# A NEUROPSYCHOLOGICAL PROFILE OF COLLEGE STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

by

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ABSTRACT

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Large scale studies of Attention Deficit Hyperactivity Disorder (ADHD) have found that in about 40% of children with a diagnosis, symptoms continue well into adulthood. This poor prognosis makes it imperative that adult ADHD become better understood at the neuropsychological level so novel therapies and diagnostic practices can be established. The purpose of the present study was to examine neuropsychological traits in college students with and without ADHD as well as compare different measures for assessment. Students ($N$=368) were recruited from a southeastern, large public university across the Fall semester of 2020 to complete an online survey. The survey included screeners for ADHD such as the Adult ADHD Self-Report Scale (ASRSv1.1), depression (PHQ-8), anxiety (GAD-7), and stress (PSS-10). The average age of participants was 18.69, with the majority being female (68.2%), White (72%), and freshman (76.9). Students were sorted into an ADHD group ($n$=100) and control group ($n$=268) depending on diagnostic history and scores on the ASRSv.1.1. A smaller subset of those participants ($n$=27 for ADHD group, $n$=19 for control group) were asked to complete an evaluation of neuropsychological functioning as per the CogniFit's Cognitive Assessment Battery and the Brown Executive Function/Attention Scales (Brown EF-A), and an assessment of ADHD symptom severity with the Conners' Adult ADHD Rating Scale (CAARS). Comparisons of each neuropsychological domain between ADHD and control groups were conducted using multivariate analyses of variance. Scores on the Brown EF-A were significantly higher ($p$<.001) for the ADHD group compared to the Control across all domains. A MANOVA for CogniFit revealed significant difference between those and without ADHD. Pearson

correlations showed strong correlations between neuropsychological functioning (Brown EF-A and CogniFit) and scores on the CAARS and the ASRS. Chi-square tests revealed significant differences between the Brown EF-A, CAARS, and ASRS for positive screening of participants for ADHD. Lastly, individuals with ADHD had significantly higher psychological symptomatology across depression and anxiety. Results from this study show a need for more consistent, accurate diagnostic practices of Adult ADHD and builds the framework for the creation of targeted interventions to address neuropsychological deficits.

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## Chapter One: Introduction and Literature Review

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity and impulsivity resulting in significant impairment in multiple settings (Austerman, 2015). The person does not need to have both inattentive and hyperactivity/impulsivity, rather, only one is necessary for a diagnosis. The onset of hyperactivity symptoms usually occurs at or before the age of 5 while inattention symptoms usually appear from ages 5 to 8 (Thapar & Cooper, 2016). As such, the disorder has almost exclusively been diagnosed in young children as per Diagnostic and Statistical Manuel of Mental Disorders IV (DSM-IV) guidelines (American Psychiatric Association, 1994). The basic symptomatology of ADHD in adulthood include difficulties starting tasks, poor attention to detail, difficulties with self-organization and prioritization, and varying degrees of impulsivity (Gentile et al., 2006)

Large scale studies have found that between 50% and 80% of those diagnosed with ADHD as a child have symptoms that continue into adolescence, and in about 40%, symptoms continue well into adulthood (Austerman, 2015). These data resolve previous misconceptions of ADHD and provide a clear longitudinal perspective of the disorder across the lifespan. Additionally, a separate study determined that ADHD was present in about 4.5 percent of US adults (Gentile et al., 2006). Thus, ADHD is a chronic condition with symptoms that can progress into adulthood.

Recent changes in the DSM-5 allow for reduced symptoms in adult ADHD and reduced severity as compared to the DSM-IV (American Psychiatric Association, 2013). However, ADHD cannot be diagnosed in adulthood without objective records from childhood such as report cards, parental records, or teachers' notes (Thapar & Cooper, 2016). Other updates to the

DSM-V include: Impairment before age 12 instead of age 6, symptoms required in at least two settings, and a clinical interview in conjunction with scales as a primary tool for diagnostics (American Psychiatric Association, 2013). Common measures of adult ADHD are the Conners' Adult ADHD Rating Scales (Conners, 2003), the Brown Executive Function/Attention Scales (Brown, 2018), and the Adult ADHD Self-Report Scale (Kessler et al., 2005).

**ADHD Risk Factors**

There appears to not be a single risk factor or cause of ADHD. Instead, it is a collection of risk factors that, any one of which, can lead to symptomatology and the development of the disorder. ADHD appears to be largely heritable; it is more heritable than major depression and has rates like that of other highly heritable conditions such as schizophrenia and bipolar disorder (Hinshaw, 2018). As such, researchers have examined the genetic components of ADHD and have found that multiple genes are associated with psychopathology (Mahone & Denckla, 2017). These studies have examined genes related to dopamine or other neurotransmitters (e.g., DAT1, DRD4, SNAP25) garnering only small effect sizes (Wu et al., 2014). Cortese & Coghill (2018) concluded that the impact of genetics on ADHD is not purely from the genes themselves, but from a complex interaction of many genes and by gene-environment interactions. In addition, several risk factors exist including exposure to environmental toxins, low birth weight, and poor familial interactions (Gentile et al., 2006). These factors, taken together, likely account for the development of ADHD and contribute to the severity of symptomatology.

**Adult ADHD Symptomatology**

Adults with ADHD suffer from a wide array of cognitive and motoric symptoms. Individuals tend to have deficits in higher-level cognitive functions necessary for goal-directed behaviors known as executive functions (Rubia et al., 2014). Of course, deficits in executive

functioning can affect a wide array of daily activities. The most pronounced deficits in executive functioning appear to be in motor response inhibition, working memory, sustained attention, response variability, cognitive switching, and temporal processing (Rubia, 2011; Willcutt et al., 2008). These deficits have clear implications in day to day activities and contribute to many achievement gaps amongst adults with and without ADHD. Pievsky and McGrath (2018) found that adults with ADHD had the greatest difficulties in the neurocognitive domains of reaction time variability (i.e., like temporal processing), intelligence, achievement, vigilance, and response inhibition. Such deficits are especially problematic in the college environment where it can be more difficult to compensate and cope. In addition to working memory difficulties, Skodzik et al. (2017) determined that adults with ADHD have significantly worse memory abilities compared to controls with the mechanism being difficulties in the stage of encoding memories. The inability to properly encode memories is likely implicated in some of the intelligence deficits seen in adults with ADHD. Adults with ADHD also have impaired access to long-term memory which can worsen performance on a wide array of daily tasks (Bueno et al., 2017). Non-executive functions such as motivational processes and learning mechanisms are also adversely affected by ADHD indicating reduced behavioral control and an aversion to delayed rewards (Banaschewski et al., 2017). Thus, adults with ADHD may be less likely to work on tasks with a long-term goal which can severely affect academic and job prospects. It is important to note, however, that cognitive impairments tend to have considerable heterogeneity across adult populations (Rubia, 2018). Consequently, more studies are needed to establish neuropsychological profiles of adults with ADHD so that precise pathophysiological pathways can be pinpointed, and cognitive deficits can be better replicated across studies.

In addition to cognitive symptoms, adults with ADHD tend to suffer from motoric difficulties. The most pronounced motor problems are related to motor inhibition (Stray et al., 2013). Motor inhibition is necessary when an action or behavior needs to be stopped after initiated due to a stimulus from the environment. A basic example of when motor inhibition is necessary is while driving a car and switching lanes. The driver needs to be able to react to sudden stimuli (e.g., the appearance of a car or the sound of a horn) and abort such action so as not to cause an accident. Another pronounced deficit is in fine motor skills which can significantly effect handwriting and academic performance at younger ages (Mokobane et al., 2019). Fine motor skills have several applications in adulthood as several careers demand precise coordination and fine motor skills. Although motor difficulties are more frequent during childhood, these issues do not improve over time even into adulthood (Dahan et al., 2018). Unfortunately, motor symptoms have gone largely unresearched in the literature especially among adults. There currently exists no single intervention that improves motor skills in adults with pharmacological interventions not producing any improvements in functioning (Stray et al., 2013); A recent study by Clark et al. (2020), however, shows promising results of a mindful movement intervention in children.

It appears that symptoms of hyperactivity and impulsivity (i.e., hallmarks of ADHD) have close relationships with motor performance with greater symptomatology leading to greater motor deficits (Kaiser et al., 2015). This relationship means that more severe inattention and/or hyperactivity symptoms negatively correlates with motor performance. Research has established a strong link between inattention and motor skills (Ghanizadeh, 2011). Thus, inattention interferes with motor control with executive functioning as a potential mechanism of action.

These difficulties represent clear hardships for those with ADHD, but their symptoms are not the only problems they face.

**Adult ADHD Challenges**

Adults with ADHD suffer from a range of economic, social, and psychological hardships brought on by or co-occurring with their condition. Mahone and Denckla (2017) write that even though there have been considerable diagnostic and treatment advances over the last few years, many adults with ADHD continue to struggle both socially and academically even when treated. Further, they point out that roughly two-thirds of adults with ADHD also have at least one co-existing psychiatric condition. This statement means that those with ADHD are more likely than not to have an additional psychiatric condition which causes even greater difficulties and hardships. As such, ADHD is now recognized as a major public health issue (Hinshaw & Ellison, 2016). Estimates have found the annual costs associated with ADHD in the United States to be well over 143 billion dollars with a quarter of these costs due solely to educational problems (Doshi et al., 2012). Thus, a large amount of money is lost due to the difficulties associated with ADHD in the educational environment. This fact should motivate academic institutions to seek out methods to improve ADHD detection, diagnosis, and treatment in their students. In school, those with ADHD struggle due to an increased likelihood of learning problems, frequent school absences, poor relationships with peers, and attentional difficulties (Doshi et al., 2012). These problems can continue into adulthood and result in a greatly decreased earning potential and an increase in the use of social assistance such as subsidized healthcare, housing accommodations, and other government programs (Fletcher, 2013). Even outside of work and academics, those with ADHD suffer from compromised relationships, poor health related outcomes, and even criminality (Hinshaw, 2018; Sayal et al., 2018). ADHD is a disorder that does not just affect one

aspect of the individual's life, rather, it is multidimensional and leads to poor outcomes across a wide range of variables. This poor prognosis makes it imperative that adult ADHD becomes better understood at the neuropsychological level so novel therapies can be established and used as an alternative to or in conjunction with psychiatric medication.

**ADHD Diagnostics**

Healthcare professionals employ a variety of tests for the diagnosis of ADHD but there tends to be great variability amongst psychiatrists, psychologists, and primary care providers. The most important piece of ADHD assessment is a clinical interview using structured scales (Gentile et al., 2006). Common measures of adult ADHD are the Conners' Adult ADHD Rating Scales (Conners, 2003), the Brown Executive Function/Attention Scales (Brown, 2018), and the Adult ADHD Self-Report Scale (Kessler et al., 2005). Each measure comes with various strengths and limitations. The Conners' Adult ADHD Rating Scales (Conners, 2003), while not openly available, offer a comprehensive range of assessment options depending on the patient. The scales include teacher ratings, parent ratings, and a self-report rating and vary depending on the age of the individual. Undoubtedly, the price tag of the scales make the access difficult leading many clinicians, especially primary care providers, to opt for the Adult ADHD Self-Report Scale (Kessler et al., 2005). While access to this measure is easily obtained through the World Health Organization, the length of the scale is cause for concern. As such, it should never be used as a stand-alone measure of ADHD and only used in conjunction with other tests. Lastly, the Brown Executive Function/Attention Scales (Brown, 2018) offer an in-depth analysis of executive functioning with a specific emphasis on attention. The measure can be used with individuals almost all ages and is available for only a marginal fee. In the same way as the Conners' Adult ADHD Rating Scales (Conners, 2003), some healthcare professionals may

choose to refrain from the use of a tool that costs money. Nevertheless, these three measures are popular in the assessment of adult ADHD. While they have each been psychometrically validated, more research needs to be conducted as to how they compare with each other and with more objective measures of ADHD such as neuropsychological functioning. Obtaining a better understanding of ADHD diagnostics will offer greater insight into how ADHD in adults should be treated.

**Adult ADHD Treatment**

The most common treatment of adult ADHD is with psychopharmacological interventions. Stimulants and medications that inhibit norepinephrine reuptake are the most prescribed drugs as they improve both behavioral and cognitive aspects of the disorder in most patients (Adler & Cohen, 2004). The purpose of the medications, at least in those in adolescence and young adulthood, is to improve attention, better academic performance, and assist working memory (Gentile et al., 2006). These medications are classified as Schedule II drugs by the Food and Drug Administration and have the potential for abuse which presents challenges due to the comorbidities presented with ADHD. In addition, stimulants have several adverse side effects which can make them largely inefficacious in certain populations. Unfortunately, there are not enough data on alternative treatments to adult ADHD and, therefore, psychopharmacological interventions remain as the only option for many. A new drug, Viloxazine, was recently approved by the FDA for use in school-aged children but clinical trials in adults are still ongoing (NCT03247530)

**ADHD in College Students**

The college years represent a unique developmental period known as emerging adulthood (Arnett, 2000). This period extends from ages 18-25 and is characterized by instability and

identity exploration. College is also a unique environment as students are uprooted out of their support network and thrust into a situation in which greater demands are placed upon them. Unfortunately, many students do not have the coping skills to meet the demands, and stress begins to form. Additionally, emerging adulthood coincides with the onset of many psychiatric conditions making for a vulnerable but crucial developmental stage (Arnett, 2016). Although ADHD cannot first appear during adulthood, the other psychiatric conditions that are comorbid with ADHD can. Thus, emerging adults and, therefore, college students are a critical population for the study of ADHD, psychological symptomatology, and long-term outcomes.

Students with ADHD face many obstacles transitioning into college. Although the management of ADHD is relatively common within pediatrics, there appears to be a high degree of treatment attrition for those in college as few adolescents are referred onto adult services (Sayal et al., 2018). Students with ADHD are arriving to college no longer supported by clinicians and are left without proper support and treatment. Even though colleges are equipped with healthcare providers, Thomas et al., (2015) found that many college clinicians express discomfort in diagnosing and treating ADHD. Not only are students leaving their long-term healthcare providers, they also enter an environment with clinicians that are uncomfortable with giving them the care that they need. The uneasiness amongst college healthcare providers stems from the misuse and abuse of stimulants on college campuses (DeSantis et al., 2008). Even when medication is prescribed and used as intended, many college students feel as though it does not do enough to eliminate academic achievement gaps (Bordoff, 2017). Especially with cases of comorbid ADHD, efficacious interventions for transitioning college students are lacking. Taken together, a better understanding of college students with ADHD is necessary to ensure proper treatment options and college resources made available to those needing them.

**Neural Underpinnings of ADHD**

ADHD is a neurodevelopmental disorder and has significant neurological correlates with relationships to both cognitive and motoric symptomatology. A review by Dark et al. (2018) found several brain regions that showed reduced volume in those with ADHD. Some areas of interest include the anterior cingulate cortex (i.e., essential for executive functioning) and the cerebellum (i.e., highly implicated in motor symptoms and executive functioning) showing reduced volume. Multiple regions of the prefrontal cortex such as the dorsolateral prefrontal cortex (i.e., attention, working memory), the ventrolateral prefrontal cortex (i.e., inhibition), and the orbitofrontal cortex (i.e., social behavior, inhibition) all show significantly reduced volumes compared to controls. It is important to note that single regions of the brain do not cause ADHD symptomatology, rather it is their connectivity with other brain regions which form faulty networks that ultimately lead to the progression of the disorder. Even in the overall volume of the cerebrum, studies have documented volume reduction (Beare et al., 2017). This finding demonstrates that higher-order functioning regions of the brain are all, to some degree, reduced. It is obvious to conclude that these neurological correlates have significant effects on the symptomatology of ADHD. Of note, cortical maturation tends to be delayed in the brains of individuals with ADHD particularly in the prefrontal areas (Banaschewski et al., 2017). This maturation delay helps explain why individuals exhibit symptoms of ADHD especially at younger ages. In healthy individuals, areas of the brain, specifically the prefrontal areas, reach maturation during emerging adulthood. In the brain of those with ADHD, however, complete maturation might not occur (Cortese & Coghill, 2018). Thus, the persistence of ADHD symptoms into adulthood is strongly correlated with the continued reduction in brain volume and other neuroanatomical abnormalities.

As mentioned, brain networks and connections play more of a role in ADHD than any singular region. Recent findings from Cortese and Coghill (2018) support the notion that the default mode network (i.e., medial temporal lobe, medial prefrontal cortex, and posterior cingulate cortex) inappropriately intrude in the activity of task-oriented networks such as the frontoparietal, ventral, and dorsal attentional networks. Thus, the default mode network competes with and interrupts the activity and connectivity of attentional networks leading to symptomatology. A groundbreaking review by Rubia and colleagues (2014) detailed various connections between executive functioning regions and found reduced activity across all networks. This finding supports the notion that large-scale brain networks between executive regions are not only highly implicated in ADHD but an avenue for therapeutic intervention. A recent review examined the relationship between executive functioning neural correlates and the neural correlates of motor performance and found significant overlap in connectivity and brain networks (Clark et al., 2015). Thus, the cognitive symptoms of ADHD are highly related to the motor symptoms. The connection between neurological functioning and symptomatology needs to be applied in more detail specifically in college students with ADHD as they enter emerging adulthood.

**Neuropsychology and ADHD**

Neuropsychology is largely concerned with how the brain influences behavior and cognition. As such, the field makes use of various neuropsychological tasks that have been established which correlate performance to the activity of various brain regions. Neuropsychological tasks are optimal as they provide an objective measure of functioning which self-report surveys do not.

Although neuropsychology has been applied to the study of ADHD extensively in the last decade, there is a significant gap in the literature for neuropsychological functioning in college students with ADHD. Generally, studies of adults with ADHD have found worsened performance on working memory, attention, and delay aversion tasks (Mostert et al., 2015). Another study in adults found that those with ADHD made significantly more errors on a verbal learning task and experienced more problems in the domain of executive functioning tasks as compared to a non-ADHD control group (In de Braek et al., 2011). Additionally, Bramham and colleagues (2012) conducted an observational study and concluded that neuropsychological measures improve with age, however the subjective experience of ADHD tends to worsen.

There have been only a few studies published that examine neuropsychological functioning and college students both by the same principal investigator. The first study by Weyandt et al. (2013) found significant group differences in executive functions, attention, academic performance, and social adjustment in college students. The problem, however, is that the study used only self-report measures. It seems obvious the difficulties of using a self-report questionnaire to measure executive functioning as they produce merely subjective findings. In addition, poor executive functioning can lead to a lack of awareness which can make introspective measures useless. While the results were intriguing, a more rigorous methodology needs to be employed to truly capture neuropsychological functioning. Then, Weyandt et al. (2017) again studied neuropsychological functioning this time employing neuropsychological tasks. They found that college students with ADHD had executive functioning deficits even when controlling for intelligence. The problem, however, is that the authors did not comprehensively assess functioning. The use of self-report measures of executive functioning were once again used but they also used the Conners' Continuous Performance Test II which

covers sustained attention, behavioral inhibition, and vigilance. To measure intelligence, the authors used the Wechsler Abbreviated Scale of Intelligence. The neuropsychological tasks only covered three domains, not enough to constitute executive functioning. Although studies by Weyandt and colleagues have aimed to address the lack of literature in the field, a comprehensive perspective of neuropsychological functioning needs to be taken to produce both valid and reliable results.

## The Current Study

The purpose of this study was to establish a neuropsychological profile of college students with ADHD. College students were recruited from a large southeastern university and participated in an online survey (Phase 1). The survey consisted of psychological symptomatology measures as well as demographic and background questions to establish inclusion and exclusion criteria. Then, a subset of students were invited to participate in a WebEx session that consisted of further testing (Phase 2). This phase contained both synchronous and asynchronous components. Part 2 featured a neuropsychological test battery that was given to students with ADHD and a control group. Further, two established ADHD scales were used during Phase 2 to measure ADHD symptomatology.

### *Research Question 1*

My first research question concerned the neuropsychological abilities of college students with ADHD. The question was as follows: How do neuropsychological abilities of college students with ADHD compare to those of college students without ADHD? I hypothesized that students with ADHD would perform worse on a variety of neuropsychological tasks compared to case-matched controls. Since ADHD has significant neural correlates, the greater degree of ADHD symptomatology should correlate with worsened scores on the tasks. As such, scores

from the ADHD measures for both groups should align well with scores from the neuropsychological test battery. In addition, those with ADHD should also perform worse on attentional tasks compared to controls. Although some studies have examined neuropsychological functioning in college students, they have all differed in their study design and how they operationally defined neuropsychological functioning. As such, the present study utilized the Brown Executive Function/Attention Scale to assess neuropsychological ability. Additionally, CogniFit was used to determine the feasibility and validity of employing a neurocognitive test battery in a virtual format to assess neuropsychological ability. The answer to this research question will significantly further the field and allow for greater understanding of the neuropsychological profile of ADHD during emerging adulthood and college.

***Research Question 2***

My second research question focused on how adult ADHD is screened for using various measures. The question was as follows: How do positive screens on three of the most used measures of ADHD compare between ADHD and non-ADHD groups? Of course, a diagnosis is not given just because someone scores above a clinical cut-off, but these measures are extremely important because they provide clinicians with valuable information pertaining to the symptomatology of the patient. As such, greater effort must be given to studying the relationships between three of the most common assessments of adult ADHD: the Conners' Adult ADHD Rating Scales (Conners, 2003), the Brown Executive Function/Attention Scales (Brown, 2018), and the Adult ADHD Self-Report Scale (Kessler et al., 2005). By comparing rates of positive versus negative screens, I would be able to answer the question as to how the scales differ in assessing ADHD symptomatology. I hypothesized that there would be great variability between the scales because adult ADHD is far more complex since comorbidities

have likely developed. Thus, a shortened scale such as the Adult ADHD Self-Report Scale (Kessler et al., 2005) might not be as accurate as the 60-question Conners' Adult ADHD Rating Scales (Conners, 2003). Sensitivity and specificity are important terms when discussing diagnostic measures. Sensitivity refers to the true positive rate. It measures the proportion of positive screens that are correctly identified (i.e., those who indeed have the condition of interest). Specificity, on the other hand, refers to the true negative rate. It measures the proportion of negative screens that are correctly identified (i.e., those who do not have the condition of interest). By addressing this research question, clinicians would be better informed as to which diagnostic test has greater sensitivity and specificity for an adult when exhibiting symptoms of ADHD.

***Research Question 3***

My third research question sought to understand the rates of comorbidity in students with ADHD. In particular, the amount of psychological symptomatology across measures of depression, anxiety, and stress. The question was as follows: How do students with a diagnostic history of ADHD score on common mental health screeners such as the PHQ-8, GAD-7, and PSS-10? How do their scores compare with those without ADHD? I hypothesize that students with a diagnostic history of ADHD would experience significantly higher levels of anxiety, stress, and depressive symptoms compared to the control group. By making these comparisons, clinicians and university officials would have much greater understanding of the psychological makeup of college students with ADHD. This knowledge, in turn, would help inform how to best support these students and address their psychological distress.

# Chapter Two: Method

## Study Design

The present study employed a cross-sectional, matched-case control design at a large, southeastern public university. The population of interest included college students, aged 17-25, above the clinical cutoff for current ADHD symptoms (i.e., ASRSv1.1), and a diagnostic history of ADHD, with a control group without a diagnostic history of ADHD and below the clinical cutoff for current ADHD symptoms for comparison. Participants were first asked to complete an online Qualtrics survey (i.e., Phase 1) assessing psychological symptomatology (e.g., ADHD, major depressive disorder, generalized anxiety disorder). After the samples were sorted based on ADHD diagnosis and current symptoms, 27 participants with ADHD were randomly selected and invited to participate in the next phase (i.e., Phase 2) of research. The control group consisted of 19 matched-case participants without a history of ADHD and current symptoms. Phase 2 of the study involved a virtual meeting which evaluated neuropsychological functioning and ADHD symptom severity through synchronous and asynchronous tasks. Analyses compared results from the ADHD group to those from the Controls to build a neuropsychological profile of college students with ADHD. IRB approval was obtained from the university prior to the study starting.

## Participants

For Phase 1 of the study, participants were any enrolled student between the ages of 17-25. No other eligibility criteria were used for the initial survey data collection. Students were recruited through a variety of efforts including via the PSYC 1000 Introduction to Psychology participant pool, Disability Support Services, the counseling center, the Student Health Center, academic advisors, student organizations, tutoring center, writing center, Honors College

listserv, faculty and staff listserv, and virtual flyers. These extensive recruiting efforts were made to ensure the sample was as representative of the population as possible. On all recruitment materials, a link was provided for interested participants to complete an initial survey which assessed inclusion and exclusion criteria. Students from PSYC 1000 received 1 research credit for their completion upon inspection of engagement items. Students that were not enrolled in PSYC 1000 received a $20 gift-card for participating.

Before participants could move on to the next phase of the study (i.e., Phase 2), they must have met the eligibility criteria. The eligibility criteria for the second phase differed between the ADHD group and the matched-case control group. For the ADHD group, the inclusion criteria included: aged 18-25; an enrolled student; a previous diagnosis of ADHD; indicated their ADHD is a current problem; and meeting the clinical cut-off on the Adult ADHD Self-Report Scale (ASRS).

Exclusion criteria for the ADHD group included: use of illicit or non-prescribed stimulants; the regular use of nicotine products; the presence of an intellectual disability, developmental language disorder, reading disability, or autism spectrum disorder; a history of a neurological condition such as Tourette's; and those taking non-stimulant psychoactive medications. Non-prescribed stimulants can reduce the ability to control for drug affects as certain illicit drugs exude undocumented neuropsychological effects. In the same way, nicotine mimics the physiological response of stimulants making it difficult to control for the effects of the drug. Intellectual disability, developmental language disorder, reading disability, or autism spectrum disorder are all ruled out due to having significant impacts on neuropsychological functioning. In addition, a neurological condition such as Tourette's has impacts on neuropsychological assessments. Non-stimulant psychoactive medication may influence co-

morbid conditions and overall psychological functioning. Of course, prescribed stimulants would also have an effect, but these can be more easily controlled for in the analyses.

For the Control group, the inclusion criteria included: aged 18-25; an enrolled student; not having a previous diagnosis of ADHD and scoring below the clinical cutoff on the ASRS. The exclusion criteria for this group were the same as those of the ADHD group.

A total of 27 participants were recruited for the ADHD group and 19 for the Control group for a total of 46 participants for Phase 2. Attempts were made to match on the basis of parental education, race/ethnicity, age, gender, and student year. All recruitments efforts were maintained throughout the duration of the semester until the participants completed Phase 2. Upon completion of Phase 2, the 46 participants were emailed an electronic Amazon gift card of $30.

**Procedures**

Recruitment was an ongoing process with two main time points where efforts were heightened. Since the fall 2020 semester was segmented into two eight-week blocks, each block had a week where recruiting was emphasized. This structure primarily targeted individuals in the PSYC 1000 participant pool since all such classes were only eight weeks rather than a semester course.

The PSYC 1000 participant pool offered a large sample of college students albeit primarily freshman. Recruitment initiatives also targeted students across the university to ensure a more well-rounded sample. Although the population at the university is largely female and White, it was essential to have students reflective of various gender identities and races/ethnicities. To reach those students not in PSYC 1000, the primary recruitment location was Disability Support Students (DSS). Since university students with ADHD may require

academic accommodations, DSS likely led to an increase in the number of participants for the ADHD group. The Student Health Center, counseling center, academic advisors, tutoring center, and writing center were all used to help recruit individuals with ADHD. In contrast, advertising through student organizations and various listservs (e.g., Honors College, faculty, and staff) all sought to enroll students without a history of ADHD. The final recruitment initiative utilized virtual fliers posted across campus to reach students that might not use any of the services already mentioned. Although the effectiveness of fliers was uncertain with COVID-19 forcing many students online and off-campus, fliers still drew the attention of the students enrolled in in-person classes.

On all recruitment material, both a URL and a QR code were presented allowing for all interested students to obtain access to an electronic survey available on Qualtrics. For the PSYC 1000 participant pool, the study was posted on Sona Systems, an online research participation management system. The study was made available to all students at the beginning of each block. If a student was interested, they would follow the sign-up link for the study and take the Qualtrics survey linked to on Sona.

The participants were first presented with a consent form which outlined the procedures for both Phase 1 and 2. If a student did not consent to the consent form, however, they were exited from the survey.

An overview of the scales and assessments for the study are shown in Table 1. The first section of the survey covered basic demographic information such as age, gender, ethnicity, race, and socioeconomic status (see Appendix B). This information was helpful in determining if the sample was representative of the population. The next series of questions concern the individual's ADHD history. Participants were asked if they had ever been diagnosed, and they

were probed about treatment history. For those that endorsed the item on a prior ADHD diagnosis, additional questions about ADHD student experiences were presented. These questions were short answer, and students were asked to answer each with three different responses. Specifically, the questions cover the difficulties and stress ADHD symptoms cause, the coping strategies used to counter the ADHD symptoms, and how ADHD affects the student in college and potentially in the future. The rest of the background questions are concerned with the remaining inclusion and exclusion criteria for Phase 2 of the study.

Table 1. Study Scales and Assessments

| Study Procedures | | |
|---|---|---|
| Phase | Measures, Scales, Assessments | Length |
| 1 | Demographics | 30 items |
| | Patient Health Questionnaire-8 | 8 items |
| | Generalized Anxiety Disorder-7 | 7 items |
| | Perceived Stress Scale-10 | 10 items |
| | Adult ADHD Self-Report Scale | 18 items |
| 2 | Conners' Adult ADHD Rating Scale | 30 items |
| | Online Cognitive Assessment: Cognitive Assessment Battery | 16 tasks |
| | Brown Executive Function/Attention Scales | 50 items |

The next section of the survey delves into psychological symptomatology. The Adult ADHD Self-Report Scale (ASRS) is used to assess for the presence of ADHD symptoms. The ASRS includes a clinical cut-off which is helpful to decipher which participants meet the inclusion criteria for Phase 2 and which do not. As such, the ASRS were used in Phase 1 of the

study (i.e., online survey) while the other two measure of ADHD were used in Phase 2. The Patient Health Questionnaire (PHQ-8) is used to assess depression, the Generalized Anxiety Disorder scale (GAD-7) is used to assess anxiety, and the Perceived Stress Scale (PSS-10) is used to determine levels of stress. The PHQ-8 and GAD-7 both include clinical cut-offs which would offer insight into comorbidities often seen in individuals with ADHD. Since comorbidities are common, scoring above the clinical cut-off on these measures will not disqualify the individual from Phase 2.

At the end of the survey, participants were provided with a collection of mental health resources since the nature of some of the measures could be emotionally triggering. For those in PSYC 1000, the completion of the survey automatically resulted in one research credit being granted to help meet their research requirements. It was estimated the survey would take approximately twenty-minutes to complete regardless of if the participant had ADHD.

Once survey data collection began, it was essential to start cleaning and organizing the data. Before the participants could be properly sorted into two distinct groups, the individuals that failed to meet all the inclusion criteria needed to be omitted. In addition, if any of the exclusion criteria items were endorsed, those participants would need to be omitted as well. After several weeks of data collection and subsequent organization, the students were split into two groups.

The first group included those with a history of ADHD and the second group was a Control group. From the ADHD group, 27 students were randomly selected to progress onto Phase Two of the study. The exact amount depended on how many students were initially in the ADHD group. The number of students with ADHD randomly selected to progress to Phase 2 did

not exceed 50% of the total number of participants in the ADHD group. This restriction ensured the random selection was in fact random and not simply due to a small sample size.

Once certain students with ADHD were selected for additional study, they were contacted via email. The email referenced the recent consent form and survey they had completed and invited them to participate in additional research. They were notified that their participation would result in compensation of a $30 Amazon gift card which was commensurate with the approximately 1.5 hours needed for Phase 2. Included in the email was a specified date on when they must commit to the next phase of research.

A virtual meeting was set-up through WebEx when both the researcher and participant had sufficient time. The researcher facilitating the meeting was either the Principal Investigator or a research assistant.

The virtual meeting commenced with a brief overview of the procedure and an opportunity for the participant to ask any questions or gain clarification. The meeting consisted of three main components both synchronously and asynchronously. The components were completed in the following order: an assessment of ADHD symptom severity (completed on Qualtrics), a neuropsychological battery (completed via Internet application), and an additional measure of attention and executive function (completed on Qualtrics). The ADHD scale used in this section, the Conners' Adult ADHD Rating Scale (CAARS), is the most common method of testing for ADHD by clinicians. The ASRS from the Qualtrics survey can be used to screen for ADHD by healthcare professionals, but it is commonly used in conjunction with other tests before a diagnosis was made. The neuropsychological battery is a fully virtual assessment called the Online Cognitive Test: General Assessment Battery (CAB). This platform comprehensively measures a user's cognitive ability across a variety of domains. The exact tests and abilities are

discussed in the Measures section. The Brown Executive Function/Attention Scales were used as the base measure for neuropsychological functioning. In addition, the Brown Executive Function/Attention Scales were also used in measuring ADHD symptomatology and come equipped with diagnostic recommendations and a clinical cut-off.

After the participant finished the Phase 2 tests, the researcher notified the Department of Psychology staff so that the participant could be issued the $30 Amazon gift-card. Detailed logs of gift card distribution and prize forms were kept up to date to ensure compliance with university guidelines.

After the 47 interviews had been conducted, the data collection process was complete. All recruiting efforts were ceased, and prior recruitment locations were made aware that students were no longer being invited to participate in the study. The gift card logs and prize forms were finalized and subsequently emailed to the appropriate point of contact at the university.

Since the study took place in phases and across multiple modalities, not all data were in the same database. There were participant responses to the initial Qualtrics survey, reports generated from the Online Cognitive Test, and responses that needed scoring from the CAARS and Brown Executive Function/Attention Scales. All data needed to be consolidated into an analysis software such as IBM SPSS before any analyses could be run. After all responses had been scored and the data were imported into SPSS, the appropriate analyses were conducted (see Data Analyses for more detail). In addition, R programming software was used for data visualization purposes.

**Measures**

The survey all participants took in Phase 1 included measures of ADHD (i.e., ASRS), anxiety, depression, stress, and demographic and background information. For Phase 2, 27

randomly selected and 19 control participants took an additional ADHD measure (i.e., CAARS), a neuropsychological and ADHD measure (i.e., Brown EF-A), and an online cognitive battery (i.e., CogniFit).

### *Demographics and Background*

Demographic items assessed age, gender, ethnicity, race, student standing, and parental education and family government assistance as indicators of socioeconomic status (SES). Background items assessed ADHD history, ADHD treatment, qualitative ADHD experiences, medication use, illicit substance use, nicotine use, caffeine use, and neurological disorder history (see Appendix B).

### *Attention Deficit Hyperactivity Disorder*

The Adult Self-Report Scale (ASRS; Kessler et al., 2005) is a brief inventory developed by the World Health Organization for the assessment of ADHD symptoms in adults. The scale is 18 items long split up into two sections. Part A is 6 items and assesses symptoms of inattention. These first six items were found to be the most predictive of ADHD psychopathology (Kessler et al., 2005). As such, if a patient endorsed the first four or more items above 2, it is recommended that further ADHD diagnostic screening take place. An example of a question from Part A is, "How often do you have difficulty getting things in order when have to do a task that requires organization?" Part B is 12 items and identifies symptoms of hyperactivity. An example of a question from Part B is, "How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?" All items are rated on a five-point Likert scale with 0=Never and 4=Very Often. Four or more responses above 2 (Somewhat) in Part A meets the clinical cutoff for ADHD. The ASRS exhibits good internal consistency with items captured by a single underlying latent variable, strong associations with other

hyperactivity/inattention measures, and significant associations with self-report school functioning in students with ADHD which supports its validity (Green et al., 2019). Cronbach's Alpha was calculated for the ASRS and found strong internal consistency ($\rho T$=.819).

The Conners' Adult ADHD Rating Scales (CAARS; Conners, 2003) is a multimodal assessment for adults with attention problems. The self-report long form is 66 items that covers 8 empirically derived scales. In particular, the self-report long form assesses inattention/memory problems, hyperactivity/restlessness, impulsivity/emotional liability, problems with self-concept, DSM inattentive symptoms, DSM hyperactivity-impulsive symptoms, DSM ADHD Symptoms total, and ADHD Index. Each question is scored on a 0 to 3 scale with 0=Not at all, never to 3=Very much, very frequently. The automated scoring system displays T-scores which show the participants score compared to the population. T-scores above 70 represent "markedly atypical" neuropsychological functioning and meet the clinical cut-off for ADHD. Thus, higher T-scores indicate worse neuropsychological functioning. Test-retest reliability has been found to be strong, and the measure has proven to be valid in distinguishing adults with ADHD from healthy controls (Erhardt et al., 1999). Cronbach's Alpha was calculated for the Brown EF-A and showed high levels of internal consistency ($\rho T$=.984).

The Brown Executive Function/Attention Scales (Brown EF/A Scales; Brown, 1996) assess a wide array of executive function impairments associated with ADHD. The self-report scale consists of 50 items and assesses six clusters of impairments: organizing, focusing, regulating alertness, managing emotions, utilizing working memory, and monitoring. Key advantages of the Brown Executive Function/Attention Scales are that it was based off of the DSM-5, focuses on severity as opposed to frequency, and provides a comprehensive evaluation of executive functioning. The Brown Executive Function/Attention Scales can be used as one

component in the assessment and diagnosis of ADHD. The Brown EF/A Scales were normed based off a national sample of 1,950 parent, teacher, and self-report forms (Brown, 1996). Following stratification of the sample, reliability and validity in a clinical sample were established as well as both gender-specific and combined-gender norms for all age groups (Brown, 1996). In addition to serving as measure of ADHD, these scales will serve as a base measure for neuropsychological functioning (e.g., Activation, Focus, Effort, Emotion, Memory, and Action).

***Depression***

The Patient Health Questionnaire 8 (PHQ-8; Kroenke et al., 2001) is an eight question self-report measure used to screen for the presence and severity of depression. The eight items are from a much larger measure called the Patient Health Questionnaire (PHQ). The items refer to the respondent's experience of symptoms of depression in the last two weeks with responses ranging from 0=Not at all to 3=Nearly every day. The respondent is prompted, "Over the last 2 weeks, how often have you been bothered by any of the following problems?" An example of one of the items is, "Little interest or pleasure in doing things." The respondent's overall score on the eight items is summed and scores at or above ten meet the clinical cut-off for depression. Cronbach's Alpha was calculated for PHQ-8 and showed high levels of internal consistency ($\rho T$=.879).

***Anxiety***

The Generalized Anxiety Disorder 7 scale (GAD-7; Spitzer et al., 2006) is a seven question self-report measure to assess for the presence of generalized anxiety disorder. Like the PHQ-8, the GAD-7 refers to a time of two weeks. The survey prompts the respondent, "Over the last 2 weeks, how often have you been bothered by the following problems." An example of an

item is, “Feeling nervous, anxious, or on edge.” Respondents respond to each problem by rating it on a scale of 0=Not at all to 3=Nearly every day. A summed score at or above ten indicates the possibility of a clinical condition. Cronbach’s Alpha was calculated for GAD-7 and showed high levels of internal consistency ($\rho T$=.937).

***Stress***

The Perceived Stress Scale 10 (Cohen et al., 1983) is a widely used instrument for the assessment of stress. The scale assesses feelings and thoughts over the course of the last month. Respondent are asked to “indicate how often you felt or thought a certain way.” Responses are on a five-point Likert scale with 0=Never and 4=Very Often. An item from the scale is: “In the last month, how often have you been upset because of something that happened unexpectedly?” Scoring the PSS-10 is not as straightforward compared to the PHQ-8 or the GAD-7 due to the presence of reverse scoring. For items 4, 5, 7 and 8, responses need to be reverse scored because they are positively stated items. After those four items are reversed scored, all responses can be summed up to obtain a score. The PSS-10 does not offer a clinical cut-off but can be helpful when comparing or tracking levels of stress. Cronbach’s Alpha was calculated for PSS-10 and showed high levels of internal consistency ($\rho T$=.868).

***Neuropsychological Functioning***

The Online Cognitive Test: Cognitive Assessment Battery (CogniFit) is a comprehensive neuropsychological battery which measures 22 cognitive abilities across five domain areas: attention (e.g., focused attention, inhibition, updating, divided attention), perception (e.g., visual scanning, estimation, recognition, spatial perception, visual perception, auditory perception), memory (e.g., visual short-term memory, short-term memory, non-verbal memory, auditory short-term memory, working memory, naming, contextual memory), reasoning (e.g., planning,

processing speed, shifting), and coordination (e.g., hand-eye coordination, response time) (CogniFit, 2021). The battery is made up of 16 neuropsychological tests (e.g., Speed test, Resolution test, Processing test, Sequencing test, Estimation test, Synchronization test, Programming test, Recognition test, Equivalencies test, Coordination test, Concentration test, Decoding test, Identification test, Inquiry test, Estimation test, and Simultaneity test) which each contribute a certain percentage to each cognitive ability. In addition, all 16 tests are based off psychometrically sound neuropsychological tasks. Each task is scored based off six different variables. These variables include accuracy, average, distance, efficiency, measurement, and reaction time. These scores contribute to the individual's cognitive profile which can be used to indicate the possibility of a clinical impairment. The entire assessment can be taken online in about 30 to 40 minutes. In terms of accessibility, participants do not have to download any software. The entire assessment is taken online, and raw scores were retrieved by CogniFit's IT and sent to the Principal Investigator. Since CogniFit represents rather new technology, the Brown EF/A were used as a base measure for neuropsychological functioning and CogniFit will serve as an exploratory measure. All 16 tasks are empirically derived from reliable and valid neuropsychological tests. Cronbach's Alphas were strong across all tasks showing high levels of internal consistency.

**Data Analyses**

IMB's SPSS statistical analysis software was used to conduct analyses and the programming software R was used for data visualization and basic descriptive statistics. It was essential that all variables remain continuous except for the categorical demographic and background variables. By keeping all data continuous, patterns could be examined across the

entire range of the data set and no data points were excluded. Each phase had a different emphasis for the data analyses.

***Research Question 1***

My first research question centered around the hypothesis that college students with an ADHD diagnosis would perform worse on neuropsychological tests compared to their Control peers. Comparisons of each neuropsychological domain, as per the Brown EF/A, between groups were conducted using a MANOVA for both the Brown EF/A and CogniFit. In addition, I hypothesized that ADHD symptomatology would be negatively correlated with performance on such tasks. Thus, it should be seen that those that score high on the CAARS and ASRS should also perform worse on the Online Cognitive Test and the Brown Executive Function/Attention Scales. Keeping the data continuous, the analyses were focused on correlating these variables to examine their relationships and to make comparisons between groups.

***Research Question 2***

The second research question sought to compare positive ADHD screens using different assessments of adult ADHD and determine their consistency. The ASRS, CAARS, and the Brown Executive Function/Attention Scales all include a clinical cut-off for ADHD and are often used in the diagnosis of ADHD by a healthcare professional. For the Brown Executive Function/Attention Measure – commonly used for the assessment and diagnosis of ADHD – T-Scores of greater than 70 represent significant impairment in functioning. As per the CAARS, T-Scores of greater than 70 also represent a likelihood of ADHD. Brown EF/A T-Scores were autogenerated via Q-Global. T-Scores for the CAARS had to be calculated and corresponding scores compared across age and gender.

The proportion of those meeting the clinical cutoff were compared across all three measures to assess for differences between ADHD and non-ADHD groups. Chi-square tests were used to test for differences between groups.

***Research Question 3***

The third research question was focused on rates of comorbidity in students with and without ADHD. Scores on the PHQ-8, GAD-7, and PSS-10 were compared using a series of Student's *t*-tests. In addition, scores on the PHQ-8 and GAD-7 were transformed to reflect clinical cut-offs. Then, Chi-Square tests were used to determine if rates of positive screens for depression and anxiety differ between the ADHD and Control group. Lastly, Pearson correlations were run to investigate if a higher score on the ASRS does, in fact, correspond to greater symptomatology.

# Chapter 3: Results

## Participants

### *Phase 1 Sample*

A total of 483 students completed the Phase 1 survey as defined by answering 80% or greater of the questions. Then, 29 students were removed because they failed to meet the engagement criteria. With a total of five engagement items, students needed to answer correctly at least three out of the five for their data to be included. The study employed rigorous inclusion criteria which resulted in the removal of 86 participants. Most of the removals were from the ADHD group because they had a neurological disability, a learning disorder, or no longer considered their ADHD to be a problem. Other removals were from the Control group due to a positive screen on the ASRS without a diagnostic history of ADHD. As such, 368 students completed Phase 1 and their data used for analyses.

The demographic characteristics of the Phase 1 sample can be seen in Table 2. Of the 368 participants, the majority identified as female, White, non-Hispanic, freshmen, and as belonging to a family that does not require government assistance.

The average age of the sample was 18.69 years with a standard deviation of 1.35 years. Ages ranged from 18-25 to fit the criteria for emerging adulthood. Parental education showed that 32.9% of the sample were first-generation college students compared with 67.1% of participants that indicated their parents completed at least a bachelor's degree. Additionally, 27.2% of respondents indicated a diagnostic history of ADHD. The remaining demographics can be seen in Table 2.

Table 2. Demographics

| Demographic Variables | N (N=368) | % |
|---|---|---|
| **Race** | | |
| Native American/ Alaskan Native | 6 | 1.6% |
| Western or South Asian | 8 | 2.2% |
| Middle Eastern/ North African | 4 | 1.1% |
| East Asian or Pacific Islander | 5 | 1.4% |
| Black or African American | 45 | 12.2% |
| White (Caucasian/ European or European American) | 265 | 72.0% |
| Mixed (please describe): | 23 | 6.3% |
| Hispanic | 11 | 3.0% |
| **Ethnicity** | | |
| Hispanic/Latina/Latino | 24 | 6.5% |
| Non-Hispanic/non-Latina/non-Latino | 341 | 92.7% |
| **Student Standing** | | |
| Freshman (1-29 hours) | 283 | 76.9% |
| Sophomore (30 – 59 hours) | 50 | 13.6% |
| Junior (60 – 89 hours) | 20 | 5.4% |
| Senior (90 or more hours) | 11 | 3.0% |
| Masters' student | 1 | 0.3% |
| **Gender/Gender Identity** | | |
| Female | 251 | 68.2% |
| Male | 116 | 31.5% |
| **Government Assistance** | | |
| No | 316 | 85.80% |
| Yes | 51 | 13.68% |

The 368 participants were categorized into two groups depending on if they met the necessary inclusion criteria for the ADHD group (i.e., history of ADHD diagnosis, met clinical cut-off on ASRS, etc.). The control group consisted of 268 participants compared to the ADHD group that consisted of 100 participants. No significant differences were found in demographics between the Control versus the ADHD group. The demographics tested included age, gender, race, government assistance, and parental education.

***Phase 2 Sample***

Following completion of Phase 1, up to 50 students were invited to complete Phase 2. In total, 46 students completed Phase 2: 27 from the ADHD group and 19 from the Control group. Students were first recruited for the ADHD group to establish demographic criteria to assist in matching. While direct matching was unfeasible due to recruitment difficulties, the researchers recruited for the Control group based off age, gender, race/ethnicity, and SES data. No significant demographic differences were found between these two groups. These variables include age, race/ethnicity, gender/identity, parental education, and SES. The average age of this smaller sample was 19.08 years with a standard deviation of 1.7 years, again ranging from 18-25. This sample was largely female with 82.6% identifying as female (*n*=38) and 17.4% identifying as male (*n*=8). Most students, 73.9%, identified as White (*n*=34), with 26.1% identifying as non-White (*n*=12). The samples from Phases 1 and 2 were compared and no significant differences in age, gender, or race were found.

**Research Question 1**

Research Question 1 sought to investigate whether college students with ADHD performed worse on neuropsychological measures compared to a Control group. To determine neuropsychological functioning, multivariate analysis of variance (MANOVAs) were run on the

Brown Executive Function/Attention scales. As shown in Table 4, across all six domains (i.e., Activation, Focus, Effort, Emotion, Memory, and Action), significant differences were observed between the ADHD and the Control group. For the MANOVA, there was a significant difference between the ADHD and control group, Wilks' Lambda = .28, $F = 11.94$, $p < .001$. The multivariate effect size was estimated at .718, which implies that 71.8% of the variance in the canonically derived dependent variable was account for by ADHD diagnostic history. T-Scores for each of the domains were calculated with higher scores indicating worse neuropsychological functioning. Across all domains, scores were significantly higher for the ADHD group compared to the Control group. These data indicate participants with ADHD have significantly impaired neuropsychological functioning compared to that of the Control group.

Table 4. Brown EF/A Results

| Brown EF/A domains | ADHD group | | Control group | | *F* | *df* | *p* | $n^2$ |
|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | | | | |
| Activation | 76.44 | 10.33 | 48.53 | 8.87 | 45.94 | 2 | <.001 | 2116 |
| Focus | 75.67 | 6.08 | 53.00 | 10.04 | 44.99 | 2 | <.001 | 2116 |
| Effort | 75.63 | 9.87 | 48.63 | 8.38 | 48.84 | 2 | <.001 | 2116 |
| Emotion | 63.52 | 8.42 | 48.58 | 7.46 | 19.56 | 2 | <.001 | 2116 |
| Memory | 76.59 | 10.67 | 51.16 | 10.24 | 33.28 | 2 | <.001 | 2116 |
| Action | 75.11 | 11.65 | 51.42 | 8.47 | 27.96 | 2 | <.001 | 2116 |

A MANOVA was also run using the CogniFit data to investigate if the same pattern emerged. Indeed, the MANOVA revealed a significant relationship between the independent variable – a diagnostic history of ADHD – and the dependent variables – CogniFit's neurocognitive tasks. The MANOVA was significant, Wilks' Lambda = 0, p < .003, $\eta^2 = 1$. Between subject tests can be examined in Appendix B which shows significant differences across all cognitive tasks.

Before these scores could be compared to ADHD symptomatology, analyses first had to be conducted comparing differences in the CAARS and ASRS between the ADHD and control groups. This step is key to establish a link between greater symptomatology and worse neuropsychological functioning. The ADHD group reported scores significantly higher across all domains compared to that of Control. For Inattention/Memory (5.63 vs. 19.93), Hyperactivity/Rest (14.37 vs. 22.70), Impulsivity/Emotion (5.74 vs. 17.81), Problems with Self-Concept (4.32 vs. 11.11), DSM Inattention (5.00 vs. 18.30), DSM Hyperactivity/Impulsivity (5.89 vs. 13.44), and the ADHD Index (6.95 vs. 19).

Next, Pearson correlations were run to investigate if higher scores on ADHD symptomatology (i.e., CAARS and ASRS) were associated with worse neuropsychological functioning (i.e., Brown EF/A). As shown in Table 5, high scores on the ASRS Part A were associated with higher scores on the Brown Executive Function/Attention Scales (higher scores indicate worse functioning).

This same pattern was observed when correlating scores on the CAARS to scores on the Brown EF/A (see Table 5). All domains demonstrated at least moderate correlations, all of which were significant. Clearly, atypical neuropsychological functioning was associated with greater ADHD symptomatology which confirms the initial hypothesis.

Table 5. Brown EF/A Correlations

| Brown Executive Function/Attention | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ASRS/CAARS | | Activation | Focus | Effort | Emotion | Memory | Action | TC |
| ASRS Part A Total | Pearson Correlation | .798** | .851** | .852** | .747** | .814** | .765** | .866** |
| Inattention/Memory | Pearson Correlation | .897** | .788** | .858** | .699** | .772** | .658** | .837** |
| Hyperactivity/Restlessness | Pearson Correlation | .553** | .749** | .642** | .638** | .698** | .779** | .728** |
| Impulsivity/Emotion | Pearson Correlation | .746** | .796** | .816** | .802** | .748** | .831** | .847** |
| Self-Concept | Pearson Correlation | .789** | .769** | .798** | .791** | .825** | .678** | .831** |
| DSM Inattention | Pearson Correlation | .885** | .897** | .892** | .770** | .856** | .807** | .914** |
| DSM Hyperactivity/Impulsivity | Pearson Correlation | .604** | .785** | .713** | .620** | .742** | .849** | .772** |
| ADHD Index | Pearson Correlation | .847** | .861** | .860** | .779** | .798** | .785** | .881** |
| DSM Symptom Total | Pearson Correlation | .817** | .904** | .869** | .752** | .859** | .875** | .909** |

**. Correlation was significant at the 0.01 level (2-tailed).

Since the Brown EF/A showed deficits across neuropsychological functioning in ADHD participants compared to control, the data provide evidence to support for the hypothesis of Research Question 1. In addition, neuropsychological functioning correlated with more severe ADHD symptomatology.

**Research Question 2**

Research Question 2 sought to determine if there was a significant difference in the rate of positive screens across the three most prevalent adult ADHD rating scales. To compare positive screens across the ASRS, CAARS, and Brown EF/A, scores had to be compared to diagnostic criteria. For the ASRS, a score of 4 or greater on the first six questions (i.e., Part A) met the clinical cut-off for adult ADHD.

Since the ASRS was used as the base measure to determine eligibility, the number of positive screens reflect that of the Phase 2 sample. As such, 27 participants had a positive screen for ADHD while 18 did not. Since the ASRS was used in Phase 1 of the study, data exist for all 368 participants. The number of positive screens with the ASRS out of this sample was 100 compared to 268 students that did not meet the clinical cut-off. As a reminder, recruitment for this study was heavily reliant on the college's Disability Support Services. Thus, a significant number of positive screens was expected.

As shown in Table 6, when testing with the Brown Executive Function/Attention Scales, the number of positive screens reduced to 22. Thus, 5 of the students that had a prior diagnosis of ADHD, indicated it was a current problem, and scored above the clinical cut-off for the ASRS did not meet the necessary cut-off for the Brown. A Chi-Square test between the ASRS and the Brown resulted in a statistically significant difference between the two scales. No participant from the Control group met the clinical cut-off for the Brown.

With the CAARS, only 9 participants met the clinical cut-off (see Table 6). This represents a reduction of 18 compared to the ASRS and a reduction of 13 compared to the Brown. The difference between the CAARS and the ASRS was found to be statistically significant as per a Chi-Square test ($p<.005$). No one from the control group had a positive screen on the CAARS. A Chi-Square Test was conducted comparing positive screens for the Brown EF/A to positive screen for the CAARS. There was a statistically significant difference in positive screens between the two measures. Thus, the three measures determined different rates of positive screens for ADHD confirming the initial hypothesis.

Table 6. Diagnostic Measures

| **Diagnostic Measures** | | | ASRS Screening | | | Pearson Chi Square | Sig (2-sided) |
|---|---|---|---|---|---|---|---|
| | | | Negative | Positive | Total | | |
| Brown EF/A Screening | Negative | # | 19 | 5 | 24 | 29.673 | <0.001 |
| | Positive | # | 0 | 22 | 22 | | |
| | Total | # | 19 | 27 | 46 | | |
| | | | ASRS Screening | | | | |
| CAARS Screening | Negative | # | 19 | 18 | 37 | 7.874 | 0.005 |
| | Positive | # | 0 | 9 | 9 | | |
| | Total | # | 19 | 27 | 46 | | |
| | | | CAARS Screening | | | | |
| Brown EF/A Screening | Negative | # | 23 | 1 | 24 | 7.561 | 0.006 |
| | Positive | # | 14 | 8 | 22 | | |
| | Total | # | 37 | 9 | 46 | | |

Since rates of positive screens varied significantly across diagnostic measures, the data provide convincing evidence for the hypothesis for Research Question 2.

**Research Question 3**

Research Question 3 concerned the rates of comorbidity and psychological symptomatology in the ADHD group compared to the Control group. To address the concern of comorbidity for those with ADHD, means on the PSS-10 (i.e., stress), PHQ-8 (i.e., depression), and GAD-7 (i.e., anxiety) were compared between the ADHD and control groups using *t*-tests. It is important to note that these data came from Phase 1 which has 368 participants. As shown in Table 7, the ADHD group displayed statistically significant higher scores on all three measures compared to the Control group.

Table 7. Mental Health Screeners

| **Mental Health Screeners** | | # | Mean | Std. Deviation | df | t | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| PSS-10 Score | Control | 268 | 16.5522 | 6.68451 | 366 | -8.546 | <.001 |
| | ADHD | 100 | 23.2200 | 6.58676 | | | |
| PHQ-8 Score | Control | 268 | 6.0448 | 4.83180 | 366 | -10.328 | <.001 |
| | ADHD | 100 | 12.0700 | 5.35461 | | | |
| GAD-7 Score | Control | 268 | 6.3582 | 5.54640 | 366 | -8.766 | <.001 |
| | ADHD | 100 | 12.0800 | 5.63302 | | | |

Scores on the GAD-7 and PHQ-8 were dichotomized to reflect whether their clinical cut-offs were met. Then, a Chi-Square test was conducted to compare those that met the clinical cut-off for ADHD with those meeting the cut-off for depression as per the PHQ-8. As shown in Table 8, the Chi-Square revealed a significant difference between the two groups indicating that those with ADHD were much more likely to also score above the cut-off for depression. Next, the ASRS cut-off was compared to the GAD-7. Again, a significant difference was observed. Those with ADHD had a much higher percentage meeting the cut-off for anxiety compared to those without ADHD (see Table 8).

In total, 68 of the 100 participants in the ADHD group scored above the clinical cut-off for the PHQ-8. Additionally, 61 of the participants scored above the clinical cut-off for the GAD-7. There is no cut-off for the PSS-10.

Table 8. Chi-Square of Clinical Cut-Offs

| **Chi-Square of Clinical Cut-Offs** | | | PHQ-8 (Depression) | | | Pearson Chi Square | Sig (2-sided) |
|---|---|---|---|---|---|---|---|
| | | | Negative | Positive | Total | | |
| ASRS Diagnostic | Control | Count | 203 | 65 | 268 | 60.387 | p<.001 |
| | | % within inclusion | 75.7% | 24.3% | 100.0% | | |
| | ADHD | Count | 32 | 68 | 100 | | |
| | | % within inclusion | 32.0% | 68.0% | 100.0% | | |
| | | | GAD-7 (Anxiety) | | | | |
| ASRS Diagnostic | Control | Count | 194 | 74 | 268 | 34.952 | p<.001 |
| | | % within inclusion | 72.4% | 27.6% | 100.0% | | |
| | ADHD | Count | 39 | 61 | 100 | | |
| | | % within inclusion | 39.0% | 61.0% | 100.0% | | |

Lastly, Pearson correlations were calculated between the ASRS, and the PSS-10, PHQ-8, and GAD-7 to see if higher scores on the ASRS – indicating greater symptomatology – were linked with greater symptomatology across stress, anxiety, and depression. Indeed, the ASRS showed moderate correlations with the PSS-10 ($r$=.619) $p < .001$, PHQ-8 ($r$=.635) $p < .001$, and the GAD-7 ($r$=.618) $p < .001$. All correlations were statistically significant. Thus, individuals experiencing greater ADHD symptoms also report significantly more symptoms of anxiety and depression than those with less ADHD symptoms. These analyses provide greater evidence for comorbidity in college students with ADHD.

## Chapter 4: Discussion

The purpose of the present study was to evaluate neuropsychological functioning in college students with ADHD, compare commonly used diagnostic scales, and assess rates of comorbidity. The data provide convincing evidence on all three aims showing distinct neuropsychological differences, differences in diagnostic measures, and greater rates of comorbidity in students with ADHD.

Since higher T-scores on the Brown Executive Function/Attention scale correspond with worse neuropsychological functioning, the ADHD group was deficient across all six subscales of the Brown EF-A: activation, focus, effort, memory, action, and total composite with strong effect sizes. All T-scores were relatively similar for the ADHD group with a mean around 75. Interestingly, the Emotion subscale was much lower at 63 for the ADHD group. Nevertheless, the mean T-score for Emotion was still significantly higher than the Control group.

Emotion is defined as the Brown EF-A as "Managing frustration and modulating emotions" (Brown, 2018). While not entirely surprising since this conceptualization is not explicitly related to ADHD symptomatology, it does present some confusion as to why these individuals also have significantly higher levels of anxiety, depression, and stress symptoms.

Not only did the ADHD group perform worse on the Brown EF-A than the Control, but their performance was correlated with severity of symptomatology. Thus, greater ADHD severity corresponds to worse neuropsychological functioning. It is important to address that causation was not tested for and these results only represent correlational analyses. Still, the strikingly low p-value and strong correlations indicate that these two phenomena (e.g., ADHD symptomatology and executive functioning) are closely linked. For correlations between the ASRS and the Brown EF-A, the strongest relationship was observed across Focus, Effort, and

Action. It is interesting that Effort was strongly correlated with ADHD symptomatology as Effort is conceptualized by the Brown EF-A as "Regulating alertness, sustaining effort, and adjusting processing speed" (Brown, 2018). As such, this area was closely associated with the Default Mode Network which has become a popular area of focus for neuroimaging studies on ADHD.

CogniFit is a relatively new paradigm that allows researchers and clinicians to assess neurocognitive functioning in an easy-to-use format. The present study wanted to first establish the feasibility of using CogniFit to assess for neuropsychological functioning. Based off the MANOVA, scores on the CogniFit tasks are clearly related to the presence of an ADHD diagnosis. This result is exciting as it shows CogniFit can discern between two different populations: those with ADHD and those without ADHD. In addition, the Between Subject Tests showed significance. CogniFit did not perform perfectly as there were some tasks that were insignificant between groups. In addition, there were some tasks in which the ADHD group performed better than the Control group. While this may seem problematic, the sheer number of cognitive variables included with CogniFit (59) shows that a few can perform counterintuitively without greatly affecting statistical analyses. The General Cognitive Assessment was normed using a healthy sample and not ADHD participants, so it is understandable that the results may be imperfect. Overall, however, CogniFit offered the participants an easy-to-use and interactive experience while also garnering valuable data that appeared to validly measure neuropsychological functioning.

Several explanations exist for the differences in positive screens across the three key diagnostic measures. First, it was expected that the ASRS may overestimate the number of participants meeting criteria for ADHD, although we cannot say definitively without a clinical

diagnosis. The reality of an open-source, six-item scale was that the accuracy will not be perfect. It is also better to overestimate than underestimate when dealing with a serious neuropsychological disorder. What is concerning, however, is that most physicians outside of a psychiatry or psychology practice will use openly available scales (Weibel et al., 2020). Adult ADHD is already an intricate disorder to diagnose, so widespread usage of a scale should reflect a balance between length, accuracy, and cost. The difference between positive screens between the Brown EF-A and the CAARS was not as surprising when considering the unique nature of the Brown EF-A. Indeed, this study was able to use the Brown EF-A as both a measure of ADHD and as a neuropsychological base measure. This possibility was due to the uniqueness in the method in which the scale was developed. While the CAARS seeks to capture the presence of symptoms and symptom severity, the Brown EF-A seeks to predict the presence of ADHD based on specific executive functioning and attentional attributes. Two measures developed from different frameworks are likely to result in different rates of positive screens. The problem, however, is that both measures intend to capture the same concept– a clinical diagnosis. Additionally, they both offer a clinical cut-off for ADHD. Both measures are widely used in clinical and research settings. By no means do these data decrease their usability in either environment. It does, however, make the argument that adult ADHD may need to be conceptualized differently. Instead of a continuation of symptoms from childhood to adulthood, these symptoms change depending on their environment. For example, ADHD is likely to present itself differently in an elementary classroom than in a college dormitory and even more different compared to an office. Regardless, the data demonstrate a need for a review of diagnostic practices especially with the updated DSM-V guidelines over the last few years. As

such, further work is needed to determine which ADHD assessment tool is most appropriate for this specific population.

The significant finding of differences in comorbidity rates between ADHD and control groups is especially intriguing. Comorbidity in ADHD is highly complex and complicates diagnostic and treatment strategies. It is interesting that scores on the ASRS showed similar correlations with stress, anxiety, and depression. Of course, anxiety and depression are closely linked along with anxiety and stress (Tafet & Nemeroff, 2016). What is interesting, however, is how the ASRS showed similar moderate correlations with the PHQ-8 and GAD-7 compared to correlations between the PHQ-8 and GAD-7. While this may seem like a insignificant nuance, it could represent a much more salient phenomenon which links these disorders together showing that they may share some of the same symptoms. It should also be noted that the control group did not have means above or near the clinical cut-offs for the ASRS, PHQ-8, and GAD-7.

Taken together, college students with ADHD have significant neuropsychological deficits spanning activation, focus, effort, memory, and action and these abnormal levels are associated with worse ADHD symptomatology. Not only do college students with ADHD have neuropsychological deficits, but they also experience higher rates of psychological symptomatology (i.e., anxiety, depression) and greater stress levels compared to other college students. With three commonly used diagnostic scales all yielding significantly different screening rates, a clinical interview is perhaps the only reliable method of assessing adult ADHD. Unfortunately, a clinical interview is not always practical in a collegiate setting. Similarly, general practitioners have started to screen for psychological symptoms in the clinic and prescribe based on those scores. It is worrisome that some individuals with ADHD will go undiagnosed when this population clearly needs extra support beyond psychostimulants. Indeed,

psychostimulant medication works well with ADHD symptoms, but can adversely affect comorbid symptomatology (Adler & Cohen, 2004).

With high rates of comorbidity, it begs the question if the neuropsychological deficits are responsible for the symptomatology. Theoretically, weak executive functioning could undoubtedly lead to life problems (Mohamed et al., 2020). Examining the Brown EF-A Scale in more detail and considering the subscale conceptualizations, a lack of activation and action would inhibit someone from addressing a task. Even if the person is able to engage in the activity, low levels of effort and focus would cause the individual to be distracted. With poor memory, the individual would struggle to maintain the short-term memory necessary for completing in-depth tasks. While struggling to complete a task might not pose as trigger for psychological distress, these difficulties can accumulate over time. Eventually, a person's coping ability may be overwhelmed by various stressors and that can result in symptoms. This is one of the reasons the population of college students and emerging adults was chosen for the study. These students are leaving their home environment in which they had an established support network, developed coping strategies to tackle everyday demands, and developed compensatory mechanisms to function with their ADHD symptoms. In addition, several students also had academic accommodations to aid in K-12 schoolwork. While these neuropsychological deficits were prevalent, they were not as likely to be problematic as numerous safeguards were in place. As someone enters emerging adulthood, they enter a critical period for the development of psychopathology (Jeffrey Jensen Arnett, 2016). The transition to college causes the loss of a support network and a rather sudden surge of unique stressors (Jeffrey Jensen Arnett, 2016). For the most part, students have to navigate the collegiate environment on their own, especially during their first few years. A longitudinal study is necessary before any definitive conclusions

can be made regarding neuropsychological deficits and comorbidities in relation to emerging adulthood, but this study helps establish a theoretical framework.

High rates of comorbidity have been well documented across individuals with ADHD (Silva et al., 2015). There has not yet, however, been a definitive explanation as to why this pattern emerges. Perhaps the most likely factor is the pervasiveness of ADHD symptomatology on daily living. These symptoms can impact school, work, relationships, and a myriad of other areas of life. Thus, children develop ADHD at a young age and then, as they progress into adulthood, begin to display symptoms of other mental illness because of their ADHD. Again, this was a key reason as to why comorbidity was assessed in this study. The other explanation, as highlighted above, was due to the neuropsychological deficits. These deficits precede the ADHD, depression, and anxiety, and these disorders manifest over time. These two explanations are not mutually exclusive, however. The explanation, though, is important because uncovering the link between ADHD and comorbidities will allow for more informed preventative and treatment measures to be implemented. By reducing any additional psychopathology, these individuals will be better primed to function in daily life and will have, ultimately, a better prognosis.

**Limitations**

This study was conducted during the COVID-19 pandemic which forced college students to move home and out of their dorms. As such, this entire study was done virtually. All measures had to be available for virtual use including the neuropsychological assessment. Thus, some conventional scales could not be used as it would be impractical for use in a virtual format. Certain neuropsychological assessments could not be used because they relied on props or could only be downloaded onto a centralized computer. For example, the Cambridge Assessment

Battery is a commonly used neuropsychological test but is unable to be used virtually. Although CogniFit can be delivered virtually, it is recommended to be administered in a controlled setting. Since most participants were in their families' home, it was likely their environment had distractions. Without a researcher with them during the assessment, it is also possible that participants were confused by certain directions and did not complete the tasks properly. Nonetheless, engagement items were used for the surveys and the CAARS was imbedded with an internal consistency check. Therefore….

Another difficulty was ensuring that all participants in the ADHD group all still met diagnostic criteria as per the DSM-V. Without a clinical interview by a neuropsychologist, or other medical professional, it is possible that some participants in the ADHD group no longer had an ADHD diagnosis. A tremendous amount of effort, however, went into addressing this limitation. Participants first had to endorse that they had received an ADHD diagnosis in the past. Then, they were asked to specify who diagnosed them (e.g., psychologist, neuropsychologist, pediatrician, psychiatrist). Next, the participants were asked to indicate if they considered their ADHD a current problem. The last check was meeting the clinical cut-off for adult ADHD as per the ASRS. Only those that met all the above criteria were considered for the ADHD group.

Although efforts were made to improve the diversity of the sample for both Phase 1 and Phase 2, (e.g., offering incentives, contacting diverse student groups) the results still showed a majority White and female sample. Nevertheless, the demographics for the study were representative of the university's student body population. In part, this finding is interesting as ADHD rates are reported higher in males than in females (Gentile et al., 2006). Otherwise, the lack of diversity serves as a barrier to the generalizability of the study's results to other

demographic subgroups. Results should be considered with caution and should be replicated with other university or emerging adult samples as well as with more diverse samples to demonstrate replicability and generalizability.

**Future Directions**

Several important themes arose from the data that will serve as starting points for future research, mental health policies, and higher education policies. First, the neuropsychological weaknesses faced by those with ADHD underscore the importance of targeted interventions. Medication is not enough to make up for neuropsychological deficits and these executive function difficulties lead to widespread hardship (Mohamed et al., 2020). As such, interventions that address these neuropsychological deficits should be explored. Interestingly, a mindful movement intervention has been employed in young children with ADHD (Clark et al., 2020). The study found significant improvement across ADHD symptoms and executive functioning. A mindful movement intervention could easily be tested in emerging adults to see if these results could be replicated in older individuals. Secondly, the disparity between diagnostic testing for ADHD needs to be addressed. It is imperative that emerging adults, with their high susceptibility to psychological disorders, undergo comprehensive assessment to ensure an accurate diagnosis. It seems clear that a more standard use of a specific openly available scale needs to be developed for use in medical facilities where a clinical interview by a psychologist is unavailable. Lastly, the comorbidity amongst college students with ADHD is concerning. Future research should consider additional comorbidities and examine neuropsychological disorders such as Obsessive-Compulsive Disorder, Tourette's Syndrome, and Post-Traumatic Stress Disorder. Colleges and universities should enhance existing policies to ensure students with ADHD get the necessary aid they need to be successful. Easier access to accommodations, streamlined access to continuation

of care, and even periodic "check-ins" would be a strong start to make the collegiate experience more equitable for those with ADHD. Overall, not enough research has been conducted on ADHD in college students and emerging adults. As such, it is imperative that the scientific field address these gaps to provide clinicians and college administrators the knowledge they need to appropriately guide decisions concerning individuals with ADHD.

**Conclusion**

This thesis sought to provide a neuropsychological profile of college students with ADHD as well as address questions related to diagnostic tests and comorbidity. Ultimately, these results will help bridge the gap in the literature between children and adults with ADHD. The results provide overwhelming support for the need for improved diagnostic practices, treatment options, and mental health resources for emerging adults with ADHD.

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# Appendices

## Appendix A

**EAST CAROLINA UNIVERSITY**
**University & Medical Center Institutional Review Board**
**4N-64 Brody Medical Sciences Building· Mail Stop 682**
**600 Moye Boulevard · Greenville, NC 27834**
**Office 252-744-2914 · Fax 252-744-2284 ·**
**rede.ecu.edu/umcirb/**

### Notification of Exempt Certification

From: Social/Behavioral IRB
To: William Guiler
CC: Christyn Dolbier
William Guiler
Date: 8/19/2020
Re: UMCIRB 20-001890
A Neuropsychological Profile of College Students with ADHD

I am pleased to inform you that your research submission has been certified as exempt on 8/19/2020. This study is eligible for Exempt Certification under category # 2b.

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

| Document | Description |
|---|---|
| ADHD ASRS(0.01) | Surveys and Questionnaires |
| Chapter 1: Literature Review and Introduction(0.01) | Study Protocol or Grant Application |
| Chapter 2: Methodology(0.01) | Study Protocol or Grant Application |
| Consent(0.01) | Consent Forms |
| Demographics(0.01) | Surveys and Questionnaires |
| Email Template(0.01) | Recruitment Documents/Scripts |
| FFMQ(0.01) | Surveys and Questionnaires |
| Flyer(0.01) | Recruitment Documents/Scripts |
| GAD(0.01) | Surveys and Questionnaires |
| Impulsivity(0.01) | Surveys and Questionnaires |
| Interview Surveys/Assessments(0.02) | Interview/Focus Group Scripts/Questions |
| Mental Health Resources(0.01) | Additional Items |
| MEWS(0.01) | Surveys and Questionnaires |
| PHQ(0.01) | Surveys and Questionnaires |
| PSQI(0.01) | Surveys and Questionnaires |
| PSS-10(0.01) | Surveys and Questionnaires |

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

## Appendix B

Demographic and Background Information

1. How old are you?
    a. _____ years old

2. How do you describe your gender or gender identity?

    ☐ Female
    ☐ Male
    ☐ Male to female transgender
    ☐ Female to male transgender
    ☐ Do not identify as male, female or transgender

3. Please describe your ethnicity.

    ☐ Hispanic/Latina/Latino
    ☐ Non-Hispanic/non-Latina/non-Latino

4. What do you consider your race to be?

    ☐ Native American/ Alaskan Native
    ☐ Western or South Asian
    ☐ Middle Eastern/ North African
    ☐ East Asian or Pacific Islander
    ☐ Caribbean Islander
    ☐ Black or African American
    ☐ White (Caucasian/ European or European American)
    ☐ Mixed (please describe):_____
    ☐ Other (please describe):_____

5. What was your current student standing?

    ☐ Freshman (1-29 hours)
    ☐ Sophomore (30 – 59 hours)
    ☐ Junior (60 – 89 hours)
    ☐ Senior (90 or more hours)
    ☐ Masters student
    ☐ Doctoral student
    ☐ Other (please describe): _____

6. What was the highest level of formal education obtained by your parents/guardians (or those who raised you? Please mark only one for each parent/guardian. Please leave any field blank that does not apply.

| | Did not finish high school | High school diploma or GED | Post-secon-dary school other than college (e.g., cosmetology) | Attended college but did not complete a degree | Associ-ate's degree (AA, AS, etc.) | Bach-elor's degree (BA, BS, etc.) | Some graduate school but did not complete a graduate degree | Master's degree (MA, MS, etc.) | Doctoral or professional degree (PhD, EdD, JD, MD, etc.) |
|---|---|---|---|---|---|---|---|---|---|
| Parent/ guardian 1 | | | | | | | | | |
| Parent/ guardian 2 | | | | | | | | | |
| Parent/ guardian 3 | | | | | | | | | |
| Parent/ guardian 4 | | | | | | | | | |

7. Does your family receive any form of government assistance?

For example: Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); Supplemental Nutrition Assistance Program (SNAP or food stamps); Temporary Assistance for Needy Families (TANF or welfare); Children's Health Insurance Program (CHIP), Supplemental Security Income (SSI); subsidized housing, housing vouchers, or public housing program; or low income home energy assistance program (LIHEAP).

☐ No
☐ Yes

8. Did you complete a FAFSA application before coming to ECU?

☐ No
☐ Yes

9. Have you ever been diagnosed with or told you have Attention-Deficit/Hyperactivity Disorder (ADHD) by a doctor or mental health professional?

☐ No
☐ Yes

10. (IF YES to 9) At what age were you first diagnosed or told you had ADHD?

☐ Open Response

11. (IF YES to 9) Who diagnosed you?

☐ Psychiatrist
☐ Pediatrician
☐ Other MD/DO
☐ Psychologist/Therapist
☐ Other (please describe)

12. (IF YES to 9) Do you consider your ADHD to be a current problem?

☐ No
☐ Yes

13. (IF YES to 9) Are you currently taking any medication for the treatment of ADHD?

☐ No
☐ Yes (If yes…. Please list)

14. Do you use any academic accommodations offered by ECU?

☐ No
☐ Yes (please list)

15. Did you ever receive therapy or counseling for your ADHD?

☐ No
☐ Yes

16. What difficulties do you experience due to ADHD symptoms? These could be related to college or related to other areas of your life. Or these could be two separate items.

17. What stresses you most about ADHD symptoms?

18. How do you deal or cope with the stress caused by ADHD symptoms?

    What are some strategies that you use to compensate for your ADHD difficulties and associated stress?

19. How do you think your ADHD symptoms are going to affect your future, if at all?

20. Which aspects of your ADHD symptoms do you wish you could improve?

21. Do you have additional thoughts or information you would like to share with us pertaining to your ADHD?

22. Are you currently taking any prescription stimulants (e.g., Adderall, Concerta, Ritalin, Dexedrine, Vyvanse, etc.)?

☐ No
☐ Yes

23. Are you currently taking any non-prescribed stimulant substance (e.g., cocaine methamphetamines, etc.) for recreational or academic purposes?

☐ No
☐ Yes

24. Are you currently taking any prescription stimulant not prescribed for you (e.g., Ritalin, Adderall) for academic purposes?

☐ No
☐ Yes

25. Are you currently taking any non-stimulant psychoactive medications (e.g. antidepressant, anti-anxiety medication, mood stabilizer etc.)?

☐ No
☐ Yes

26. Do you regularly use any product that results in the use of nicotine (e.g., smoking, vaping, patch, gum, chew)?

☐ No
☐ Yes

27. How often do you ingest caffeine (coffee, tea) ?

☐ Never
☐ Rarely

- ☐ Sometimes
- ☐ Weekly
- ☐ Daily

28. Have you ever been diagnosed with a learning disability, intellectual disability, developmental language disorder, or autism spectrum disorder?

- ☐ No
- ☐ Yes

29. Have you ever been diagnosed with a neurologic disorder (e.g., epilepsy, cerebral palsy, traumatic brain injury, Tourette Syndrome)?

- ☐ No
- ☐ Yes

**Appendix C**

| ADHD Diagnostic History | df | Mean Square | F | Sig. | Partial Eta Squared | Observed Power |
|---|---|---|---|---|---|---|
| C&Hs - Visual Scanning (Down) | 2 | 290.94 | 749.80 | 0.000 | 0.971 | 1.000 |
| C&Hs - Visual Scanning (Left) | 2 | 329.27 | 1053.48 | 0.000 | 0.980 | 1.000 |
| C&Hs - Visual Scanning (Right) | 2 | 310.76 | 1280.89 | 0.000 | 0.983 | 1.000 |
| C&Hs - Visual Scanning (Up) | 2 | 325.90 | 519.26 | 0.000 | 0.959 | 1.000 |
| A Big Circle - Response Time | 2 | 681033.01 | 631.93 | 0.000 | 0.966 | 1.000 |
| C&Hs - Hand-eye Coord. (Horizontal) | 2 | 1647.62 | 116.92 | 0.000 | 0.842 | 1.000 |
| C&Hs - Hand-eye Coord. (Vertical) | 2 | 1358.06 | 109.76 | 0.000 | 0.833 | 1.000 |
| C&Hs - Focused attention (Detection) | 2 | 52091860.51 | 1667.35 | 0.000 | 0.987 | 1.000 |
| F&C - Speed (Estimation-1) | 2 | 1864.13 | 680.77 | 0.000 | 0.969 | 1.000 |
| F&C - Speed (Estimation-2) | 2 | 169.05 | 421.65 | 0.000 | 0.950 | 1.000 |
| F&C - Speed (Estimation-3) | 2 | 72.48 | 123.66 | 0.000 | 0.849 | 1.000 |
| F&C - Speed (Estimation-4) | 2 | 67.16 | 93.25 | 0.000 | 0.809 | 1.000 |
| F&C - Speed (Estimation-5) | 2 | 118.79 | 98.32 | 0.000 | 0.817 | 1.000 |
| F&C - Speed (Efficiency-1) | 2 | 1438382961.74 | 44.08 | 0.000 | 0.667 | 1.000 |
| F&C - Speed (Efficiency-2) | 2 | 425836399.94 | 88.38 | 0.000 | 0.801 | 1.000 |
| F&C - Speed (Efficiency-3) | 2 | 1058785666.51 | 31.39 | 0.000 | 0.588 | 1.000 |
| F&C - Speed (Efficiency-4) | 2 | 1078012754.13 | 68.63 | 0.000 | 0.757 | 1.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| F&C - Speed (Efficiency-5) | 2 | 1498134794.81 | 81.10 | 0.000 | 0.787 | 1.000 |
| F&C - Speed (Accuracy%-1) | 2 | 77471.03 | 724.28 | 0.000 | 0.971 | 1.000 |
| F&C - Speed (Accuracy%-2) | 2 | 129487.09 | 516.74 | 0.000 | 0.959 | 1.000 |
| F&C - Speed (Accuracy%-3) | 2 | 60065.79 | 163.97 | 0.000 | 0.882 | 1.000 |
| F&C - Speed (Accuracy%-4) | 2 | 41972.47 | 93.25 | 0.000 | 0.809 | 1.000 |
| F&C - Speed (Accuracy%-5) | 2 | 93074.44 | 123.25 | 0.000 | 0.849 | 1.000 |
| F&C - Speed (RT-1) | 2 | 259895233.32 | 247.35 | 0.000 | 0.918 | 1.000 |
| F&C - Speed (RT-2) | 2 | 206321605.33 | 81.87 | 0.000 | 0.788 | 1.000 |
| F&C - Speed (RT-3) | 2 | 177959083.10 | 93.81 | 0.000 | 0.810 | 1.000 |
| F&C - Speed (RT-4) | 2 | 194930158.47 | 91.65 | 0.000 | 0.806 | 1.000 |
| F&C - Speed (RT-5) | 2 | 549315039.43 | 141.33 | 0.000 | 0.865 | 1.000 |
| Follow the Ball - Hand-eye Coord (Accuracy-1) | 2 | 175013.11 | 2823.92 | 0.000 | 0.992 | 1.000 |
| Follow the Ball - Hand-eye Coord (Accuracy-2) | 2 | 171126.49 | 2674.32 | 0.000 | 0.992 | 1.000 |
| Follow the Ball - Hand-eye Coord (Precision) | 2 | 4997.88 | 272.64 | 0.000 | 0.925 | 1.000 |
| Glowing Circles - Visual STM (Accuracy) | 2 | 650.51 | 487.30 | 0.000 | 0.957 | 1.000 |
| Glowing Circles - Speed (RT) | 2 | 14861659.73 | 578.87 | 0.000 | 0.963 | 1.000 |
| Glowing Circles - Planning (Retrieval) | 2 | 523103066.21 | 725.15 | 0.000 | 0.971 | 1.000 |
| Glowing Circles - Visual STM/Planning (SL-1) | 2 | 797.87 | 489.01 | 0.000 | 0.957 | 1.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Glowing Circles - Visual STM/Planning (SL-2) | 2 | 619.40 | 328.57 | 0.000 | 0.937 | 1.000 |
| Musical Notes - Estimation (Time-1) | 2 | 97966.03 | 1193.41 | 0.000 | 0.982 | 1.000 |
| Musical Notes - Estimation (Time-2) | 2 | 23179.19 | 1193.37 | 0.000 | 0.982 | 1.000 |
| Musical Notes - Estimation (Time-3) | 2 | 24320.90 | 1428.36 | 0.000 | 0.985 | 1.000 |
| Musical Notes - Estimation (Time-4) | 2 | 157388.43 | 1227.06 | 0.000 | 0.982 | 1.000 |
| N&S - Inhibition (Accuracy-1) | 2 | 15239401.75 | 620.82 | 0.000 | 0.966 | 1.000 |
| N&S - Inhibition (Accuracy-2) | 2 | 50643.59 | 2.15 | 0.128 | 0.089 | 0.417 |
| N&S - Inhibition (Accuracy-3) | 2 | 26888.49 | 0.23 | 0.794 | 0.010 | 0.084 |
| OSorHB - Contextual Memory (Speed) | 2 | 39283351.27 | 456.87 | 0.000 | 0.954 | 1.000 |
| OSorHB - Contextual Memory (Recognition) | 2 | 40316471.87 | 438.92 | 0.000 | 0.952 | 1.000 |
| OSorHB - Non-verbal Memory (Recognition) | 2 | 36520734.47 | 514.51 | 0.000 | 0.959 | 1.000 |
| P&Ws - Contextual memory (Accuracy) | 2 | 182483.70 | 1649.26 | 0.000 | 0.987 | 1.000 |
| P&Ws - Contextual memory (Correct) | 2 | 2717.95 | 1705.86 | 0.000 | 0.987 | 1.000 |
| P&Ws - Speed (RT) | 2 | 46933207.76 | 472.65 | 0.000 | 0.956 | 1.000 |
| P&Ws - Contextual Memory (RT) | 2 | 50426981.91 | 381.48 | 0.000 | 0.945 | 1.000 |
| B&C - Divided Attention (Time) | 2 | 17253311.09 | 578.45 | 0.000 | 0.963 | 1.000 |
| The Letters - Naming/Perception (Speed) | 2 | 15011922.26 | 126.92 | 0.000 | 0.852 | 1.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| The Mazes - Planning (Ability-1) | 2 | 12.16 | 14.19 | 0.000 | 0.392 | 0.998 |
| The Mazes - Planning (Ability-2) | 2 | 112.45 | 131.28 | 0.000 | 0.856 | 1.000 |
| The Numbers - Speed (RT) | 2 | 30964293.85 | 641.58 | 0.000 | 0.967 | 1.000 |
| The Numbers - Planning (Speed) | 2 | 609327207.87 | 244.45 | 0.000 | 0.917 | 1.000 |
| C&Ws - Inhibition (Time) | 2 | 24651373.34 | 122.80 | 0.000 | 0.848 | 1.000 |
| Three Shapes - Speed (RT) | 2 | 168519092.53 | 558.67 | 0.000 | 0.962 | 1.000 |
| Three Shapes - Recognition (Time) | 2 | 166438770.55 | 551.77 | 0.000 | 0.962 | 1.000 |