey, Epstein, & Curry, 2004; Raz, Bar-Haim, Sadeh, & Dan, 2014). Participants with ADHD demonstrated high levels of response speed inconsistency, as evidenced by significantly more response time standard errors and poorer performance on the variability index. These findings support previous research documenting that college students with ADHD perform more variably on the CPT-II (Advokat et al., 2007; Johnson, et al., 2007; 2008; Leth-Steensen, Elbaz, & Douglas, 2000; McLoughlin et al., 2010; Weyandt et al., 2013). Although children with ADHD typically perform worse on laboratory tasks of EF, Leth-Steensen and colleagues (2000) found better performance (i.e., faster and less variable) among children with ADHD when compared to a younger control group, but worse performance when compared to an age-matched control group. These findings highlight the importance of age and development on CPT-II performance. Furthermore, Advokat and colleagues (2007) found that college students with ADHD and a cognitive disorder, respectively, performed with significantly greater variability on these indices compared to students with psychiatric disorders. Perhaps, college students with ADHD and/or a cognitive disorder compared to those with a psychiatric disorder differ in the types of executive functioning deficits experienced. Although a number of studies have documented that college students with ADHD demonstrate more variable response time than controls (Advokat et al., 2007; Weyandt et al., 2013), Jarrett and colleagues (2014) reported no significant group differences in this area of executive function. In summary, present findings revealed that college students with ADHD performed more poorly on neuropsychological tasks of attention, as evidenced by poor detectability, greater errors of omission and commission, and high levels of inconsistency in response speed (i.e., hit reaction time standard error and variability).

Sustained Attention and Vigilance Outcomes

College students with ADHD also demonstrated greater difficulty with sustained attention, as evidenced by greater hit reaction time block change and hit reaction time standard error block change. In addition, students with ADHD presented difficulties with vigilance as evidenced by greater hit reaction time inter-stimulus interval change. Previously, sustained attention and vigilance were often considered the same construct, however, current research differentiates the two (Egeland et al., 2009). Sustained attention may be defined as the student's ability to maintain attention as the CPT administration progresses, while vigilance is the student's ability to maintain their performance level even when the task rate is slow. Interestingly, previous research has documented greater sustained attention difficulties among students with ADHD predominantly inattentive subtype, while those with ADHD combined subtype demonstrated greater difficulties with vigilance (Egeland et al., 2009).

Impulsivity Outcomes

On both a laboratory-based neuropsychological measure (CPT-II) of executive functioning and a self-report rating scale (BRIEF) of executive functioning, college students with ADHD demonstrated significantly more difficulty with impulse control.

On the CPT-II students with ADHD demonstrated greater perseverations and errors of commission, and these findings suggest college students with ADHD may be more impulsive than students without ADHD, which is generally consistent with previous research conducted with adults with ADHD (Epstein, Conners, Sitarenios, & Erhardt, 1998; Hervey, Epstein, & Curry, 2004; Raz, Bar-Haim, Sadeh, & Dan, 2014). It is also important to note that although a majority of studies documented greater perseverations and commission errors among participants with ADHD, other studies have not found such differences (Egeland, Johansen, & Ueland, 2009; Jarrett et al., 2014). Alternatively, previous research also indicates that individuals with a cognitive disorder (e.g., reading disorder; Advokat et al., 2007; McGee, Clark, & Symons, 2000) and/or a psychiatric condition (e.g., depression; Porter, Gallagher, Thompson, & Young, 2003) have also committed greater commission errors on continuous performance tasks, therefore it is important to note that poor performance on CPT tasks is *not* unique to ADHD. In fact, results from the present study suggest college students with one or more non-ADHD psychiatric diagnoses (e.g., mood, anxiety, and other disorders) performed *more poorly* on CPT-II tasks compared to those without such a diagnosis. No statistically significant interaction between ADHD and psychiatric diagnostic group status emerged; therefore, having a psychiatric diagnosis, irrespective of ADHD status, may be predictive of executive functioning deficits, i.e., executive function deficits are not necessarily characteristic of nor unique to ADHD (Weyandt, 2009). Psychiatric diagnostic group status also was predictive of self-reported EF, as measured by the BRIEF-A. For example, college students with one or more diagnoses reported greater EF deficits compared to participants without a clinical diagnosis. Therefore, collectively these findings suggest that having a comorbid psychiatric diagnosis in addition to an ADHD diagnosis is associated with even greater EF deficits than having either an ADHD or a psychiatric diagnosis alone. Given the importance of executive functions in daily living and academic performance, future research is needed to further examine executive function performance in college students with ADHD and other clinical groups.

On the BRIEF-A, students reported greater difficulties with inhibition and emotional control. As such, students with ADHD appear to perceive themselves as struggling more with thinking before acting, as well as negative emotional responses and outbursts, as compared to their non-ADHD peers.

In summary, present findings revealed that college students with ADHD performed more poorly on neuropsychological indices of attention, as evidenced by greater omission, commission, and response time standard errors, and poorer performance on the variability, detectability, and hit reaction time standard error indices. College students with ADHD also performed more poorly on indices of sustained attention, as evidenced by greater hit reaction time by block change and hit reaction time standard error block changes. Students with ADHD also demonstrated a loss of vigilance, with greater hit reaction time inter-stimulus interval changes. Lastly, college students with ADHD performed more poorly on executive function indices of impulsivity, as evidenced by greater commission and perseveration errors. Overall, these findings support that college students with well-defined ADHD perform more poorly on executive function indices of attention, sustained attention, vigilance, and impulse control compared to their non-ADHD peers.

Non-significant Outcomes

Interestingly, statistically significant differences were not found between college students with and without ADHD on hit reaction time, response style, and hit reaction time standard error by interstimulus change. To some degree, these findings are similar to those reported by Cohen and Shapiro (2007) who did not find statistically significant differences on the hit reaction time, response style, and hit standard error by interstimulus change measures of the CPT-II across groups of young adults with and without ADHD; however, unlike the present results, Cohen and

Shapiro (2007) did not find significant differences for errors of omission, variability, perseverations, hit reaction time block change, and hit standard error block change either. Collectively, results suggest that college students with ADHD demonstrate poorer EF performance on some, but not all EF measures compared with their peers without ADHD. These results support Weyandt's (2009) and more recently Craig et al. (2016) analysis that neuropsychological, particularly executive function deficits are not uniformly characteristic of ADHD, nor are these deficits unique to students with ADHD.

Although a number of studies have found that individuals with ADHD demonstrate poorer performance on the CPT-II indices, it is plausible that discrepant findings across studies examining CPT-II performance result from methodological differences (e.g., medication status), ceiling effects, small samples, within-group heterogeneity, and varying diagnostic criteria (Epstein et al., 1998; Nigg et al., 2005). One of the particular strengths of the current investigation, however, is the relatively large sample, statistical power, and the rigorous diagnostic procedure to identify ADHD and other psychiatric conditions, collectively supporting the validity of the present findings. Interestingly, no differences were found between college students with and without ADHD on intelligence as measured by the WASI-II FSIQ-2 estimate. This finding supports results from Weyandt and colleagues (2002), who also reported that college students with and without ADHD performed similarly on a standardized, norm-referenced IQ test. These findings suggest IQ may not be an important factor affecting the difficulties faced by some college students with ADHD. Although other research has found lower IQ scores in children and adults with ADHD compared to controls, fundamental differences may exist in individuals with ADHD who attend college compared to individuals with ADHD who do not (Barkley, Murphy, & Fischer, 2007; Glutting, Youngstrom, & Watkins, 2005). In other words, students with ADHD who pursue postsecondary education may represent a highly selective subgroup of individuals with ADHD whose cognitive/intellectual functioning may be higher than that of those with ADHD who do not attend college. Overall, these results highlight the need for additional neuropsychological research focusing on the unique group of college students with ADHD.

Medication Outcomes

A critical finding in the present study is that college students taking stimulant medication performed significantly better than those with ADHD who were not taking stimulants on several of the CPT-II measures, namely, hit reaction time standard error, variability, perseverations, and hit reaction time ISI change. While increased variability in response time is considered a primary deficit of ADHD, the present study and previous research highlight the positive effects prescription stimulants have on such outcomes (Johnson et al., 2008). The present study, therefore, supports previous research that has demonstrated an association between stimulant medication and enhanced performance on several ADHD-related tasks (e.g., Finke et al., 2010; Johnson et al., 2008). More specifically, it appears that stimulant medication is associated with improved vigilance and impulse control among college students with ADHD.

Additional CPT-II indices, however (e.g., Omissions %, Commissions %), were not significantly different across the two groups (i.e., participants with ADHD on vs. off medication), which was a significant weakness within the ADHD group in the present study, corroborated by previous research findings (Epstein et al., 1998; Hervey et al., 2004; Raz et al., 2014). These findings, however, differ from previous research, where stimulant medication administration was associated with normalized levels of commission errors (Johnson et al., 2008). The present study also found that college students with ADHD performed more poorly on the detectability index. Hence, it appears that stimulant medication is associated with improvement on some (i.e., hit reaction time standard error, variability, perseverations, and hit reaction time ISI change), but not all, laboratory measures of executive functioning. It is important to note, however, that due to ethical considerations, participants were not assessed off medication and it remains unknown how these participants would have performed without medication. A prior double-blind, placebo-controlled study by DuPaul et al (2012), however, did find that prescription stimulant medication (lisdexamfetamine dimesylate) was associated with substantial improvement in self-reported levels of executive functioning (as measured by the BRIEF-A) compared to a placebo, among college students with ADHD. Given the findings of the present study along with those of DuPaul et al (2012), future studies are clearly needed to further investigate the effects of medication on neuropsychological functioning of college students with ADHD.

Collectively, the results from the present study suggest college students with ADHD are more likely to struggle with attention, planning, and organization, skills that are critical for college student success, thereby placing these students at increased risk for academic and psychosocial difficulties (Advokat et al., 2011; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999; Murphy et al., 2002; Pope, 2010; Schwanz, Palm, & Brallier, 2007; Weyandt et al., 2013; Wolf et al., 2009). Moreover, research has found that ADHD symptoms in conjunction with executive function deficits in college students are associated with a number of risky behaviors including alcohol use (Langberg, Dvorsky, Kipperman, Molitor, & Eddy, 2014; Rooney, Chronis-Tuscano, & Huggins, 2012), and risky sexual behavior (Golub, Starks, Kowalczyk, Thompson, & Parsons, 2012). It is plausible that executive function deficits lead to impaired decision-making, which, in turn, may lead to unsafe sexual behavior and substance use.

The present findings, therefore, may have implications for prevention/intervention programs targeting college student risky behavior, especially among students with ADHD.

Limitations

Several important limitations should be considered when interpreting the present findings. First, high levels of comorbidity in our sample of college students with ADHD were present (55%) with anxiety and depression as the most commonly occurring comorbid conditions (Anastopoulos et al., 2015). A similar comorbidity rate was reported by Heiligenstein and Keeling (1995) among a sample of college students with ADHD, and childhood and adult studies consistently report high comorbidity rates within the ADHD population (Barkley et al., 2007; Pliszka, 2014; Willcutt et al., 2012). It should be noted, however, that anxiety and depression are also associated with attention and concentration difficulties (American Psychiatric Association, 2013) and these symptoms may have influenced the self-reported and/or behavioral executive function outcomes in the present study. For example, ADHD with comorbid anxiety has been associated with increased response inhibition on the CPT-II, whereas cognitive anxiety appears to be associated with decreased response inhibition among students with ADHD and comorbid anxiety (Epstein, Goldberg, Conners, & March, 1997). Importantly, however, we did address comorbidity in our MANOVA analyses, which revealed significant main effects both for comorbidity as well as ADHD, without statistically significant interactions. Self-selection bias also must be considered as a potential issue, as students who do and do not volunteer for a longitudinal research study may differ in various ways that could conceivably affect study results. Study results may also be affected by the non-random nature of assignment to medication treatment groups, as students who opt to receive stimulants may differ from those receiving non-stimulant medications and those not taking medication for ADHD-related difficulties.

Furthermore, the present study did not examine acuteness of stimulant use, therefore, the amount of stimulant medication needed to produce obtained effects remains unknown. Furthermore, the present study did not examine non-stimulant treatment options. Future research should consider examining the effects of non-stimulants on neuropsychological functioning.

Conclusion

Results from the present study revealed that first-year college students, rigorously defined with ADHD, compared to those without the disorder, performed more poorly on selected neuropsychological tasks measuring executive functions (e.g., impulsivity, sustained attention; i.e., CPT-II), and endorsed greater executive dysfunction on the BRIEF-A rating scale. Differences were not found, however, with respect to intellectual functioning. Prescription stimulant medication was associated with better performance on behavioral measures of executive function. In addition, an important finding emerged that having one or more comorbid psychiatric diagnoses in addition to an ADHD diagnosis was associated with even greater self-reported and performance-based executive dysfunction.

Despite limitations, the study's thorough clinical consideration and strong methodology (e.g., rigorous inclusion criteria, expert panel review to determine ADHD status) attest to the reliability and validity of the findings. The results contribute to the limited knowledge about college students with ADHD, specifically how they compare to their non-ADHD peers with respect to neuropsychological functioning and the effect of medication on cognitive performance. Future studies are needed to further examine how differences in neuropsychological functioning, specifically executive functions, relate to academic, psychological, and social outcomes among college students with ADHD.

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Appendices

Table 1. *Participant demographic and ADHD features by group (ADHD vs. Comparison)*

	ADHD (*n* = 216)	Comparison (*n* = 220)
	%	%
Gender (% female)	51.4	51.8
Ethnicity		
Hispanic/Latino	10.6	10.0
Race		
*Caucasian	76.9%	65.9%
African American	11.6	13.6%
**Asian	2.3	8.6
Multiracial	4.2	3.6
Other	5.1	8.2
**Ethnic/racial diversity	28.3	35.9
**1 or more comorbid disorder(s)	55%	11%
	M (SD)	*M (SD)*
Age	18.25 (0.53)	18.20 (0.46)
**CAARS *DSM-IV* IN	78.57 (12.30)	47.20 (9.79)
**CAARS *DSM-IV* HI	63.53 (13.65)	40.72 (9.79)
**CAARS Total ADHD	74.40 (13.62)	42.90 (8.58)

Note. ADHD = Attention-deficit/hyperactivity disorder; CAARS = Conners Adult ADHD Rating Scale; DSM = Diagnostic and Statistical Manual of Mental Disorders; IN = Inattention T score; HI = Hyperactivity-Impulsivity T score.
* = group difference statistically significant at 0.05 level
** = group difference statistically significant at 0.01 level

Table 2. *Participant demographic and ADHD features by group (ADHD group on stimulant medication vs. ADHD group not on stimulant medication)*

	ADHD (on stimulant medication) (*n* = 63)	ADHD (not on stimulant medication) (*n* = 145)
	%	%
Gender (% female)	50.8	51.7
Ethnicity		
Hispanic/Latino	6.3	13.1
Race		
**Caucasian	93.7	69.0
**African American	3.2	15.9
Asian	0.0	3.4
Multiracial	0.0	4.8
Other	3.2	6.9
**Ethnic/racial diversity	9.5	36.6
1 or more comorbid disorder(s)	61.9	60.7
	M (SD)	*M (SD)*
Age	18.22 (0.61)	18.26 (0.50)
CAARS *DSM-IV* IN	79.25 (11.88)	78.16 (12.43)
CAARS *DSM-IV* HI	61.21 (14.71)	64.30 (12.80)
CAARS Total ADHD	72.92 (15.37)	74.84 (12.61)

Note. ADHD = Attention-deficit/hyperactivity disorder; CAARS = Conners Adult ADHD Rating Scale; DSM = Diagnostic and Statistical Manual of Mental Disorders; IN = Inattention T score; HI = Hyperactivity-Impulsivity T score
** = group difference statistically significant at 0.01 level

Table 3. *CPT-II performance by group (ADHD vs. comparison)*

CPT-II Measure	ADHD (*n*=216) T-score (SD)	Comparison (*n*=220) T-score (SD)	*t* (434)	*p*	Cohen's *d*
Omissions %	55.16 (19.92)	49.08 (14.02)	3.69	<0.001	0.35
Commissions %	60.69 (11.47)	52.18 (10.82)	7.97	<0.001	0.76
Hit RT	47.85 (9.21)	49.61 (10.51)	-1.85	0.064	-0.18
Hit RT Std. Error	50.30 (14.44)	46.99 (11.87)	2.62	0.009	0.25
Variability	52.57 (12.87)	48.30 (9.98)	3.88	<0.001	0.37
Detectability (d')	57.35 (9.13)	51.32 (9.85)	6.63	<0.001	0.63
Response Style (Beta)	46.75 (6.72)	47.66 (7.23)	-1.36	0.174	-0.13
Perseverations %	56.32 (17.20)	51.06 (13.00)	3.61	<0.001	0.35
Hit RT Block Change	51.33 (9.19)	48.20 (9.43)	3.51	<0.001	0.34
Hit SE Block Change	58.19 (11.63)	53.71 (12.15)	3.93	<0.001	0.38
Hit RT ISI Change	51.64 (12.09)	49.20 (10.47)	2.25	0.025	0.22
Hit SE ISI Change	52.57 (12.10)	50.53 (9.72)	1.95	0.052	0.19

Table 4. *BRIEF-A self-report ratings by group (ADHD vs. comparison)*

BRIEF-A Measure	ADHD (*n*=204) T-score (SD)	Comparison (*n*=216) T-score (SD)	*t* (418)	*p*	Cohen's *d*
Inhibit	65.54 (10.99)	46.27 (7.85)	20.76	<0.001	2.03
Shift	61.11 (10.79)	47.19 (8.88)	14.47	<0.001	1.41
Emotional Control	53.85 (11.54)	43.63 (7.03)	11.03	<0.001	1.08
Self-Monitor	59.01 (12.86)	44.19 (7.78)	14.38	<0.001	1.40
Behavioral Regulation Index (BRI)	61.25 (10.70)	44.07 (7.00)	19.58	<0.001	1.91
Initiate	62.90 (10.96)	46.47 (7.78)	17.79	<0.001	1.74
Working Memory	70.68 (10.11)	47.44 (8.01)	26.19	<0.001	2.56
Plan/Organize	63.96 (10.99)	46.31 (7.78)	19.07	<0.001	1.86
Task Monitor	68.11 (10.54)	49.33 (8.76)	19.91	<0.001	1.94
Organization of Materials	57.11 (11.97)	45.00 (8.17)	12.17	<0.001	1.19
Metacognition Index (MI)	66.85 (10.53)	46.67 (7.80)	22.41	<0.001	2.19
Global Executive Composite (GEC)	65.39 (10.06)	45.05 (7.39)	23.72	<0.001	2.31

Table 5. *WASI-II performance by group (ADHD vs. comparison)*

WASI-II Measure	ADHD (*n*=205) Scale score (SD)	Comparison (*n*=213) Scale score (SD)	*t* (416)	*p*	Cohen's *d*
Vocabulary Scale Score	57.33 (8.53)	57.68 (8.89)	-0.41	0.648	-0.04
Matrix Reasoning Scale Score	55.40 (9.54)	54.06 (9.30)	1.46	0.131	0.14
FSIQ-2 Estimate	110.93 (12.68)	110.57 (11.82)	0.30	0.775	0.03

Table 6. *CPT-II performance within the ADHD group by stimulant medication status on the day of assessment*

CPT-II Measure	On stimulant medication (*n*=62) T-score (SD)	Not on stimulant medication (*n*=143) T-score (SD)	*t* (203)	*p*	Cohen's *d*
Omissions %	53.44 (22.82)	55.24 (17.67)	0.610	0.542	-0.09
Commissions %	58.82 (12.12)	61.54 (11.30)	1.55	0.122	-0.24
Hit RT	46.63 (8.71)	48.29 (9.33)	1.19	0.234	-0.18
Hit RT Std. Error	44.20 (13.91)	52.90 (13.37)	4.23	<0.001	-0.64
Variability	47.73 (11.80)	54.69 (12.65)	3.69	<0.001	-0.56
Detectability (d')	56.38 (9.78)	57.69 (9.08)	0.93	0.355	-0.14
Response Style (Beta)	47.10 (9.51)	46.68 (5.38)	-0.40	0.687	0.06
Perseverations %	51.65 (12.12)	58.25 (18.33)	2.60	0.010	-0.40
Hit RT Block Change	49.93 (7.18)	51.97 (10.02)	1.45	0.149	-0.22
Hit SE Block Change	56.56 (10.63)	59.05 (11.99)	1.41	0.160	-0.21
Hit RT ISI Change	48.04 (10.14)	52.91 (12.24)	2.75	0.006	-0.42
Hit SE ISI Change	51.04 (10.22)	53.38 (12.80)	1.27	0.205	-0.19

Table 7. *WASI-II performance within the ADHD group by stimulant medication status on the day of assessment*

WASI-II Measure	On stimulant medication (*n*=51) Scale score (SD)	Not on stimulant medication (*n*=147) Scale score (SD)	*t* (196)	*p*	Cohen's *d*
Vocabulary Scale Score	57.10 (9.80)	57.12 (8.05)	0.018	0.987	0.00
Matrix Reasoning Scale Score	57.43 (10.03)	54.51 (9.32)	-1.89	0.072	0.31
FSIQ-2 Estimate	112.55 (15.02)	109.88 (11.54)	-1.31	0.252	0.21