ADULT ADHD TRAITS AND SELECTIVE VISUAL ATTENTION

A Thesis
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Abstract

ADULT ADHD TRAITS AND SELECTIVE VISUAL ATTENTION

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Literature that evaluates sustained attention and response inhibition with adult participants with ADHD is extremely limited. While differences were demonstrated when participants with ADHD were compared to a control group, it is not known if comparing levels of traits on a self-report scale for ADHD symptoms can predict any sustained attention and response inhibition differences. The current study used an adapted version of the Conners' Continuous Performance Task (CPT) with eye tracking to test if higher self-reported ADHD symptoms and related functional impairment were predictive of participants' eyes looking at the target less and more response time variability. Breadth of ADHD-related impairment (i.e., number of settings) predicted more misses in the distractor condition of the CPT. ADHD related symptoms, themselves, were not a significant predictor for any outcome measures.

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I thank my cohort members for their incredible support throughout the program. They motivated me to make the most out of every moment I had in the classroom. The energy, commitment, and inspiration everyone had was infectious and I will never forget or take that experience for granted. As I continue to develop professional skills and foster new academic friendships, I will continue to remember and model my own behavior based on what my cohort did for each other at Appalachian State University.

Dedication

To my family and supportive peers and adults as I was growing up: My experiences with you all continue to motivate me as an adult.

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Attention-deficit hyperactivity disorder (ADHD) is a developmental disorder and clinical diagnosis distinguished by inattentiveness, hyperactivity, impulsivity, and deficits in executive functioning (American Psychiatric Association, APA, 2013; Willcutt et al., 2005). Symptoms and impairment, while identified in childhood, continue into adulthood for many individuals. For example, one study that sampled diagnosed children and re-tested them as adolescents found that 80% of the sample still met the criteria for an ADHD diagnosis at the second timepoint (Barkley et al., 1990). A follow up study based on Barkley et al.'s (1990) work evaluated a different group of individuals with ADHD from childhood to adulthood (Barkley et al., 2002). Diagnosed children were retested after 13 years, with 46% to 66% of the hyperactive group still meeting the criteria for an ADHD diagnosis. Notably, when children and adolescents diagnosed with ADHD were revisited as adults, the latter time was characterized by present albeit typically less severe symptoms (Slobodin et al., 2018).

Overall, it has been reported that 4.4% of the overall adult population meets diagnostic criteria for ADHD in the United States (Barkley, 1999; Kessler et al., 2006; Munoz et al., 2003; Roberts et al., 2011; Slobodin et al., 2018). Meta-analyses of ADHD's global prevalence estimated that ADHD affects 5.3% of children (Polanczyk et al., 2007) and 2.5% of adults (Simon et al., 2009). Two to eight percent of college students self-report an ADHD diagnosis (DuPaul et al., 2009). This population of college students demonstrates lower grade point averages and is less likely to graduate compared to their peers (DuPaul et al., 2009).

The purpose of the current study is to take a more nuanced approach to evaluating sustained attention by clarifying where participants maintain their attention to a stimulus during a task that requires response inhibition and maintaining attention.

Adult ADHD Traits and Selective Visual Attention

ADHD-related Cognitive and Neuropsychological Differences

As noted previously, ADHD is a clinical and developmental disorder that is characterized by various executive functioning differences (Willcutt et al., 2005). These traits include deficits in response inhibition (Barkley, 1997, 1999; Goto et al., 2010) and sustained attention (Adams et al., 2009; Berger & Cassuto, 2014; Chan et al., 2009; Friedman-Hill et al., 2010). Physiologically, these executive functioning deficits are linked to lower levels of and delays in activation of neurons in the cerebrum and frontal regions of the brain in a longitudinal study in which routine cortical scans were given to a sample of 223 children with ADHD over 2.8 years (Shaw et al., 2007). Another study of adults with ADHD demonstrated these executive functioning deficits continue into adulthood, demonstrated in adaptive visual and auditory discrimination tasks during functional magnetic resonance imaging (fMRI) that recorded higher brain activation in the frontal areas, compared to non-diagnosed peers (Salmi et al., 2018).

Response inhibition is an executive functioning ability that allows one to withhold pre-potent, potentially maladaptive actions, or to allow someone to focus on the salient stimuli or actions involved with goal-directed behavior by avoiding distractions (Barkley, 1999). Response inhibition is a critical process that helps facilitate sustained attention to relevant cues and has implications for everyday tasks. One example of an application of response inhibition is driving (Kingery et al., 2015; Michaelis et al., 2012) because the driver must pay attention only to relevant stimuli such as signs, other cars, and traffic lights. Numerous attention shifts away from these stimuli would demonstrate a deficit in response inhibition (Kingery et al., 2015; Michaelis et al., 2012). Such a response inhibition deficit was suggested as the fundamental deficit of ADHD, based on its wide array of applications and settings in which impulsive behavior may be inappropriate (Barkley, 1997; Carr et al., 2006; Feifel et al., 2004; Nigg, 1999). Interestingly, there is research that indeed shows that people with ADHD experience impairment in driving (Kingery et al., 2015; Narad et al., 2018).

Functionally, the response inhibition deficit is evidenced to involve frontal lobe impairment in the brain (Barkley, 1999; Hervey et al., 2004; Mostofsky & Simmonds, 2008; O'Halloran et al., 2018; Shaw et al., 2007; Weyandt et al., 2013). Due to executive functioning's role in regulating responses or behaviors, an executive functioning deficit would be demonstrated behaviorally as difficulty stopping a habitual behavior or response pattern. There may be little to no delay with a habitual response, which leads the individual to only realize they acted after their habitual response. On tasks that required children (Shaw et al., 2007), adolescents (O'Halloran et al., 2018), and adults (Boonstra et al., 2005; Salmi et al., 2018) to delay a response, frontal lobe impairment and a deficit in motor cortex activation or other regions that are involved with carrying out the task-related behavior were also found.

These aforementioned findings related to frontal lobe impairment (Barkley, 1999; Boonstra et al., 2005; Hervey et al., 2004; Mostofsky & Simmonds, 2008; O'Halloran et al., 2018; Salmi et al., 2018; Shaw et al., 2007; Weyandt et al., 2013) are consistent with the documented benefits of methylphenidate as treatment for adult individuals with ADHD (Barrilleaux & Advokat, 2009; Spencer et al., 2005) as well as a short-term intervention to improve sustained attention task performance (Boonstra et al., 2005; Surman et al., 2017). This medication stimulates the regions of the brain that are typically deficient in people with

ADHD. Methylphenidate accomplishes this by releasing agonists after it is used, which is a type of substance that forces the neurons in the frontal lobe to respond (Arnsten et al., 2007).

Sustained attention is another component of executive functioning, which is defined by maintaining focus on a stimulus or set of stimuli. This ability interacts with response inhibition. If response inhibition is intact, it will be easier to sustain attention to a stimulus for goal directed behavior and ensure attention is not directed towards irrelevant stimuli (Barkley, 1997, 1999; Feifel et al., 2004). Many studies of sustained attention and response inhibition used the Continuous Performance Task (CPT; Adams et al., 2009; Berger & Cassuto, 2014; Friedman-Hill et al., 2010), a common diagnostic tool that will be discussed later.

Various sustained attention tasks have documented deficits in people with ADHD (Adams et al., 2009; Avisar & Shalev, 2011; Berger & Cassuto, 2014; Cross-Villasana et al., 2015; Dankner et al., 2017; Friedman-Hill et al., 2010). Adams et al. (2009) observed an ADHD-related sustained attention deficit in a sample of nineteen boys aged 8 to 14 with a clinical diagnosis of ADHD that participated in a virtual reality task that replicated audio and visual stimuli in a school setting with distractors (e.g. paper planes, kids talking) in order to impose additional attentional demands common to that setting. When participants were tasked with only responding to certain letters that appeared in the middle of the chalkboard (X) with one type of distractor (visual or auditory), differences emerged in performance between the ADHD group and control group on the task. If both types of distractors were present, this further decreased performance in the ADHD group. Such difficulties were thought to involve both response inhibition and sustained attention deficits in the ADHD group (Barkley, 1999).

Theoretical Basis of ADHD

ADHD's theoretical work is primarily based on three theories: Executive Dysfunction (Barkley, 1997; Willcutt et al., 2005), State Regulation (Sanders, 1983; Sanders & van Duren, 1998), and Dynamic Developmental Theory (Sagvolden et al., 2005). Each of these theories attempts to explain the behavioral symptoms of the disorder with different models. It should be noted that none of these models are able to successfully explain all of the symptoms of ADHD (for a review, see Johnson et al., 2009). However, they are still the basis for many methods in the literature, including the present study.

The Executive Dysfunction theory of ADHD proposes that the symptoms of ADHD emerge due to an executive control deficit that facilitates other processes involved in purposeful behavior before motor movements are executed (Barkley, 1997; Willcutt et al., 2005). Barkley (1997) exemplified executive functioning's hierarchical nature through a Venn diagram that starts with (a) behavioral inhibition at the top, followed by (b) working memory, self-regulation, internalization of speech, and reconstitution (c) motor control (i.e., the successful execution or inhibition of task-related responses). While this model does not explicitly address sustained attention deficits, Barkley (1997) does specify that the model can account for this because self-regulation is still necessary to prevent distractibility.

Response inhibition is generally evaluated using tasks known as go no-go tasks, which require the participant to inhibit an ongoing response to a stimulus. The CPT, used in this study, is a variant of this type of task and will be discussed in a later section. Booth et al. (2005) provides an example of direct evidence that supports this theory. Using fMRI with child participants' who engaged in a go no-go task, they found additional activation in the fronto-striatal regions in the ADHD group when compared to non-diagnosed peers. Higher activation in these regions is generally associated with difficulty regulating response inhibition (Booth et al., 2005; Sagvolden et al., 2005).

The State Regulation Theory is based on the Cognitive-energetic model by Sanders (1983; Sanders & van Duren, 1998) and was applied to children with ADHD by Sergeant (2000). This theory states that difficulty with exerting the appropriate amount of effort is the main reason for the performance deficits for children with ADHD. When a task is performed, the availability of encoding a stimulus, memory search, binary decision, and motor preparation (Sternberg, 1969) is dependent on the arousal and activation of the individual. Activation is preparedness for action, while arousal is the physiological response to a stimulus. To make up for low activation and arousal, extra effort would have to be dedicated. According to the theory, children with ADHD have difficulty with making the appropriate effort, which inhibits optimal task performance (Sergeant, 2000). Wiersema et al.'s (2006) slow presentation of stimuli during a go no-go task demonstrated that children with ADHD had a longer delay responding to the stimuli (i.e., low arousal). The P3 location of the parietal lobe had lower activation, a region that has implications in response priming (i.e., low activation; Kok, 2001; Kopp et al., 1996; Wickens et al., 1983).

Finally, the Dynamic Developmental Theory (Sagvolden et al., 2005) is based on the premise that if the delay between a response and internal reinforcement is smaller the reinforcer is more effective. When this premise is applied to individuals with ADHD, it hypothesizes that those with ADHD have a window of reinforcement that passes faster when compared to neurotypical children. Therefore, in order to internally reinforce behavior for an ADHD child, the reinforcement has to be presented quickly after the onset of behavior. This theory was applied across a broad range of ADHD symptoms, including attentional processes and socially acceptable behavior. Physiologically, this theory hypothesizes the core issues are due to the low levels of dopamine involved in the anterior cingulate and dorsolateral prefrontal cortices (Sagvolden et al., 2005). An example of evidence that led to the creation of this theory were findings that children with ADHD had preferences for small, immediate rewards compared to a larger, delayed reward (Sonuga-Barke et al., 1992).

The relevance these theories have in the present study regards response inhibition. Barkley's (1997) theory addresses this directly by stating that response inhibition acts in a downstream fashion with other executive functions before behavior is initiated. The increased delay in response inhibition involving participants with ADHD is the reason for deficits involved in behavior. Measures that assess responses to stimuli can address this theory, such as the Continuous Performance Task (CPT), which are used to assess (a) inhibition to a rare critical stimulus and (b) if there is variability in the response time participants make after the onset of stimulus presentation. State Regulation theory (Sanders, 1983; Sanders & van Duren, 1998) and Sergeant's (2000) application of this theory to ADHD children does not address response inhibition directly. However, it does address the activation of a motor response, albeit because those with ADHD cannot make adequate effort to compensate for underarousal or underactivation (Sergeant, 2000). The Dynamic Developmental Theory is also response related but is primarily concerned with reinforcement. Within the current study, more outcome variables have direct implications for Barkley's (1997) theory of Executive Dysfunction, response inhibition, and control over goal-directed behavior, as compared to these other competing theories.

Visual Attention

Visual attention is broadly defined as allocating visual processing resources, typically by fixating on a stimulus or set of stimuli, to foster effective goal-directed behavior. Sustained visual attention, one of the primary components of attention that was assessed in the current study, requires participants to focus over a period of time (Van Zomeren & Brouwer, 1994). Deficits in response inhibition that are central to ADHD (APA, 2013) tend to make sustained attention in tasks difficult for affected individuals. Experimental research suggests that a clinical diagnosis of ADHD will be associated with responses to distracting stimuli that reflect ineffective inhibition, particularly with regard to auditory stimuli (Adams et al., 2009; Berger & Cassuto, 2014; Gomes et al., 2012) and visual stimuli (Adams et al., 2009; Berger & Cassuto, 2014; Pelletier et al., 2016).

Visual attention can be considered overt or covert. Covert attention is attending to information and processing it without this information necessarily being within the visual field. Overt attention represents attending to information that is being processed visually. If a person or object is being viewed, overt attention would suggest someone is paying attention to that person or object. Covert attention towards that person or object would be represented by the participant listening to that person or object or by viewing that person or object without directly fixating on that person or object.

Indexing sustained attention visually has been demonstrated to be a valid construct in basic research (Moore & Zirnsak, 2017), and it has been applied to measure differences in the population of adults with ADHD (Dankner et al., 2017). A change in eye position is called a saccade, which is a representation of where attention is shifted in measures of overt attention. During a task involving a necessary eye movement towards a target, these shifts are intrinsically linked to where attention is sustained in goal directed behavior (Moore & Zirnsak, 2017). Glances off target would then be an indicator of no longer sustaining attention.

Covert Attention Measures and Adults with ADHD

Previous literature that studied response inhibition and sustained attention used tasks that required attention to a stimulus and a subsequent response to it. These could be auditory stimuli (Pelletier et al., 2016), visual stimuli (Advokat et al., 2007; Altgassen et al., 2014; Avisar & Shalev, 2011; Ballard, 2001; Barrilleaux & Advokat, 2009; Bloch et al., 2013; Jusyte et al., 2017; Nigg, 1999; Nigg et al., 2005; Polner et al., 2014; Tucha et al., 2017), or both (Adams et al., 2009; Berger & Cassuto, 2014; Salmi et al., 2018; Slobodin et al., 2018). One of these tasks is the Continuous Performance Task (CPT). During the CPT, participants are presented with a sequence of stimuli and must respond to one stimulus for the majority of the task while suppressing a response to the designated critical stimulus. Participants respond with either a button press on a keyboard or a held button box. Typically, there is an explicit instruction for the participant to inhibit a button press when the critical stimulus appears (10% of the task trials), and the participant presses the button upon the other stimulus presentation in the rest of the trials.

Responding to a stimulus during a CPT draws upon sustained attention. This is because the task's design requires participants to grant attention to the stimulus continuously and over an extended period of time and respond selectively, thus eliciting both sustained attention and response inhibition. Any misses when the target appears or a button press when the critical stimulus appears (false alarms) would demonstrate a deficit in sustained attention and response inhibition, respectively. None of these measures are directly assessed in tracking eye movements but are *implied* by locations a participant is paying attention to because of the task demands. This is known as covert attention in the literature; areas of interest a person is paying attention to that are not necessarily be linked to gaze location (i.e. peripheral vision, listening to verbal cues).

In a meta-analytic review, Hervey et al. (2004) noted that when stimuli are verbally presented to adults with ADHD, they demonstrate deficits in sustained covert attention that worsened with distractors. If a task requires participants to respond as quickly as possible or to pay attention to more stimuli, this effect was exacerbated. Pelletier et al. (2016) corroborated these findings for a serial recall task that used auditory stimuli and auditory distractors that were office sounds. During this task, participants had to recall sequences of seven consonants from a set of nine (B, F, H, J, K, M, Q, R, T) presented in random order. After the seven consonants were shown over a 7s window, participants had 10s to write what they could remember on their answer sheet. These sequences were repeated for 25 experimental trials, divided into five blocks with five trials per block. The experimental condition presented these letters with the office sounds, while the control condition was silent. The results of this experiment demonstrated that serial recall performance of participants with ADHD in the experimental condition was the lowest despite some improvement across the five blocks.

Tucha et al. (2017) also demonstrated this effect with the Vienna Test System (VTS), a test with four tasks that represents and measures a different component of sustained attention. These were selective attention, divided attention, flexibility, and alertness. Each task was twenty minutes each, with measures taken over four of five minutes with the same number of stimuli per block.

The alertness task required participants to fixate on the center of the computer screen and press a button to respond to a black dot in the center of the screen that appeared for 1500ms for 340 target stimuli. The stimulus disappeared sooner if a response is given within the 1500ms presentation of the black dot. The interstimulus interval (ISI) varied between 3s and 5s. The mean reaction time of the responses, response time standard deviation, and number of omissions was calculated for each time block. If no response was given, the target disappeared after the 1500ms and was counted as an error of omission.

The selective attention task required participants to view 475 stimuli of various shapes (circles, squares, triangles) that were presented for 1500ms. Then, the stimuli changed its shade (darker or lighter) 500ms after its presentation. Participants had to respond to the changes during the 1s ISI with circles and squares as fast as possible with a button press while ignoring triangles. One hundred of these stimuli required a button press response. If the participant did not push the button during the 1500ms presentation of the stimulus, this was considered an error of omission.

The divided attention task required participants to maintain attention to a stimuli (400 total) on a computer screen while listening auditory stimuli (400 sounds) that were the same pitch. All of the visual stimuli were pairs of shapes presented for 1500ms that are two rectangles, two circles, or one of each. After 500ms, the shade of the stimulus changed while the tone softens or stays the same. If the sound softens over two stimulus presentations in a row, participants had to respond as quickly as possible during the 1s ISI. Participants also had to respond as quickly as possible during the 1s ISI to the pair of shapes if both were the same kind (i.e. two circles or two rectangles) and both became lighter over two stimulus presentations in a row.

The last task, flexibility, required participants to switch between tasks to respond to 560 triangle or circle stimuli that were colored grey or black for up to 5000ms and disappeared once the participant responded. Then, there is a 750ms interval between the response to the current stimulus and the presentation of the next stimulus. When a participant had to respond to stimuli during the task, they were instructed to focus on responding to shape in two consecutive trials and color in the following two consecutive trials before switching back for the next two trials. Participants had to repeat this order of responses throughout the trial.

For the selective attention, alertness, and divided attention tasks, medium effects were demonstrated when participants with ADHD were compared to controls, thus supporting that sustained attention deficits appear in adults with ADHD. These medium effects were demonstrated during the aforementioned tasks via increased reaction times and more errors of omission with participants in the ADHD group. When blocks were compared, a performance decrease was demonstrated as more blocks were introduced, with the highest response times' peak at the end of the fourth block (Tucha et al., 2017).

The Continuous Performance Task (CPT)

While there are other possible measures for sustained attention, the Continuous Performance Task (CPT) was chosen based on its history of differentiating between control and attentional-deficit samples. Epstein et al. (2001) compared if other sustained attention tasks could also assess response inhibition. When the CPT was compared to the Posner Visual Orienting Task and the Stop Signal Task, it was the only one that detected response inhibition successfully. Laasonen et al. (2012) also evaluated the Attentional Blink, Multiple

Object Tracking, and Useful Field of View tasks, finding no deficits in performance with the sample of adults with ADHD when compared to control participants.

The first CPT was designed by Rosvold et al. (1956) as an early tool to assess “brain damaged” participants. Children and adults with cerebral palsy or those who had brain surgery were also included. While most CPT tasks require participants to inhibit responding to a critical stimulus, usually at a rate of 10% among the stimuli presented, other versions of the CPT exist. These differ in stimuli presented and the length of the task itself. Rosvold’s first variation to his original experiment introduced the AX-type CPT, a task in which responses to X are inhibited only if A came before the presentation of the X (Rosvold et al., 1956). Because there are potential ceiling effects with the X-type CPT, a format that requires attention to multiple stimuli like the AX-CPT is used with adults more often (Riccio & Reynolds, 2001). Modern applications of the X-type CPT include the Integrated Visual and Auditory CPT (Sandford & Turner, 1995) and the Gordon Diagnostic System (GDS; Gordon, 1982); modern adaptations of the AX-CPT include the Test of Variables of Attention (Greenberg, 1993), and Conners’ CPT (Conners, 1992, 1995). Other variations of the CPT have been adapted to be classroom related (Adams et al., 2009).

The requirement for participants to inhibit a button press in response to a stimulus that appears infrequently is a CPT measure of response inhibition. With participants who are children (Adams et al., 2009; Moreno-García et al., 2015; Rapport et al., 1993), adolescents (Berger & Cassuto, 2014; Slobodin et al., 2018; Stern & Shalev, 2013), and adults (Avisar & Shalev, 2011; Barrilleaux & Advokat, 2009; Boonstra et al., 2005), errors of commission are indicators of a failure to inhibit responding. An error of commission in the aforementioned CPTs always involves a button press in response to a stimulus, A or X in this case, that they are supposed to inhibit otherwise. In between these letters, the screen will usually go blank for a duration that may last up to 2s before the next letter appears. This is called the interstimulus interval (ISI).

These studies and other studies were limited by assessing mostly response inhibition and reliance on misses as the only sustained attention measure. It is also unknown if anything else caught participants' visual attention during the task or if they looked away from the target altogether. The latter would be clarified if measures were used to assess sustained attention by using measures that determine where attention is sustained via eye position, an overt level of measuring sustained attention. This may enable the discovery of variables that were not present in covert measures alone (response inhibition and misses in this case), as exemplified by Laasonen et al.'s (2012) aforementioned findings. Although covert attention is a critical component of sustained attention, as indicated by the differences between the ADHD and control population in many CPT studies, there was no concrete indicator after stimulus onset that indicates whether eye movement precedes motor movement (i.e. button press in response to the target) or vice-versa.

Eye Tracking

Eye tracking is a tool used in experimental research to measure eye movements in real time. Specific characteristics of visual attention and how these characteristics correlate with varying levels of ADHD traits can be investigated. In relation to sustained attention, eye-tracking can measure eye movements in real time to assess where attention is directed and how long it is directed there.

Despite evidence indicating that people can attend to or memorize locations different from where they are looking (covert attention), a covert attention shift can often precede a gaze shift (Clark, 1999; Hoffman & Subramaniam, 1995; Kowler et al., 1995; Tas et al., 2016). For example, cues that are peripheral can allow individuals to decide if eye movement attends to the peripheral cue (MacLean et al., 2015). Thus, overt and covert attention are linked, but can remain functionally independent from the other if an eye movement is inhibited (Roberts et al., 2017).

A representative example of how sustained visual attention can be measured is in Adams et al.'s (2011) study that measured premature saccades with the delayed oculomotor response task (DOR) and response time with the stop-signal task (SST). The SST requires participants to sustain attention to stimuli that participants would either respond to or inhibit responding with a key or button press. The DOR task requires participants to inhibit making a saccade towards distractors that were irrelevant to the task. The goal of Adams et al.'s (2011) study was to determine if outcome measures related to response measures in the SST are also predictors of outcome measures (i.e. premature saccades) in the DOR task.

The SST required participants to press a button or key when a "go signal" appeared on screen, then inhibit when a tone for a "stop signal" is played. One second after participants looked at a plus sign in the center of the screen, circles appeared in the far right, middle right, far left, or middle left of the screen. For left circles, the period key (.) was pressed by participants, while the right circles required the forward slash key to be pressed (/). There are 128 trials, with each of the four circles represented an equal number of times. The stop signal occurred after 32 trials and were equally represented among each circle. Adams et al. (2011) found that participants with ADHD have higher latency in response inhibition compared to controls, have slower reaction times, more variability in response time, and more errors of omission (Adams et al., 2011).

The DOR task measured sustained attention by evaluating participants' ability to withhold a reflexive saccade to a visual stimulus. After participants fixated on the plus sign in the center of the screen, the white circle stimulus appeared 1.5s later and remained on screen for only 100ms on the left or right of the plus sign. Participants waited for the next stimulus during an ISI with a randomly chosen duration between 800ms and 1,200ms while inhibiting a saccade in this duration. Then, after the plus sign disappeared, participants made a saccade to the location the target appeared. There are 96 trials overall for this DOR task. Adults with ADHD had more premature saccades than the control group. Increased variability in response time predicted premature saccades. These findings establish that intraindividual variability in response time (RTSD) is a valid predictor of inattention, reflected by more saccades and slower reaction time to focus on another stimulus if RTSD was high (Adams et al., 2011).

Implementing eye-tracking measures was previously encouraged in covert attention studies with children as participants to measure where their attention was directed and to subsequently acknowledge the previous limitation of covert attention studies (Huang-Pollock et al., 2005). It is already used to investigate conditions in which there are executive functioning deficits, such as Autism Spectrum Disorder (Hamner & Vivanti, 2019; Klin et al., 2002) depression (Hammar & Ardai, 2009; Holas et al., 2018; Sanchez et al., 2013) and anxiety (Macatee et al., 2017). For example, those with depression will focus on personally salient words (Holas et al., 2018) and will take longer to make an anti-saccade from depression related stimuli like sad faces (Sanchez et al., 2013). This bias towards dysphoric stimuli also replicated in participants with clinical levels of anxiety (Macatee et al., 2017).

A total of 12 studies were reviewed for the current study that used a sample of adults with ADHD and eye-tracking or other methods of assessing eye movements to compare behavior to that of a control sample (Adams et al., 2011; Armstrong & Munoz, 2003; Carr et al., 2006; Cross-Villasana et al., 2015; Dankner et al., 2017; Feifel et al., 2004; Fried et al., 2014; Michaelis et al., 2012; Munoz et al., 2003; Roberts et al., 2011, 2017; Ross et al., 2000). Sustained attention was the primary focus of all of these, with premature saccades and inhibiting saccades remaining the most frequent indicator of sustained attention (Adams et al., 2011; Cross-Villasana et al., 2015; Dankner et al., 2017; Feifel et al., 2004; Fried et al., 2014; Michaelis et al., 2012; Munoz et al., 2003; Roberts et al., 2011, 2017; Ross et al., 2000). Others managed to assess sustained attention and response inhibition (Carr et al., 2006; Cross-Villasana et al., 2015). However, Fried et al. (2014) was the only study to use a variant of the CPT, the TOVA CPT (Greenberg, 1993) with eye-tracking and two time intervals, pre- and post-stimulus presentation.

In adults with ADHD, there were only two studies that empirically demonstrated response inhibition and sustained attention deficits using eye tracking. Adams et al. (2011) found deficits in overt attention. Reflexive glances towards distractors were significantly greater in the ADHD participants, compared to controls who were able to inhibit these reflexes. This result was corroborated in a separate task with a far greater sample of participants and ages (6-59) that demonstrated a lack of inhibited glances towards distractors and more difficulty generating an anti-saccade away from the critical stimulus when participants were explicitly told to do so (Munoz et al., 2003).

Only two studies have assessed sustained attention measures in adults with ADHD over time. The first used the Vienna Test System, a battery of tasks designed to assess sustained attention (Tucha et al., 2017). The second required participants to perform a serial recall task of 7 out of 9 consonants (B, F, H, J, K, M, Q, R, T) while ambient sounds were played through headphones (Pelletier et al., 2016). These former measures were administered across different blocks, which were compared to each other in order to evaluate if differences emerge over time. Tucha et al. (2017) demonstrated a decrease in attention performance by comparing blocks, while Pelletier et al. (2016) demonstrated that serial recall accuracy increased over each block.

Overall, this review suggests a couple of gaps in the literature that evaluate adult ADHD experimentally. The former studies (Pelletier et al., 2016; Tucha et al., 2017), despite comparing blocks to evaluate performance, did not use eye tracking. The TOVA CPT is also the only variant of the CPT with an adult sample that was used with eye tracking so far (Fried et al., 2014). Comparisons between ADHD subjects and a control group during tasks that evaluated response inhibition also compared participants based on diagnosis or no diagnosis (e.g., Advokat et al., 2007; Nigg, 1999) or based on ADHD subtype (e.g., Adams et al., 2010; Nigg et al., 2005) rather than along a continuum of symptom scores.

Current Study

The aforementioned gaps in literature warranted another study that combined the methods from each example (Adams et al., 2010; Advokat et al., 2007; Fried et al., 2014; Nigg, 1999; Nigg et al., 2005; Pelletier et al., 2016; Tucha et al., 2017). The present study attempted to do so by having adults complete separate CPT task blocks while their eye movements were recorded. Diagnostic evaluation was not administered to separate participants into formal ADHD group and non-diagnosed control groups. Instead, ADHD symptoms were evaluated on a continuous scale using the BAARS-IV (Barkley, 2011) to determine if total ADHD score and number of settings of ADHD-related impairment reported on the BAARS-IV could predict any outcome measures.

The DASS-21 (Brown et al., 1997) scale was added in case any confounds in sustained attention emerge due to depression (Hammar & Ardai, 2009) or anxiety (Macatee et al., 2017) that could be mistaken for ADHD symptoms. Stress was added as an exploratory measure because of the mixed evidence stress has on go no-go tasks (Shields et al., 2016) that are similar to the CPT. Self-reported tiredness was added as another exploratory measure, particularly for response inhibition measures because a previous driving simulator study demonstrated self-reported tiredness as marginally significant ($p = 0.08$) with another response inhibition measure (*SART* no-go inhibition errors; Walker & Trick, 2018). The inclusion of these measures is also meant to address the criticism that Riccio and Reynolds (2001) presented for the sensitivity the CPT has to central nervous system dysfunctions at the expense of specifying which dysfunction impairs CPT performance.

Data for the current study were collected with a non-clinical sample of participants recruited from an undergraduate subject pool at Appalachian State University. The levels of ADHD traits, number of settings of ADHD-related impairment, tiredness, and levels of depression, anxiety, and stress were measured. Participants then completed the Continuous Performance Task (CPT) while their eye movements were recorded. This particular CPT required participants to inhibit a response when the letter X, the critical stimulus during the task, appeared on screen 10% of the time and to respond with a button press to other stimuli. Two conditions were used: one without distractors and one with distractors that were irrelevant to the task. Each condition also had two blocks of trials. The current study also calculated the DVs of each block of both CPTs separately to examine if there was change over time.

Manual response measures in the current study included: RTSD (standard deviation of response times), false alarms (responses to the critical stimulus), and percentage of missed targets. Eye movement measures included: total gaze on target duration, mean gaze on target duration, and number of gazes off target.

For outcome measures related to response inhibition, I hypothesized that higher overall score on the BAARS-IV (Barkley, 2011) and a higher number of reported settings of ADHD-related impairment would predict higher RTSD and more false alarms. The association of these ADHD indices and number of gazes off target was also hypothesized to reach significance, but only in the distractor condition. These predicted outcome measures would be consistent with other literature that investigated RTSD and ADHD (e.g. Adams et al., 2011), tasks that used false alarms as a measure of response inhibition (e.g. Avisar & Shalev, 2011; Barrilleaux & Advokat, 2009; Boonstra et al., 2005), and the finding that more saccades occurred when distractors are present (e.g. Hervey et al., 2004). These outcomes would also align with Barkley's (1997) model of ADHD and other evidence that demonstrated inhibitory differences through significantly more variability in reaction time for the ADHD group compared to the control group (Adams et al., 2011; Advokat et al., 2007).

For the measures related to sustained attention, I hypothesized that higher ADHD symptoms on the BAARS-IV (Barkley, 2011) and a higher number of settings of ADHD-related impairment would predict a decreased total gaze on target duration and mean gaze on target duration for the distractor CPT. However, it was anticipated that misses would reach a near floor effect and thus not be related to these ADHD variables. These predicted results align with the previously mentioned evidence that distractors elicited more saccades (e.g. Hervey et al., 2004), a finding that elucidates Barkley's theory (1997) of deficient response inhibition. I did not think that the decrease in gaze on target duration and mean gaze on target duration would be significant in the no-distractor CPT compared to the distractor CPT for participants regardless of BAARS-IV score (Barkley, 2011) because of a lack of cues that would challenge participants to inhibit a glance towards a distractor, even when participants were told the task required inhibition (Feifel et al., 2004; Munoz et al., 2003). Evidence for the hypothesis of a floor effect for misses aligns with the previously mentioned evidence that demonstrated few errors of omission that appear on CPT tasks (e.g. Advokat et al., 2007). This hypothesis also considers a critique that Conners (2004) made about the CPT, which was that errors of omission, measured via percentage of missed responses, neglected response latency and variability by itself. It should also be noted that the demand characteristic imposed on the participant to withhold responses during the task would mean that misses were likely to reach near floor effects for this relatively "normal" sample, unless a participant misunderstood the instructions provided during the experiment.

Method

Participants

Participants signed up for the study via the online SONA participant recruitment system and were compensated with course credit. Eighty-five Appalachian State University undergraduates were recruited during the Fall 2018 semester via the SONA recruitment system, completing procedures for course credit. Participants were primarily women (57 females, 28 males) whose ages ranged from 18 to 24 (M = 19). IRB approval was granted on 10/19/2018 (Appendix A) and consent forms were provided at the start of the study

(Appendix B). A questionnaire battery was administered to participants before they completed the CPTs. This battery consisted of the following self-report measures: tiredness (scale 1-10), Barkley Adult ADHD Rating Scale-IV (Appendix D; BAARS-IV; Barkley, 2011), Depression Anxiety Stress Scales (Appendix C; DASS-21; Brown et al., 1997), and sluggish cognitive tempo (Appendix E; BAARS-IV; Barkley, 2011). Experimenters were trained to instruct all participants the same way, reading slowly and allowing the opportunity for participants to ask questions at any time. Out of the 85 participants recruited, 29 were excluded from analysis for the following reasons: Eighteen participants had missing eye data; five had miss rates higher than 97% in one block of the CPT; four were excluded because their maximum duration between blinks, a measure of intentional blink suppression, was more than three standard deviations above the mean for at least one block of the CPT; and two were missing self-report data. This left 56 participants (41 females, 15 males) whose ages ranged from 18 to 24 (M = 19). The BAARS-IV (Barkley, 2011) scores for the excluded participants had a mean of 21.6 (ranged 0 to 55) and number of settings of impairment that ranged from zero to 4.

Self-Report Measures

ADHD Symptom Measure

The Barkley Adult ADHD Rating Scale-IV (Appendix D; BAARS-IV; Barkley, 2011) is a self-report questionnaire that was administered at the time of the study to measure symptoms of ADHD experienced in the past 6 months across 19 questions. These questions include: nine questions for inattention, five questions for hyperactivity, four for impulsivity, and one where participants check the settings in which they experienced impairment from their ADHD symptoms. Each question could be answered on a scale ranging from 1 to 4 (1 =

never or rarely; 4 = *very often*) and every score answered as three or above contributed to the separate symptom count score. A total ADHD score of 36 (90th percentile) on this scale is an indication that the participant is at risk for an ADHD diagnosis (Barkley, 2011). The possible settings of impairment participants report include school, home, work, and social life. The overall count of these settings was used as a measure of the breadth of ADHD impact that participants experienced. If any participants usually take medication, they were instructed to report the symptoms as if they were not on their medication. Internal consistency for the BAARS-IV in the current study was high (α = 0.91) and each subscale that evaluated inattention (α = 0.91), hyperactivity (α = 0.83), and impulsivity (α = 0.83) was also high.

Anxiety, Depression, and Stress Measure

Anxiety, depression, and stress was measured to control for confounds that would otherwise be mistaken as ADHD symptoms. These symptoms were measured with the 21-question Depression Anxiety Stress Scales (Appendix C; DASS-21; Brown et al., 1997). There are seven, 4-point items for anxiety, depression, and stress respectively, which asked how much each item applied to them over the past week; answers were on a scale ranging from zero to three (0 = *did not apply to me at all*; 3 = *applied to me very much, or most of the time*). Internal consistency for the DASS-21 in the current study was high (α = 0.94) and each subscale that evaluated depression (α = 0.91), anxiety (α = 0.87), and stress (α = 0.87) was also high.

Sluggish Cognitive Tempo and Tiredness

Sluggish cognitive tempo was measured for exploratory purposes using a scale suggested by Barkley (Appendix E; BAARS-IV; Barkley, 2011). Each question could be answered on a scale ranging from 1 to 4 (1 = *never or rarely*; 4 = *very often*) and every score answered as three or above contributed to the separate symptom count score. Tiredness is a one item scale that participants self-reported on a 1-10 scale (1 = *not tired at all*; 10 = *extremely tired*). Internal consistency for sluggish cognitive tempo was high ($\alpha = 0.93$).

Apparatus

Continuous Performance Task and Stimuli

Participants completed two CPT tasks on a desktop computer with an LCD computer display and pressed a button on a button box in response to all letters except for the critical stimulus (X). These CPTs were adapted from the Conners' Continuous Performance Test 3rd Edition (C-CPT-3; Folsom & Levin, 2013). One practice CPT trial with 25 letters preceded each pair of experimental blocks of trials. Black stimulus letters 2 degrees in height on a white background were presented individually in the center of the screen for 250 ms, followed by a fixed interstimulus interval (ISI) that was 2000 ms long. Participants had to press the button as quickly as they could for all letters in the center of the screen other than the critical stimulus, X, that appeared 10% of the time. One of the two CPTs had a distractor letter appear at 1 of 12 clock positions 5.5 degrees away from the display center for 250 ms after the primary stimulus was offset in 30% of the ISIs. In the distractor condition, a distractor letter appeared an equal number of times in both blocks. A 5 degree by 5 degree invisible square surrounded the center of the letter and defined the region to determine if the eye was fixated on the stimulus.

Eye-tracker and Eye-movement Measurement

The Eyelink 1000 eye tracker and its accompanying Eyelink software were used. Eyegaze was recorded monocularly at 500 Hz. Participants sat in a chair and placed their chin on a chinrest to minimize head movement that would otherwise create instrument calibration problems. The experimenter who ran the task was required to ensure that participants' fixations on calibration targets had an accuracy threshold of 1.0 degrees outside the calibration target so calibration for the least accurate point will not have more than 1.0 degree of error.

Eye data measures were calculated relative to the target region, which was defined as a 5 degree by 5 degree square that surrounded the center of the stimulus letters during the CPT tasks. Every fixation was identified as either inside or outside the target region. The duration of each gaze period was calculated by the differences between the start time of the first fixation in the region and the end time of the last fixation in that region.

Procedure

Experimenters who ran participants were undergraduates who had training from me and Dr. Dickinson. These assistants were also observed by me or Dr. Dickinson for one session with a participant to ensure the procedure was followed correctly.

After participants provided voluntary consent at the outset of their session, a self-report demographic sheet was provided that asked the levels of tiredness participants' had at the time of the study, how many hours they slept, age, gender, and if they took stimulant medication that day. If participants took their medication the morning before they participated, they were asked to reschedule. Participants were then asked to complete the BAARS-IV (Appendix D; BAARS-IV; Barkley, 2011), BAARS-IV sluggish cognitive tempo measure (Appendix E; BAARS-IV; Barkley, 2011), and the DASS (Appendix C; Brown et al., 1997). The BAARS-IV sluggish cognitive tempo measure (Barkley, 2011) was excluded from analysis because it was collected for exploratory purposes. After they finished all measures, participants placed their chin in the chinrest and went through a calibration process so the eye tracker could accurately estimate their eye position. Eyegaze was recorded monocularly at 500 Hz. After calibration, they engaged in two CPT tasks, each preceded by a practice CPT block that consisted of 25 stimuli and could be finished in less than 1 min. Each block was initiated with a fixation cross in the center of the screen, the same location where the stimulus letters would appear. After participants pressed the button, they began the practice CPT trial without distractors and a fixed ISI, followed by a 100-letter stimulus block with no distractors, a 2 min break, then another 100-letter stimulus block with no distractors. Then, after another 2 min break after the no-distractor trials, a calibration was performed. If it was unsuccessful, the participant was debriefed and the session ended. If it was successful, participants engaged in a practice CPT task with distractors. After this practice task, participants engaged in a CPT task with distractors, fixed ISI, and 100 letter stimuli. After a final two minute break, participants completed another CPT task with distractors that had the same parameters as the previous one. Participants were debriefed after they completed the final CPT task. This procedure took less than 60 minutes to complete per participant.

Results

Data Analysis

I conducted 36 hierarchical regressions with self-reported tiredness and the three factors of the DASS-21 (depression, anxiety, and stress) as predictor variables in the null model (i.e., first step). The second step included the BAARS-IV ADHD scores and number of settings of ADHD-related impairment as predictor variables. The Variance Inflation Factor (VIF) statistics for the first step ranged from 1.17 (tiredness) to 2.89 (DASS-21 anxiety subscale). In the second step, the VIF statistics ranged from 1.2 (tiredness) to 3.21 (DASS-21 anxiety subscale). These values were collected because an increased VIF statistic is an indicator of the level of multicollinearity between predictor variables. For example, the DASS-21 anxiety subscale value of 3.21 is an indicator of moderate correlation with other predictor variables. The tiredness subscale VIF statistic of 1.2 is the only predictor that is less of a concern because it indicates that the variance of this coefficient is 20% larger than usual because of the slight correlation with the other predictor variables. Despite this issue (see Table 8 for examples), I still included every DASS-21 subscale (depression, anxiety, stress) because of the implications anxiety and depression had for difficulty making anti-saccades away from personally salient stimuli (Holas et al., 2018; Macatee et al., 2017) and to address the mixed evidence involved with the effect stress has on tasks that evaluate response inhibition (Shields et al., 2016). The VIF statistics for the DASS-21 subscales after the second step were 3.21 (anxiety), 2.06 (depression), and 2.87 (stress).The BAARS-IV ADHD scores (VIF = 2.87) and the number of settings of ADHD-related impairment (VIF = 2.13) were included (see Table 8) because it is possible for number of settings of ADHD-related impairment to be less susceptible to underreporting that adults with ADHD otherwise have a tendency to make on self-report measures for ADHD symptoms (Barkley et al., 2002; Wolf et al., 2009).

The dependent variables included in these regressions are three manual response measures and three eye movement measures. Manual response measures include: RTSD (standard deviation of response times), number of false alarms, and number of misses. Eye movement measures include: total gaze on target duration, mean gaze on target duration, and number of gazes off target. The means of these variables were calculated across the entire duration of each CPT condition and every individual block. The variables that assessed sustained attention are total gaze on target duration, mean gaze on target duration, and misses. For response inhibition, the variables that assessed this process are RTSD, number of false alarms, and number of gazes off target. Descriptive statistics for the predictor variables can be found on Table 1. Descriptive statistics for all of the dependent variables in the no distractor CPT condition can be found on Tables 2-4. Descriptive statistics for all of the dependent variables in the distractor CPT condition can be found on Tables 5-7. Zero-order correlations for the predictor variables can be found on Table 8. Zero-order correlations can also be found for the outcome variables measured across both blocks for the no distractor condition on Table 9 and the outcome variables measured across both blocks for the distractor condition on Table 10. All reported coefficients are standardized. All outcomes reported in text will only focus on the change in *R*-squared (ΔR^2) and significant results because the multicollinearity issue makes Beta weights difficult to interpret. Any interpretations of coefficients should be considered tentative. Non-significant results are still reported in the tables mentioned parenthetically in each section.

For the eye-movement measures, on-target is operationally defined as participants' eye position falling with the 5 degree by 5 degree square region around the stimulus. Otherwise, any eye position away from this square region was considered off the target stimulus.

Sustained Attention Outcome Variables

Misses - No Distractor Condition (Tables 11-13)

The overall model for misses across both no distractor CPT blocks combined explained 23.7% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.04$, $p = 0.288$), which suggests that ADHD trait severity was not related to differences for this outcome variable for both blocks combined. The model was significant on the first step $F(4, 56) = 3.13$, $p = 0.022$ and the second step $F(6, 56) = 2.54$, $p = 0.032$. Increased stress values ($\beta = -0.45$, $p = 0.037$) were a significant predictor of fewer misses and increased depression values were a significant ($\beta = 0.5$, $p = 0.007$) predictor of more misses.

The overall model for misses across the first no distractor CPT block (Block 1) explained 19% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.05$, $p = 0.251$), which suggests that ADHD trait severity was not related to differences for this outcome variable in this block. Increased depression values were the only significant predictor of increased misses ($\beta = 0.42$, $p = 0.026$).

The overall model for misses across the second no distractor CPT block (Block 2) explained 25.3% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.04$, $p = 0.294$), which suggests that ADHD trait severity was not related to differences for this outcome variable in this block. The model was significant on the first step $F(4, 56) = 3.48$, $p = 0.014$ and the second step $F(6, 56) = 2.76$, $p = 0.022$. Increased depression values ($\beta = 0.52$, $p = 0.005$) were a significant predictor of increased misses and increased stress values ($\beta = -0.49$, $p = 0.024$) were a significant predictor of fewer misses.

Depression reached significance across both blocks combined, Block 1, and Block 2. This result demonstrated that increased depression values were a predictor of increased misses. The overall model was significant for both blocks combined and Block 2. This was primarily influenced by depression and stress reaching significance for both blocks combined and Block 2. Higher stress values predicted fewer misses and higher depression values predicted increased misses. Change in *R*-squared (ΔR^2) was not significant for the analyses of all blocks, which suggests that ADHD trait severity was not related to misses in this condition.

Misses - Distractor Condition (Tables 14-16)

The overall model for misses across both distractor CPT blocks combined explained 13.4% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.11$, $p = 0.059$), which suggests that ADHD trait severity was not related to differences for this outcome variable in this block. Increased number of settings of ADHD-related impairment was the only significant coefficient ($\beta = 0.47$, $p = 0.018$), but this was not interpreted because the change in *R*-squared (ΔR^2) was not significant.

The overall model for misses across the first distractor CPT block (Block 1) explained 9.2% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.06$, $p = 0.217$), which suggests that ADHD trait severity was not related to differences for this outcome variable in this block. Neither the overall model nor the predictors were significant, which suggests that ADHD trait severity was unrelated to misses in this block.

The overall model for misses across the second distractor CPT block (Block 2) explained 26.3% of the variance after the second step. The increase in variance explained after the second step was significant ($\Delta R^2 = 0.15$, $p = 0.011$), which suggests that ADHD trait severity was related to differences for this outcome variable in this block. The model was not significant on the first step $F(4, 56) = 1.63$, $p = 0.182$ but was significant on the second step $F(6, 56) = 2.91$, $p = 0.017$. Increased number of settings of ADHD-related impairment was a significant predictor of more misses (β = 0.56, p = 0.003), which suggests that the breadth of ADHD impact was related to differences for this outcome variable in this block.

The overall model was significant for Block 2, a result that was influenced by the number of settings of ADHD-related impairment as a significant predictor for this block. These results demonstrate that an increased number of settings where ADHD symptoms were reported to be linked to impairment was a predictor of misses for Block 2 of the distractor CPT. This result does not support the hypothesis that an increased number of settings of ADHD-related impairment would be negligible due to the task requirements requiring consistent button presses that would result in floor effects.

The results for both conditions demonstrate that change in R-squared (ΔR^2) was only significant for number of settings of ADHD-related impairment for Block 2 of the distractor condition.

Mean Gaze On Target Duration - No Distractor Condition (Tables 17-19)

The overall regression model for mean gaze on target duration across both no distractor CPT blocks combined explained 16.6% of variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.01, p = 0.762). Tiredness was significant after the first step (β = -0.28, p = 0.049) but was not significant after the second step (β = -0.28, p = 0.055). The other coefficients and the overall model were not significant, which suggests that neither of the ADHD measures were significant predictors of mean gaze on target duration across both blocks combined.

The overall regression model for mean gaze on target duration across Block 1 explained 11.8% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.04, p = 0.348). The model and coefficients were not significant, which suggests that neither of the ADHD measures were significant predictors of mean gaze on target duration for Block 1.

The overall regression model for mean gaze on target duration across Block 2 explained 14.7% of the total variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.01$, $p = 0.862$). The model and coefficients were not significant, which suggests that neither of the ADHD measures were significant predictors of mean gaze on target duration for Block 2.

Tiredness was only significant in the first step after both blocks combined were analyzed. This indicates that higher values of tiredness predicted decreased mean gaze on target duration for both blocks combined. Change in R-squared (ΔR^2) for ADHD measures was not significant for all analyses in this condition related to mean gaze on target duration.

Mean Gaze On Target Duration - Distractor Condition (Tables 20-22)

The overall regression model for mean gaze on target duration across both distractor CPT blocks combined explained 19.4% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.567$). The model was significant after the first step $F(4, 56) = 2.71$, $p = 0.040$ but was not significant after second step $F(6, 56) = 1.97$, $p = 0.088$. Increased tiredness was a significant predictor of decreased mean gaze on target duration ($\beta = -0.31$, $p = 0.034$).

The overall regression model for mean gaze on target duration across Block 1 explained 13.2% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.05$, $p = 0.243$). The overall model and coefficients were not significant.

The overall model for mean gaze on target duration across Block 2 explained 24.8% of the total variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.01$, $p = 0.858$). This model was significant on the first step $F(4, 56) = 4.1$, $p = 0.006$ and the second step $F(6, 56) = 2.69$, $p = 0.024$. Increased tiredness was a significant predictor of decreased mean gaze on target duration ($\beta = -0.38$, $p = 0.007$).

The overall model was significant in the first step for both blocks combined and both steps were significant for Block 2. This significance was influenced by tiredness reaching significance in the first step for both blocks combined and for both steps for Block 2. The standardized Beta coefficients for tiredness in the aforementioned analyses were negative, which demonstrates that increased tiredness predicted decreased mean gaze on target duration.

Results across both conditions demonstrated that change in R-squared (ΔR^2) was not significant for mean gaze on target duration. Tiredness was significant after the first step for both blocks combined in the no distractor condition and after the second step for both blocks combined and Block 2 of the distractor condition.

Total Gaze On Target Duration - No Distractor Condition (Tables 23-25)

The overall regression model for total gaze on target duration across both no distractor CPT blocks combined explained 20.1% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.558$). The overall model was significant on the first step $F(4, 56) = 2.83$, $p = 0.034$ but not the second step $F(6, 56) = 2.05$, $p = 0.076$. Tiredness was the only significant coefficient after the second step ($\beta = -0.29$, $p = 0.046$).

The overall regression model for total gaze on target duration across Block 1 explained 9.5% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.633$). The overall model and coefficients were not significant.

The overall regression model for total gaze on target duration across Block 2 explained 24.6% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.557$). The overall model was significant on the first step $F(4, 56) = 3.76$, $p = 0.009$, and the second step $F(6, 56) = 2.66$, $p = 0.026$. Tiredness was the only significant coefficient after the second step ($\beta = -0.31$, $p = 0.028$).

The overall model was significant for both blocks combined on the first step and was also significant for Block 2 after the second step. The significance of these overall models was influenced by the significance of tiredness for both blocks combined and Block 2, which paralleled the results of mean gaze on target duration and its prediction that increased tiredness predicted decreased mean gaze on target duration.

Total Gaze On Target Duration - Distractor Condition (Tables 26-28)

The overall regression model for total gaze on target duration across both distractor CPT blocks combined explained 25.2% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.03$, $p = 0.431$). The model was significant after the first step $F(4, 56) = 3.71$, $p = 0.010$ and after second step $F(6, 56) = 2.75$, $p = 0.022$. No coefficients were significant.

The overall regression model for total gaze on target duration across Block 1 explained 21.2% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.04$, $p = 0.295$). The model reached significance on the first step $F(4, 56) = 2.64$, $p = 0.044$ but was not significant after the second step $F(6, 56) = 2.2$, $p = 0.059$. No coefficients were significant.

The overall model for total gaze on target duration across Block 2 explained 23.5% of the total variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.507$). This model was significant on the first step $F(4, 56) = 3.45$, $p = 0.014$ and the second step F(6, 56) = 2.5, $p = 0.034$. No coefficients were significant.

The overall model for both blocks combined, Block 1, and Block 2 was significant on the first step while the overall model for both blocks combined and Block 2 was still significant after the second step. However, no coefficients were significant.

Results across both conditions demonstrated that change in *R*-squared (ΔR^2) was not significant for total gaze on target duration.

Interim Summary of Sustained Attention Outcome Variables

The present study hypothesized that misses would reach a near floor effect regardless of total ADHD score on the BAARS-IV (Barkley, 2011) and number of settings of ADHD related impairment in addition to no relationship between misses and both ADHD predictors. The results demonstrated that a higher number of settings of ADHD related impairment predicted more misses for Block 2 of the distractor CPT condition, which is contrary to the aforementioned hypothesis. It was also hypothesized that mean gaze duration and total gaze duration would decrease in the distractor condition as total ADHD score on the BAARS-IV (Barkley, 2011) and number of settings of ADHD related impairment increased. This hypothesis was not supported.

Increased depression was a significant predictor of more misses in the analyses of both blocks combined, Block 1, and Block 2 of the no distractor CPT. Stress was also a significant predictor of fewer misses for both blocks combined and Block 2 of the no distractor CPT. Outcome measures related to mean gaze on target duration and total gaze on target duration demonstrated that increased tiredness was a significant predictor of decreased mean gaze on target duration and total gaze on target duration across both blocks combined and Block 2, but not Block 1.

Response Inhibition Outcome Variables

Response Time Standard Deviation (RTSD) - No Distractor Condition (Tables 29-31)

The overall regression model for RTSD across both no distractor CPT blocks combined explained 25.2% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.05$, $p = 0.196$). The model was significant on the first step $F(4, 56) = 3.2$, $p = 0.020$ and second step $F(6, 56) = 2.75$, $p = 0.022$. Higher stress values predicted decreased RTSD ($\beta = -0.49$, $p = 0.024$) and higher depression values predicted increased RTSD ($\beta = 0.54$, $p = 0.004$), but these predictors were only significant after the second step. No other coefficients were significant.

The overall model for RTSD across Block 1 explained 23.3% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.01$, $p = 0.635$). The model reached significance on the first step $F(4, 56) = 3.56$, $p = 0.012$ and second step $F(6, 56) = 2.48$, $p = 0.036$. Higher depression values predicted increased RTSD for Block 1 ($\beta = 0.57$, $p = 0.002$) and was a slightly stronger predictor in this block when compared to the entire CPT. No other coefficients were significant.

The overall model for RTSD across Block 2 explained 26.6% of the total variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.08$, $p = 0.076$). This model was significant on the first step $F(4, 56) = 3.56$, $p = 0.031$ and second step $F(6, 56) = 2.48$, $p = 0.015$. Higher depression values predicted increased RTSD ($\beta = 0.51$, $p = 0.006$) and higher stress values predicted decreased RTSD ($\beta = -0.54$, $p = 0.013$). No other coefficients were significant.

The significance of depression and positive standardized coefficients across both blocks combined, Block 1, and Block 2 demonstrates that higher depression values were a predictor of increased RTSD in the current study. Stress values were also significant as a predictor and had a negative standardized coefficient, which indicates that increased stress values correlated with a decrease in RTSD for both blocks combined and Block 2.

Response Time Standard Deviation (RTSD) - Distractor Condition (Tables 32-34)

The overall regression model for RTSD across both distractor CPT blocks combined explained 23.9% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.07$, $p = 0.11$). The model was significant on the first step $F(4, 56) = 2.57$, $p = 0.049$ and second step $F(6, 56) = 2.57$, $p = 0.030$. Increased number of settings of ADHD-related impairment was the only significant coefficient ($\beta = 0.38$, $p = 0.041$), but this was not interpreted because the change in R-squared (ΔR^2) was not significant.

The overall model for RTSD across Block 1 explained 14.8% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.07$, $p = 0.160$). The overall model and coefficients were not significant.

The overall model for RTSD across Block 2 explained 32.3% of the total variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.06$, $p = 0.111$). This model was significant on the first step $F(4, 56) = 4.47$, $p = 0.004$ and second step $F(6, 56) = 3.9$, $p = 0.003$. Increased number of settings of ADHD-related impairment was a significant coefficient ($\beta = 0.37$, $p = 0.037$), but this was not interpreted because the change in R-squared (ΔR^2) was not significant. Increased depression was a significant predictor of increased RTSD ($\beta = 0.49$, $p = 0.006$).

The overall model for RTSD in the distractor condition was significant for both blocks combined and Block 2. Depression was significant for Block 2. This result may demonstrate the effect of depression increases as the task progresses.

Results across both conditions demonstrated that change in R-squared (ΔR^2) was not significant for RTSD. Depression was a significant predictor of increased RTSD for both blocks combined, Block 1, and Block 2 of the no distractor condition and Block 2 of the distractor condition. Increased stress values predicted decreased RTSD for both blocks combined and Block 2 of the no distractor condition.

False Alarms - No Distractor Condition (Tables 35-37)

The overall model for false alarms across both no distractor CPT blocks combined explained 13% of the variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.03$, $p = 0.398$). No other coeffecients were significant.

The overall model for false alarms across Block 1 of no distractor CPT blocks explained 7.2% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.02, p = 0.668). No other coeffecients were significant.

The overall model for false alarms across Block 2 of no distractor CPT blocks explained 19.9% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.06, p = 0.197). Increased tiredness was a significant predictor of more false alarms (β = 0.29, p = 0.044). No other coefficients were significant.

Overall, increased tiredness was the only significant predictor of more false alarms, but only for Block 2.

False Alarms - Distractor Condition (Tables 38-40)

The overall model for false alarms across both distractor CPT blocks combined explained 14.3% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.05, p = 0.270). Increased stress was a significant predictor for fewer false alarms (β = -0.53, p = 0.022). No other coefficients were significant.

The overall model for false alarms across Block 1 of the distractor CPT blocks explained 14.3% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.07, p = 0.138). Increased stress was a significant predictor for a fewer false alarms (β = -0.55, p = 0.018). No other coefficients were significant.

The overall model for false alarms across Block 2 of distractor CPT blocks explained 11.5% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.02, p = 0.610).

Stress was the only significant predictor for false alarms after the second step for both blocks combined and Block 1. The standardized coefficients were negative, a result that demonstrates increased stress values predicted fewer false alarms.

Results across both conditions demonstrated that change in *R*-squared (ΔR^2) was not significant for false alarms. Tiredness was a significant predictor of increased false alarms for Block 2 of the no distractor condition. Stress was a significant predictor of fewer false alarms for both blocks combined and Block 1 of the distractor condition.

Number of Gazes Off Target - No Distractor Condition (Tables 41-43)

The overall regression model for number of gazes off target across both no distractor CPT blocks combined explained 15.5% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.03$, $p = 0.479$). No coefficients were significant.

The overall regression model for the number of gazes off target across Block 1 explained 9.3% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.03$, $p = 0.462$). No coefficients were significant.

The overall regression model for the number of gazes off target across Block 2 explained 17.1% of variance after the second step. The increase in variance explained after the second step was not significant ($\Delta R^2 = 0.02$, $p = 0.508$). This model was significant on the first step $F(4, 56) = 2.63$, $p = 0.045$ but was not on the second step $F(6, 56) = 1.96$, $p = 0.090$. Increased tiredness was the only significant predictor on the first step for increased number of gazes off target ($\beta = 0.29$, $p = 0.039$) but was not significant for the second step ($\beta = 0.27$, $p = 0.064$).

Tiredness was the only significant predictor for Block 2. Increased tiredness as a predictor of gazes off target in this block is consistent with the previous results that indicated increased tiredness resulted in fewer gazes on target for Block 2.

Number of Gazes Off Target - Distractor Condition (Tables 44-46)

The overall regression model for the total number of gazes off target across both distractor CPT blocks combined explained 12.3% of variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.02, p = 0.549). The overall model and coefficients were not significant.

The overall regression model for the total number of gazes off target across Block 1 explained 16.9% of the variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.03, p = 0.389). The overall model and coefficients were not significant.

The overall model for the total number of gazes off target across Block 2 explained 7.8% of the total variance after the second step. The increase in variance explained after the second step was not significant (ΔR^2 = 0.01, p = 0.736). The overall model and coefficients were not significant.

No models or coefficients were significant.

Results across both conditions demonstrated that change in R-squared (ΔR^2) was not significant for number of gazes off target. Tiredness was a significant predictor of increased number of gazes off target for Block 2 of the no distractor condition.

Interim Summary of Response Inhibition Outcome Variables

The present study hypothesized that RTSD and false alarms would increase as the BAARS-IV (Barkley, 2011) scores and number of settings of ADHD-related impairment increased in the distractor condition. This hypothesis was not supported because the changes in *R*-squared (ΔR^2) were not significant in all analyses related to RTSD. However, there is some indication the number of settings of ADHD-related impairment may be related to RTSD because the individual Beta weights were significant in both blocks and Block 2. A replication with a larger sample size would be necessary to make a stronger conclusion regarding this relationship. Number of gazes off target was also hypothesized to increase as the BAARS-IV (Barkley, 2011) scores and number of settings of ADHD-related impairment increased in the distractor condition. This hypothesis was not supported.

Significant predictors not related to the hypotheses includes depression, stress, and tiredness. Increased depression was a significant predictor of increased RTSD across both blocks combined, Block 1, and Block 2 of the no distractor CPT condition and Block 2 of the distractor CPT condition. Increased stress predicted fewer false alarms for both blocks combined and Block 1 of the distractor CPT condition. Increased stress was also a predictor of decreased RTSD for both blocks combined and Block 2 of the no distractor CPT condition. Increased tiredness predicted an increase in false alarms for Block 2 of the no distractor CPT condition.

Discussion

The current study tested if sustained attention and response inhibition deficits were present in adult participants with varied levels of ADHD symptoms in a basic CPT task with eye tracking, in an attempt to address a noticeable gap in the related literature. People with clinical diagnoses of ADHD were often represented in the existent literature (e.g. Advokat et al., 2007; Barrilleaux & Advokat, 2009; Dankner et al., 2017), as well, and this was one of the first studies to compare participants across a continuum instead of using ADHD as a categorical variable to compare participants with a clinical diagnosis of ADHD and participants without a clinical diagnosis of ADHD.

Sustained Attention

The only significant results related to the hypotheses were the results that demonstrated an increased number of settings of ADHD-related impairment significantly correlated with misses in Block 2 of the distractor condition (see Table 16). This was the opposite of the hypothesized floor effects for misses. Despite these results not aligning with the former hypothesis, they still align with other X CPT studies that sampled adult participants with a clinical diagnosis of ADHD (Advokat et al., 2007; Barrilleaux & Advokat, 2009). These findings also parallel the previously mentioned non-eye tracking studies (Pelletier et al., 2016; Tucha et al., 2017) because the attention decrease peaked by the last block (Block 2 of the distractor condition in the current study). First, these results may indicate that participants' self-report of number of settings related to ADHD impairment on the BAARS-IV (Barkley, 2011) is a more authentic measure of risk for actual ADHD than total ADHD score in this sample that can generally be characterized as "normal." Self-report of the number of settings related to ADHD impairment may also avoid the issue with young adult participants with ADHD who underestimate their symptoms on scales with more items (Barkley et al., 2002; Wolf et al., 2009). Second, it is also possible that the significant findings in the previously mentioned studies that used the X CPT (Advokat et al., 2007; Barrilleaux & Advokat, 2009) were present at the end of the CPT tasks if measures were taken at different points in time, which would parallel the results for misses in Block 2 of the distractor condition in current study.

Total ADHD score was not a significant predictor for any sustained attention variables (see Tables 11-28). This was likely due to the skewed distribution of total ADHD values on the BAARS-IV that can be observed by the clustered scores at the lower end of the scale (see Table 1). Another explanation is the moderate level of multicollinearity indicated by the VIF statistics of the outcome measures that ranged from 1.2 (tiredness) to 3.21 (DASS-21 anxiety subscale; see Table 8). This multicollinearity issue is a possible reason for the occasional sign changes for the Beta values (see Tables 29-31 for an example) and the lack of significance for change in *R*-squared (ΔR^2) for the majority of hierarchical regressions. The brevity of the CPT blocks was probably responsible for the lack of a significant relationship as well, a point that will be discussed later.

Tiredness occasionally emerged as a significant predictor for shorter total gaze on target duration in the distractor condition (see Tables 26-28) and across both conditions for mean gaze on target duration (see Tables 17-22). These results indicate that higher levels of self-reported tiredness were more likely to decrease gaze on target duration. To my knowledge, this is the only study in the adult ADHD literature with eye tracking that controlled for self-reported tiredness as an artifact. Outside of the scope of this study, this evidence is similar to another study that used self-reported tiredness to predict distracted driving, albeit on a scale from 1-9, that reached marginal significance ($p = 0.08$) as a predictor for a measure of sustained attention (*SART* accuracy; Walker & Trick, 2018). Thus, the current study is also the second study that used a one-item measure of tiredness as a predictor for performance on a task that measured sustained attention.

It should be briefly noted that rates of ADHD among those diagnosed with chronic fatigue syndrome is estimated to be as high as 20.9% (Sáez-Francàs et al., 2012). Measures of self-reported fatigue in a sample of 243 adults diagnosed with ADHD reported that 62% of their sample met criteria for fatigue caseness (Rogers et al., 2017). When these examples are considered, it may be possible that the levels of tiredness in the current study made detecting ADHD effects more difficult. However, this was unlikely in the current study because tiredness was not strongly related to the ADHD measures (see Table 8). Participants were also students and might have been prone to tiredness depending on their coursework at the time they participated in the current study.

Higher stress values predicted fewer misses in both blocks (see Table 11) and Block 2 (see Table 13) of the no distractor condition, which does not align with previous theoretical work that demonstrated stress contributes to outcome variables indicative of a sustained attention deficit (e.g. Hancock & Warm, 1989). This may be due to the levels of stress not reaching clinical levels, similar to the issue related to total ADHD values (see Table 1) or multicollinearity related to the predictor variables (see Table 8). For stress, a score of 10 would be necessary for a participant to reach “mildly [impairing]” symptoms (DASS-21; Brown et al., 1997). If the issue involving multicollinearity is ignored, these results may only serve to demonstrate that non-clinical levels of stress are indicative of fewer misses. Alternatively, these stress scores may be indicative of these values representing just enough arousal for improvement in cognitive performance (Shields et al., 2016). There was a skewed distribution towards the lower end of the stress scale in the sample of values to be indicative of whether scores that reach a clinically significant level predict fewer misses or increased misses. Depression as a predictor for misses was skewed towards the lower end of the scale as well (10; DASS-21; Brown et al., 1997).

There is a possibility that the fixed ISI and short block length (2 min 45s) was not challenging enough for participants and mitigated the effects of ADHD symptoms, which would also be responsible for the lack of a significant relationship between total ADHD score and all of the outcome variables. Other X CPT tasks with an adult sample used a variable ISI (Advokat et al., 2007; Barrilleaux & Advokat, 2009) that lasted 14 min each and demonstrated differences between the control group and experimental group. This potential limitation related to ISI length will be discussed further in the Limitations section.

In addition, both no distractor blocks were completed before the distractor condition was presented. This may have introduced a practice effect because participants had experience with two other blocks before they started the CPT in the distractor condition (cf. Halperin et al., 1991). Finally, the length of each block for the present study was 2 min 45s with a 2 min break between each block. Fried et al. (2014), as mentioned earlier, had a longer CPT that lasted 21.6 min without a break. Advokat et al. (2007) and Barrilleaux and Advokat (2009) both used 14 min X CPT tasks without any breaks as well.

Response Inhibition

The only coefficient that was significant among the response inhibition measures (RTSD, false alarms, and number of gazes off target) was a higher count of settings for ADHD related impairment as a predictor for higher RTSD in both blocks (see Table 32) Block 2 (see Table 34) of the distractor condition. However, a replication with a larger sample size would be necessary because the change in *R*-squared (ΔR^2) for RTSD was not significant and indicates that this coefficient does not support any hypotheses related to the response inhibition measures. If the change in *R*-squared (ΔR^2) for RTSD was significant, this evidence would align with most of the adult ADHD literature reviewed for the current study that used RTSD as a measure of response inhibition (e.g. Adams et al., 2011; Advokat et al., 2007). Total ADHD score was not a significant predictor for any response inhibition measures, which was most likely due to the skewed distribution of the sample that was previously discussed in the sustained attention section of the Discussion.

The lack of variable ISI likely may have eased the difficulty of the task, although there is a discrepancy in the literature over this. Studies that have used the X CPT with adult participants generally have used only a variable ISI and outcome measures related to sustained attention, and response inhibition were significant (Advokat et al., 2007; Barrilleaux & Advokat, 2009). However, Dankner et al.'s (2017) CCPT task evaluated if participants in the ADHD group were able to inhibit saccades based on the type of ISI. Dankner et al.'s (2017) CCPT demonstrated that participants had more difficulty inhibiting saccades regardless of condition, a result that contrasts the results of number of gazes off target not reaching significance in either the distractor (see Tables 44-46) or no distractor condition (see Tables 41-43) of the CPT in the current study. As mentioned previously, the length difference of the blocks (2 min 45s) and the break in between blocks (2 min) may not have allowed for a representation of cognitive decline in performance when compared to the fixed ISI condition of Dankner et al. (2017) at 11.2 min and the X CPT tasks with adult participants lasting 14 min each (Advokat et al., 2007; Barrilleaux & Advokat, 2009). The stimuli were also different shapes with varying colors instead of letters in Dankner et al.'s (2017) study.

Higher values of depression on the DASS-21 (Brown et al., 1997) predicted higher rates of RTSD for both blocks, Block 1, Block 2 in the no distractor condition (see Tables 29-31), and Block 2 in the distractor condition (see Table 34). Increased stress values were a predictor of *decreased* false alarms in the distractor CPT in the second step for both blocks and Block 1 (see Tables 38-39). These significant relationships paralleled the results that depression and stress had for misses in both blocks and Block 2 of the no distractor condition (see Tables 11 & 13). Increased stress values as a predictor of decreased false alarms in the distractor CPT condition (see Tables 38-39) may also be indicative of a practice effect, another parallel to what may have occurred with misses.

Higher values of tiredness predicted an increase in false alarms for Block 2 of the no distractor condition (see Table 37). There is no direct parallel in the literature other than the previously mentioned distracted driving study that correlated participants' response inhibition errors during the *Sustained Attention to Response Task (SART*; Robertson et al., 1997) with their self-reported level of tiredness ($p = 0.08$; Walker & Trick, 2018). The significance of the current study's result compared to Walker and Trick's (2018) approaching significance was probably due to the sample size of the current study ($n = 56$) compared to Walker and Trick's (2018) sample size ($n = 40$). The range of tiredness values in the present study also included an extra point on the tiredness scale (1-10) versus Walker and Trick's (2018) scale (1-9) to allow for more variance. Ignoring sample differences, the effect self-reported tiredness may have only occurred as the no distractor task continued and only reached significance for Block 2 of the no distractor condition (see Table 37) before the practice effect might have helped participants develop fewer response inhibition errors like false alarms. It should be noted that this possibility of a practice effect is only speculative but can be a component that future studies can explore if tiredness is measured to avoid potential artifacts associated with self-reported tiredness.

Finally, if the outcome measures are categorized based on motor response indices (misses, false alarms, RTSD) and gaze-based indices (total gaze on target duration, mean gaze on target duration, number of gazes off target), higher number of settings of ADHD-related impairment predicted higher misses (see Table 14 & 16) and had Beta weights that were significant for RTSD (see Table 32 & 34) in both blocks and Block 2 of the distractor CPT condition. Organizing the data in this manner tentatively suggests that measures related to a participant's motor response are more likely to be affected by participants that report higher number of settings of ADHD-related impairment. The lack of significance for higher number of settings of ADHD-related impairment and total ADHD values related to gaze-based indices (see Tables 17-28, 41-46) when compared to the aforementioned motor response variables, with the exception of false alarms, tentatively suggests that motor responses occur after the onset of gaze behavior and was one reason why no gaze-based indices were significant. This is also speculative because most of the previously mentioned literature that used the X CPT task (e.g. Advokat et al., 2007; Barrilleaux & Advokat, 2009) indexed misses as a measure of sustained attention and RTSD as response inhibition. Change in *R*-squared (ΔR^2) was not significant for any of the RTSD measures as well, which indicates that the significant Beta weights for the relationship between higher number of settings of ADHD-related impairment and RTSD (see Table 32 & 34) as evidence of motor responses being affected in those that report higher number of settings of ADHD-related impairment is only speculative as well.

Limitations

The results indicating ADHD scores did not predict differences in any outcome variables and number of settings of ADHD related impairment only predicting differences in misses in Block 2 of the distractor condition was most likely due to the skewed distribution of BAARS-IV (Barkley, 2011) scores at the lower end of the scale (see Table 1). Participants with a clinical diagnosis of ADHD were not recruited as well, which would have allowed for additional comparisons on the outcome measures and more prominent differences between a diagnosed and non-diagnosed sample that were similar to other X CPT studies (e.g. Advokat et al., 2007; Barrilleaux & Advokat, 2009). In addition, standardized CPT tests are more reliable when detecting differences between a clinical and non-clinical sample (Epstein et al., 2001; Riccio & Reynolds, 2001) rather than individual differences from behavioral ratings that assess hyperactivity-impulsivity and inattention (Barkley, 1991; Edwards et al., 2007). There is also evidence that participants with a clinical diagnosis of ADHD will underestimate their symptoms when compared to parent ratings of their child's symptoms, even as young adults (Barkley et al., 2002; Wolf et al., 2009), which may have also contributed to the skewed distribution of BAARS-IV (Barkley, 2011) scores at the lower end of the scale (see Table 1). Overreporting ADHD symptoms is also more likely to occur in a non-clinical population of young adults (Sibley et al., 2012). While there is no literature that discussed priming effects for any of self-report measures used in the current study, there is still a possibility that forcing participants to think about their symptoms might have led to a difference in accurate reporting of their symptoms on any of the self-report measures. Future studies that replicate this method should attempt to recruit a larger sample of participants in order to increase the predictor variance. Additional reports like parent ratings or a clinical interview at the time of the study or participants waiting until after the study is completed can be used to avoid the previously mentioned self-report issues and potential priming effects from participants that complete the scales before the CPT task, if any were present.

Participants were not asked about when medication is routinely taken. A confound was probably present on the day it was taken or if it was only taken as needed. For example, if a participant did the study around the time they would have normally taken their medication, their previous dose may not have exited their system. There is also the possibility that participants lied about not taking their medication. If these medications were taken recreationally or misused, the participant may not consider them a form of medication and state they do not take any medication. This is also salient in individuals with clinical levels of ADHD because stimulant prescription misuse and possible stimulant abuse were previously stated to be a concern in a clinical young adult population (e.g. DuPaul et al., 2009; Hartung et al., 2013). Participants that took methylphenidate, caffeine, or nicotine may also demonstrate improvement in rates of commission, omission, or decreased reaction time during the CPT (Riccio et al., 2001). Future studies should encourage potential participants to participate in the study on a day where medication use may not be necessary in order to minimize consequences when ADHD related impairments may otherwise have consequences in a particular setting before or after participation in the study.

Another possible limitation is that the DASS-21 (Brown et al., 1997) does not distinguish between state anxiety and trait anxiety. Trait anxiety was demonstrated to affect executive functioning and response inhibition. If a participant also had ADHD, their response inhibition performance decreases further than a participant with an ADHD diagnosis and no comorbid trait anxiety (González-Castro et al., 2015). DASS-21 not making this distinction potentially limits the generalizability of results.

The 2 min 45s blocks and 2 min breaks in between each block was also less demanding when compared to other X CPT tasks that were 14 min (Advokat et al., 2007;

Barrilleaux & Advokat, 2009) and 21.6 min for the TOVA CPT with eye tracking (Fried et al., 2014) without a break. Fried et al.'s (2014) study also had fixed ISIs, which may have led some participants to predict when the next letter would appear. However, there is evidence that those with ADHD do not benefit from this predictability in a CCPT task that a fixed ISI would otherwise allow because there were no outcome variable differences between the fixed ISI and variable ISI conditions for adult participants with a clinical diagnosis of ADHD (Dankner et al., 2017). In addition, both no distractor blocks were completed before the distractor blocks, which may have enabled a practice effect that led participants to be less susceptible to distractors. These discrepancies should be reconciled in future studies.

The 5 degree by 5 degree square used in the current study may have been too large to capture a saccade that was otherwise oriented towards a distractor or other parts of the screen. While the current study did not use saccades for sustained attention or response inhibition outcome measures, not measuring saccades may have failed to capture symptoms of inattention (e.g. Fried et al., 2014) that were present otherwise. The appearance of the distractor 5.5 degrees from the center further warrants a saccade measure, as eye movements towards the distractor may not have always been completed or did not reach the position of the distractor to be considered "off target."

Finally, there were two reasons why no strong conclusions were made in the present study. The first reason is because of the high familywise error rate for the present study due to the amount of hierarchical regressions (36) and dependent variables (6) in each regression. This was calculated for the present study using this formula: FWE $\leq 1 - (1 - \alpha_{IT})^c$ (α_{IT} = alpha level, c = number of comparisons). In the present study, the output of the formula grants $1 \leq 1 - (1 - 0.5)^{216} = 0.999$. This indicates that there is close to a 100% chance a Type

I error was committed in the present study. When the previously discussed outliers that likely influenced depression as a significant variable and the levels of stress that failed to reach clinical levels are considered, it is very likely that these were the result of a Type I error. A post hoc power analysis using G*Power3 (Faul et al., 2007) with four tested predictors and six total predictors also demonstrated that a sample size of 85 would have been necessary to detect a relationship in one hierarchical regression (α = 0.05, f^2= 0.15, $\beta = 0.2$).

The second reason no strong conclusions were made is because Beta weights faced moderate multicollinearity issues that were indicated by VIF statistics of the outcome measures that ranged from 1.2 (tiredness) to 3.21 (DASS-21 anxiety subscale; see Table 8). Although analysis of the change in R-squared (ΔR^2) was still relevant to assess the level of change BAARS-IV total ADHD score and number of settings of ADHD-related impairment presented (Barkley, 2011), interpreting Beta values may not be meaningful. The only R-squared (ΔR^2) change that was significant was for misses in Block 2 of the Distractor CPT condition, which leaves the Beta values in the other hierarchical regression models as tentative results.

Conclusion

The current study observed participants' performance in an X CPT task with eye tracking and examined whether the number of settings of ADHD-related impairment and total ADHD scores would predict differences in sustained attention and response inhibition outcome variable measures. Total ADHD scores did not predict differences in any outcome variables. Number of settings of ADHD-related impairment, a measure that reflects the breadth of ADHD impact, predicted higher rates of misses in the second block of the distractor condition.

The primary contribution this study makes to the literature is the comparison of participants based on ADHD values on a self-report scale (BAARS-IV; Barkley, 2011) rather than a clinical diagnosis. Eye tracking was also used for additional measures of sustained attention via mean gaze on target duration and total gaze on target duration as well as an additional measure of response inhibition via the number of gazes off target. Based on the factors that influenced results of the present study, notably a high familywise error rate and small sample size, these results are tentative. Future studies should focus on developing a more challenging task, a larger sample size, and a more varied representation of total ADHD values on the BAARS-IV (Barkley, 2011) or a similar clinical measure. Research evaluating adult samples with varying ADHD traits, and even clinical diagnoses, is underrepresented and more research is necessary to understand task conditions that impose too many attentional demands and response inhibition demands in adults. Furthermore, if the level of ADHD traits can be demonstrated as a predictor of sustained attention or response inhibition deficits, this predictor can be generalizable to a non-clinical population.

A more challenging CPT can be created by granting all blocks a variable ISI or by including a variable ISI condition. Participants can complete the distractor block from the start to avoid a practice effect later in the procedure. This distractor task can also be its own condition that, when consolidated with the previous suggestion of a variable ISI, can be evaluated via a 2 (fixed ISI, variable ISI) x 2 (no distractor CPT, distractor CPT) ANOVA. Each block can be up to 14 minutes without breaks much like previous X CPT tasks with participants that have adult ADHD (Advokat et al., 2007; Barrilleaux & Advokat, 2009) and incorporate eye tracking as an additional measure of sustained attention.

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Table 1

Descriptive Statistics - Predictor Variables

	Number of settings	ADHD Score	Anxiety	Stress	Depression	Tiredness
Mean	1.36	29.11	6.29	9.43	5.68	4.57
SD	1.41	9.32	8.14	8.61	7.79	2.24
Minimum	0	13	0	0	0	1
Maximum	4	62	34	38	30	10

Note. Number of settings = Number of settings of ADHD-related impairment. Number of settings of ADHD-related impairment can range from zero to 4. ADHD score can range from zero to 72. Anxiety, Stress, and Depression scores were taken from the DASS-21 self-reports and can range from zero to 42. Tiredness rating scores can range from 1 (not at all tired) to 10 (extremely tired).

Table 2

Descriptive Statistics - On Target Eye movement variables, no distractor condition

	Gaze On Target Duration Block 1	Gaze On Target Duration Block 2	Gaze On Target Duration Both Blocks	Mean Gaze On Duration Block 1	Mean Gaze On Duration Block 2	Mean Gaze On Duration Both Blocks
Mean	222301	218177	440478	133384	99246	102278
SD	6242	13038	18454	91851	86770	79880
Minimum	189713	174646	364359	3387	2239	2719
Maximum	225270	225237	450507	225270	225237	225254

Note. Gaze on target duration and mean gaze on target duration were measured in milliseconds.

Table 3

Descriptive Statistics - Number of Gazes off target and RTSD, no distractor condition

	Number of Gazes Off Target Block 1	Number of Gazes Off Target Block 2	Number of Gazes Off Target Both Blocks	RTSD Block 1	RTSD Block 2	RTSD Both Blocks
Mean	5.64	9.63	15.27	94.10	111.18	105.78
SD	10.94	17.68	27.9	90.97	123.21	106.05
Minimum	0	0	0	35.58	38.44	40.47
Maximum	55	79	134	648.70	868.02	763.94

Note. RTSD was measured in milliseconds.

Table 4

Descriptive Statistics - False Alarms and Misses, no distractor condition

	False Alarms Block 1	False Alarms Block 2	False Alarms Both Blocks	Misses Block 1	Misses Block 2	Misses Both Blocks
Mean	37.14	38.21	37.68	0.30	0.58	0.44
SD	20.86	22.49	19.35	0.89	1.94	1.39
Minimum	0	0	15	0	0	0
Maximum	90	100	90	5.56	13.33	9.44

Note. All values represent percentages.

Table 5

Descriptive Statistics - On Target Eye movement variables, distractor condition

	Gaze On Target Duration Block 1	Gaze On Target Duration Block 2	Gaze On Target Duration Both Blocks	Mean Gaze On Duration Block 1	Mean Gaze On Duration Block 2	Mean Gaze On Duration Both Blocks
Mean	215270	212205	427475	61139	50458	47916
SD	16840	24086	37625	74167	63656	54963
Minimum	136468	94850	265113	2504	2156	2367
Maximum	225237	225237	450474	225237	225237	225237

Note. Gaze on target duration and mean gaze on target duration were measured in milliseconds.

Table 6

Descriptive Statistics - Number of Gazes off target and RTSD, distractor condition

	Number of Gazes Off Target Block 1	Number of Gazes Off Target Block 2	Number of Gazes Off Target Both Blocks	RTSD Block 1	RTSD Block 2	RTSD Both Blocks
Mean	13.5	14.46	28.96	121.67	129.71	128.60
SD	16.87	16.75	32.86	100.48	103.72	99.04
Minimum	0	0	0	36.74	46.23	47.95
Maximum	68	73	137	552.59	548.21	513.03

Note. RTSD was measured in milliseconds.

Table 7

Descriptive Statistics - False Alarms and Misses, distractor condition

	False Alarms Block 1	False Alarms Block 2	False Alarms Both Blocks	Misses Block 1	Misses Block 2	Misses Both Blocks
Mean	36.61	39.82	38.21	1.41	1.33	1.33
SD	24.96	24.08	22.55	5.09	2.75	3.51
Minimum	0	0	0	0	0	0
Maximum	100	100	100	36.67	11.11	22.78

Note. All values represent percentages.

Table 8

Zero-order correlations - Predictor Variables

	Number of settings	ADHD Score	Anxiety	Stress	Depression	Tiredness
Number of settings	-					
ADHD Score	0.69***	-				
Anxiety	0.6***	0.66***	-			
Stress	0.51***	0.71***	0.74***	-		
Depression	0.49***	0.53***	0.7***	0.6***	-	
Tiredness	0.12	0.3***	0.31*	0.37***	0.26	-

Note. * $p < .05$, ** $p < .01$, *** $p < .001$. Number of settings = Number of settings of ADHD-related impairment. Number of settings of ADHD-related impairment can range from zero to 4. ADHD score can range from zero to 72. Anxiety, Stress, and Depression scores were taken from the DASS-21 self-reports and can range from zero to 42. Tiredness rating scores can range from 1 (not at all tired) to 10 (extremely tired).

Table 9

Zero-order correlations - Outcome Variables, No Distractor Condition Both Blocks

	False Alarms	Number of Gazes Off Target	RTSD	Misses	Gaze On target duration	Mean Gaze On target duration
False Alarms						
Number of Gazes Off Target	0.36**					
RTSD	0.51***	-0.03				
Misses	0.54***	0.04	0.84***			
Gaze On target duration	0.13	0.14	-0.01	0.09		
Mean Gaze On target duration	-0.41**	-0.6***	-0.18	-0.21	-0.17	

* $p < .05$, ** $p < .01$, *** $p < .001$.
Note. All values are outcome variables from both blocks.

Table 10

Zero-order correlations - Outcome Variables, Distractor Condition Both Blocks

	False Alarms	Number of Gazes Off Target	RTSD	Misses	Gaze On target duration	Mean Gaze On target duration
False Alarms						
Number of Gazes Off Target	0.29*					
RTSD	0.47***	0.3*				
Misses	0.26	0.18	0.67***			
Gaze On target duration	0.12	0.04	-0.18	-0.33*		
Mean Gaze On target duration	-0.34*	-0.58***	-0.23	-0.19	-0.34*	

* $p < .05$, ** $p < .01$, *** $p < .001$.
Note. All values are outcome variables from both blocks.

Table 11

Misses – No distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.2*	0.2*
	Anxiety (DASS)	0.05		
	Stress (DASS)	-0.37		
	Depression (DASS)	0.53**		
	Tiredness	-0.06		
2			0.24*	0.04
	Anxiety (DASS)	-0.07		
	Stress (DASS)	-0.45*		
	Depression (DASS)	0.5**		
	Tiredness	-0.04		
	Number of Settings of ADHD-related Impairment	0.19		
	ADHD Score	0.11		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 12

Misses – No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.14	0.14
	Anxiety (DASS)	0.02		
	Stress (DASS)	-0.31		
	Depression (DASS)	0.46*		
	Tiredness	-0.07		
2			0.19	0.05
	Anxiety (DASS)	-0.1		
	Stress (DASS)	-0.36		
	Depression (DASS)	0.42*		
	Tiredness	-0.04		
	Number of Settings of ADHD-related Impairment	0.28		
	ADHD Score	-0.01		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 13

Misses – No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.21*	0.21*
	Anxiety (DASS)	0.06		
	Stress (DASS)	-0.39*		
	Depression (DASS)	0.55**		
	Tiredness	-0.05		
2			0.25*	0.04
	Anxiety (DASS)	-0.05		
	Stress (DASS)	-0.49*		
	Depression (DASS)	0.52**		
	Tiredness	-0.04		
	Number of Settings of ADHD-related Impairment	0.15		
	ADHD Score	0.16		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 14

Misses – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.03	0.03
	Anxiety (DASS)	0.11		
	Stress (DASS)	0.06		
	Depression (DASS)	0.03		
	Tiredness	-0.07		
2			0.13	0.11
	Anxiety (DASS)	-0.03		
	Stress (DASS)	0.09		
	Depression (DASS)	-0.03		
	Tiredness	-0.01		
	Number of Settings of ADHD-related Impairment	0.47*		
	ADHD Score	-0.23		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 15

Misses – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.03	0.03
	Anxiety (DASS)	0.23		
	Stress (DASS)	0.03		
	Depression (DASS)	-0.17		
	Tiredness	-0.09		
2			0.09	0.06
	Anxiety (DASS)	0.14		
	Stress (DASS)	0.06		
	Depression (DASS)	-0.20		
	Tiredness	-0.05		
	Number of Settings of ADHD-related Impairment	0.35		
	ADHD Score	-0.19		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 16

Misses – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.11	0.11
	Anxiety (DASS)	-0.15		
	Stress (DASS)	0.11		
	Depression (DASS)	0.46		
	Tiredness	0		
2			0.26*	0.15*
	Anxiety (DASS)	-0.32		
	Stress (DASS)	0.12		
	Depression (DASS)	0.31		
	Tiredness	0.07		
	Number of Settings of ADHD-related Impairment	0.56**		
	ADHD Score	-0.23		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 17

Mean Gaze On Target Duration – No distractor, both blocks

Steps	Variable	β	R^2
1			0.16
	Anxiety (DASS)	-0.44	
	Stress (DASS)	0.19	
	Depression (DASS)	0.18	
	Tiredness	-0.29*	
2			0.17
	Anxiety (DASS)	-0.39	
	Stress (DASS)	0.25	
	Depression (DASS)	0.19	
	Tiredness	-0.28	
	Number of Settings of ADHD-related Impairment	-0.04	
	ADHD Score	-0.11	

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 18

Mean Gaze On Target Duration – No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.08	0.08
	Anxiety (DASS)	-0.25		
	Stress (DASS)	-0.07		
	Depression (DASS)	0.13		
	Tiredness	-0.11		
2			0.12	0.04
	Anxiety (DASS)	-0.24		
	Stress (DASS)	0.06		
	Depression (DASS)	0.12		
	Tiredness	-0.08		
	Number of Settings of ADHD-related Impairment	0.18		
	ADHD Score	-0.33		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 19

Mean Gaze On Target Duration – No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.14	0.14
	Anxiety (DASS)	-0.42		
	Stress (DASS)	0.13		
	Depression (DASS)	0.25		
	Tiredness	-0.26		
2			0.15	0.01
	Anxiety (DASS)	-0.38		
	Stress (DASS)	0.15		
	Depression (DASS)	0.26		
	Tiredness	-0.27		
	Number of Settings of ADHD-related Impairment	-0.09		
	ADHD Score	0.00		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 20

Mean Gaze On Target Duration – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.18*	0.18*
	Anxiety (DASS)	-0.02		
	Stress (DASS)	-0.07		
	Depression (DASS)	-0.15		
	Tiredness	-0.30*		
2			0.20	0.02
	Anxiety (DASS)	0.06		
	Stress (DASS)	0		
	Depression (DASS)	-0.13		
	Tiredness	-0.31*		
	Number of Settings of ADHD-related Impairment	-0.1		
	ADHD Score	-0.12		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 21

Mean Gaze On Target Duration – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.08	0.08
	Anxiety (DASS)	-0.1		
	Stress (DASS)	-0.07		
	Depression (DASS)	-0.04		
	Tiredness	-0.16		
2			0.13	0.05
	Anxiety (DASS)	0.03		
	Stress (DASS)	-0.01		
	Depression (DASS)	-0.01		
	Tiredness	-0.19		
	Number of Settings of ADHD-related Impairment	-0.28		
	ADHD Score	-0.03		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 22

Mean Gaze On Target Duration – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.24**	0.24**
	Anxiety (DASS)	-0.02		
	Stress (DASS)	-0.01		
	Depression (DASS)	-0.18		
	Tiredness	-0.4**		
2			0.25*	0.01
	Anxiety (DASS)	-0.03		
	Stress (DASS)	0.02		
	Depression (DASS)	-0.19		
	Tiredness	-0.38**		
	Number of Settings of ADHD-related Impairment	0.09		
	ADHD Score	-0.1		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Mean gaze on target duration was measured in milliseconds.

Table 23

Total Gaze On Target Duration – No distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.18*	0.18*
	Anxiety (DASS)	-0.09		
	Stress (DASS)	-0.19		
	Depression (DASS)	0.12		
	Tiredness	-0.31*		
2			0.2	0.02
	Anxiety (DASS)	-0.13		
	Stress (DASS)	-0.15		
	Depression (DASS)	0.11		
	Tiredness	-0.29*		
	Number of Settings of ADHD-related Impairment	0.2		
	ADHD Score	-0.16		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 24

Total Gaze On Target Duration – No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.08	0.08
	Anxiety (DASS)	-0.1		
	Stress (DASS)	-0.08		
	Depression (DASS)	0.16		
	Tiredness	-0.23		
2			0.1	0.02
	Anxiety (DASS)	-0.15		
	Stress (DASS)	-0.05		
	Depression (DASS)	0.14		
	Tiredness	-0.21		
	Number of Settings of ADHD-related Impairment	0.20		
	ADHD Score	-0.13		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 25

Total Gaze On Target Duration – No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.23**	0.23**
	Anxiety (DASS)	-0.08		
	Stress (DASS)	-0.23		
	Depression (DASS)	0.1		
	Tiredness	-0.33*		
2			0.25*	0.02
	Anxiety (DASS)	-0.11		
	Stress (DASS)	-0.19		
	Depression (DASS)	0.08		
	Tiredness	-0.31*		
	Number of Settings of ADHD-related Impairment	0.19		
	ADHD Score	-0.17		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 26

Total Gaze On Target Duration – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.23*	0.23*
	Anxiety (DASS)	-0.26		
	Stress (DASS)	-0.34		
	Depression (DASS)	0.22		
	Tiredness	-0.09		
2			0.25*	0.03
	Anxiety (DASS)	-0.17		
	Stress (DASS)	-0.25		
	Depression (DASS)	0.24		
	Tiredness	-0.1		
	Number of Settings of ADHD-related Impairment	-0.11		
	ADHD Score	-0.15		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 27

Total Gaze On Target Duration – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.17*	0.17*
	Anxiety (DASS)	-0.25		
	Stress (DASS)	-0.33		
	Depression (DASS)	0.28		
	Tiredness	-0.03		
2			0.21	0.04
	Anxiety (DASS)	-0.14		
	Stress (DASS)	-0.28		
	Depression (DASS)	0.31		
	Tiredness	-0.05		
	Number of Settings of ADHD-related Impairment	-0.24		
	ADHD Score	-0.03		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 28

Total Gaze On Target Duration – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.21*	0.21*
	Anxiety (DASS)	-0.23		
	Stress (DASS)	-0.3		
	Depression (DASS)	0.15		
	Tiredness	-0.12		
2			0.24*	0.02
	Anxiety (DASS)	-0.17		
	Stress (DASS)	-0.2		
	Depression (DASS)	0.16		
	Tiredness	-0.12		
	Number of Settings of ADHD-related Impairment	0.78		
	ADHD Score	-0.22		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. Total gaze on target duration was measured in milliseconds.

Table 29

RTSD - No distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.2*	0.2*
	Anxiety (DASS)	-0.03		
	Stress (DASS)	-0.35		
	Depression (DASS)	0.56**		
	Tiredness	-0.09		
2			0.25*	0.05
	Anxiety (DASS)	-0.15		
	Stress (DASS)	-0.49*		
	Depression (DASS)	0.54**		
	Tiredness	-0.08		
	Number of Settings of ADHD-related Impairment	0.1		
	ADHD Score	0.27		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 30

RTSD - No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.22*	0.22*
	Anxiety (DASS)	-0.10		
	Stress (DASS)	-0.32		
	Depression (DASS)	0.59**		
	Tiredness	-0.14		
2			0.23*	0.01
	Anxiety (DASS)	-0.17		
	Stress (DASS)	-0.35		
	Depression (DASS)	0.57**		
	Tiredness	-0.12		
	Number of Settings of ADHD-related Impairment	0.15		
	ADHD Score	0.00		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 31

RTSD - No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.19*	0.19*
	Anxiety (DASS)	-0.01		
	Stress (DASS)	-0.35		
	Depression (DASS)	0.53**		
	Tiredness	-0.05		
2			0.27*	0.08
	Anxiety (DASS)	-0.14		
	Stress (DASS)	-0.54*		
	Depression (DASS)	0.51**		
	Tiredness	-0.05		
	Number of Settings of ADHD-related Impairment	0.07		
	ADHD Score	0.38		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 32

RTSD – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.17*	0.17*
	Anxiety (DASS)	0.25		
	Stress (DASS)	-0.29		
	Depression (DASS)	0.36		
	Tiredness	-0.06		
2			0.24*	0.07
	Anxiety (DASS)	0.12		
	Stress (DASS)	-0.3		
	Depression (DASS)	0.32		
	Tiredness	-0.01		
	Number of Settings of ADHD-related Impairment	0.38*		
	ADHD Score	-0.13		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 33

RTSD – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.08	0.08
	Anxiety (DASS)	0.24		
	Stress (DASS)	-0.17		
	Depression (DASS)	0.18		
	Tiredness	-0.11		
2			0.15	0.07
	Anxiety (DASS)	0.1		
	Stress (DASS)	-0.22		
	Depression (DASS)	0.14		
	Tiredness	-0.08		
	Number of Settings of ADHD-related Impairment	0.33		
	ADHD Score	-0.01		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 34

RTSD – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.26**	0.26**
	Anxiety (DASS)	0.21		
	Stress (DASS)	-0.39*		
	Depression (DASS)	0.52**		
	Tiredness	-0.01		
2			0.32**	0.06
	Anxiety (DASS)	0.11		
	Stress (DASS)	-0.35		
	Depression (DASS)	0.49**		
	Tiredness	0.03		
	Number of Settings of ADHD-related Impairment	0.37*		
	ADHD Score	-0.2		

* $p < .05$, ** $p < .01$, *** $p < .001$
Note. RTSD was measured in milliseconds.

Table 35

False Alarms – No distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.13	0.13
	Anxiety (DASS)	0.16		
	Stress (DASS)	-0.09		
	Depression (DASS)	0.15		
	Tiredness	0.17		
2			0.13	0.03
	Anxiety (DASS)	0.07		
	Stress (DASS)	-0.21		
	Depression (DASS)	0.13		
	Tiredness	0.16		
	Number of Settings of ADHD-related Impairment	0.04		
	ADHD Score	0.24		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 36

False Alarms – No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.06	0.06
	Anxiety (DASS)	0.21		
	Stress (DASS)	-0.06		
	Depression (DASS)	0.1		
	Tiredness	-0.02		
2			0.07	0.02
	Anxiety (DASS)	0.14		
	Stress (DASS)	-0.11		
	Depression (DASS)	0.08		
	Tiredness	-0.01		
	Number of Settings of ADHD-related Impairment	0.13		
	ADHD Score	0.05		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 37

False Alarms – No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.14	0.14
	Anxiety (DASS)	0.08		
	Stress (DASS)	-0.1		
	Depression (DASS)	0.17		
	Tiredness	0.31*		
2			0.2	0.06
	Anxiety (DASS)	0		
	Stress (DASS)	-0.27		
	Depression (DASS)	0.16		
	Tiredness	0.29*		
	Number of Settings of ADHD-related Impairment	-0.05		
	ADHD Score	0.37		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 38

False Alarms – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.1	0.1
	Anxiety (DASS)	0.33		
	Stress (DASS)	-0.38		
	Depression (DASS)	0.04		
	Tiredness	0.19		
2			0.14	0.05
	Anxiety (DASS)	0.26		
	Stress (DASS)	-0.53*		
	Depression (DASS)	0.04		
	Tiredness	0.177		
	Number of Settings of ADHD-related Impairment	-0.04		
	ADHD Score	0.34		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 39

False Alarms – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.07	0.07
	Anxiety (DASS)	0.32		
	Stress (DASS)	-0.36		
	Depression (DASS)	0.03		
	Tiredness	0.12		
2			0.14	0.07
	Anxiety (DASS)	0.24		
	Stress (DASS)	-0.55*		
	Depression (DASS)	0.02		
	Tiredness	0.1		
	Number of Settings of ADHD-related Impairment	-0.09		
	ADHD Score	0.44		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 40

False Alarms – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.1	0.1
	Anxiety (DASS)	0.29		
	Stress (DASS)	-0.34		
	Depression (DASS)	0.04		
	Tiredness	0.23		
2			0.12	0.02
	Anxiety (DASS)	0.23		
	Stress (DASS)	-0.43		
	Depression (DASS)	0.03		
	Tiredness	0.23		
	Number of Settings of ADHD-related Impairment	0.03		
	ADHD Score	0.18		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 41

Number of Gazes Off Target – No distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.13	0.13
	Anxiety (DASS)	0.26		
	Stress (DASS)	0.05		
	Depression (DASS)	-0.21		
	Tiredness	0.26		
2			0.16	0.03
	Anxiety (DASS)	0.28		
	Stress (DASS)	-0.03		
	Depression (DASS)	-0.2		
	Tiredness	0.23		
	Number of Settings of ADHD-related Impairment	-0.20		
	ADHD Score	0.23		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 42

Number of Gazes Off Target – No distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.06	0.06
	Anxiety (DASS)	0.16		
	Stress (DASS)	0.06		
	Depression (DASS)	-0.18		
	Tiredness	0.18		
2			0.09	0.03
	Anxiety (DASS)	0.2		
	Stress (DASS)	0		
	Depression (DASS)	-0.16		
	Tiredness	0.15		
	Number of Settings of ADHD-related Impairment	-0.23		
	ADHD Score	0.22		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 43

Number of Gazes Off Target – No distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.17*	0.17*
	Anxiety (DASS)	0.31		
	Stress (DASS)	0.04		
	Depression (DASS)	-0.22		
	Tiredness	0.29*		
2			0.19	0.02
	Anxiety (DASS)	0.32		
	Stress (DASS)	-0.04		
	Depression (DASS)	-0.21		
	Tiredness	0.23		
	Number of Settings of ADHD-related Impairment	-0.18		
	ADHD Score	0.23		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 44

Number of Gazes Off Target – Distractor, both blocks

Steps	Variable	β	R^2	ΔR^2
1			0.1	0.1
	Anxiety (DASS)	0.24		
	Stress (DASS)	0.08		
	Depression (DASS)	-0.1		
	Tiredness	0.137		
2			0.12	0.02
	Anxiety (DASS)	0.174		
	Stress (DASS)	-0.02		
	Depression (DASS)	-0.12		
	Tiredness	0.14		
	Number of Settings of ADHD-related Impairment	0.03		
	ADHD Score	0.2		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 45

Number of Gazes Off Target – Distractor, Block 1

Steps	Variable	β	R^2	ΔR^2
1			0.14	0.14
	Anxiety (DASS)	0.28		
	Stress (DASS)	0.15		
	Depression (DASS)	-0.16		
	Tiredness	0.12		
2			0.17	0.03
	Anxiety (DASS)	0.2		
	Stress (DASS)	0.03		
	Depression (DASS)	-0.17		
	Tiredness	0.12		
	Number of Settings of ADHD-related Impairment	0.03		
	ADHD Score	0.25		

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 46

Number of Gazes Off Target – Distractor, Block 2

Steps	Variable	β	R^2	ΔR^2
1			0.07	0.07
	Anxiety (DASS)	0.19		
	Stress (DASS)	0.01		
	Depression (DASS)	-0.04		
	Tiredness	0.15		
2			0.08	0.01
	Anxiety (DASS)	0.14		
	Stress (DASS)	-0.06		
	Depression (DASS)	-0.05		
	Tiredness	0.15		
	Number of Settings of ADHD-related Impairment	0.03		
	ADHD Score	0.14		

* $p < .05$, ** $p < .01$, *** $p < .001$

Appendix A

To: Zachery Mondlak
Psychology
CAMPUS EMAIL

From: Dr. Andrew Shanely, IRB Chairperson
RE: Notice of IRB Approval by Expedited Review (under 45 CFR 46.110)

STUDY #: 17-0327
STUDY TITLE: Eye Movement, Visual Attention, and ADHD Traits
Submission Type: Modification
Expedited Category: (4) Collection of Data through Noninvasive Procedures Routinely Employed in Clinical Practice,(6) Collection of Data from Recordings made for Research Purposes,Minor Change to Previously Approved Research
Approval Date: 10/19/2018
Expiration Date of Approval: 10/03/2019

The Institutional Review Board (IRB) approved the modification for this study. The IRB found that the research procedures meet the expedited category cited above. IRB approval is limited to the activities described in the IRB approved materials, and extends to the performance of the described activities in the sites identified in the IRB application. In accordance with this approval, IRB findings and approval conditions for the conduct of this research are listed below.

Submission Description:

The only changes have to do with personnel. Zach Mondlak is a new graduate student in the experimental psychology program and has taken up this project where another student left off after graduation. Zach is being primarily advised by Dr. Chris Dickinson, with me as his secondary advisor. I am therefore asking to change Zach to PI, Dr. Dickinson to Faculty Advisor, and myself to a consulting faculty role.

Study Regulatory and other findings:

The IRB waived the requirement to obtain a signed consent form for some or all subjects because the only record linking the subject and research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern.

Appendix B

Information to Consider about this Research

Eye Movement, Visual Attention, and ADHD Traits

Principal Investigator: Zack Mondlak mondlakza@appstate.edu
Faculty Advisor: Chris Dickinson dickinsonca@appstate.edu (828) 262-8940
Co-Investigator: Will Canu canuwh@appstate.edu (828) 262-8935
IRB Office: irb@appstate.edu (828) 262-2692
Psychology Department, Appalachian State University

You are invited to participate in a research study that is examining visual attention and eye movements in college students with different levels of attention-deficit/hyperactivity disorder (ADHD) traits. Anyone at least 18 years of age may apply, regardless of whether or not you have ADHD.

If you agree to be part of the research study you will be asked to perform **two simple, computer-administered attention tasks** while having your **eye movements recorded** using infrared (IR) light. Both tasks involve looking at a screen and pressing a button when a certain letter appears. During the second task, distracting letters will also appear on the screen. Some distractors may blink slowly or move across the screen. In addition to the attention tasks, you will be given a 5-minute questionnaire to measure symptoms of anxiety and depression, as well as a short questionnaire to measure ADHD symptoms. All data will remain confidential: your answers to the questionnaires will be stored in a locked private lab room, and your results on the eye-tracking task will be stored confidentially on an encrypted, password-protected USB drive.

There is no direct personal benefit to participating in this study. You will not be paid for your participation in this study. However, **you will earn 2 ELC credits for your participation.** There are other research options and non-research options for obtaining extra credit or ELC's. One non-research option to receive 1 ELC is to read an article and write a 1-2 page paper summarizing the article and your reaction to the article. More information about this option can be found at: psych.appstate.edu/research. You may also wish to consult your professor to see if other non-research options are available.

Risks and discomforts are unlikely and minimal. You will be putting your chin on a chin rest for the duration of the two tasks (20 minutes each) in order to avoid any head movements that would obscure the eye-movement data. The study will take no more than an hour in total. The eye-tracking technology projects infrared (IR) light onto the eyes. An IR camera picks up the reflection of the IR light off of the eyes in order to see where the eyes are looking.

The video camera used by the EyeLink 1000 eye tracker to record and track the locations of observers' gaze requires that the eyes are illuminated. To accomplish this, the video camera assembly includes light-emitting diodes (LEDs) that emit infrared (IR) radiation at a wavelength of 890 nm (considered in the range of Class A IR radiation). The EyeLink CL illuminators are compliant with the IEC-60825-1 LED safety standard as a Class 1 LED device. This standard has been or is in the process of being adopted by most countries, and regulates many aspects of LED and laser eye safety, including retinal, corneal and skin safety. Class 1 products are "safe under reasonably foreseeable conditions of operation, including the use of optical instruments for intrabeam viewing" (EyeLink 1000 User Manual version 1.4.0, Copyright © 2005–2008, SR Research Ltd). The amount of radiant energy used to illuminate each eye has been calculated to be less than 1 mW/cm2. This amount of IR radiation conforms to the standards set forth by numerous organizations (see attached Declaration of Conformity from SR Research, Inc.). The amount of radiant energy emitted by the IR LEDs is less than the recommended maximum exposure level, which suggests that the radiant energy from these IR LEDs poses no health risks to observers. EyeLink video-based eye tracking systems have been in use since 1995 without any reports of adverse effects and are used in laboratories worldwide.

Participating in this study is completely voluntary. Even if you decide to participate now, you may change your mind and stop at any time. You may choose not to answer any survey question for any reason. Refusal to participate or a decision to discontinue participation at any time will involve no penalty or loss of benefits to you as a participant.

If you have questions about this research study, you may contact Zack Mondlak or Chris Dickinson. If you have questions about your rights as a research subject, please contact the IRB at irb@appstate.edu.

This research project has been approved on October 4, 2018 by the Institutional Review Board (IRB) at Appalachian State University. This approval will expire on October 3, 2019 unless the IRB renews the approval of this research.

By continuing to the research procedures, I acknowledge that I am at least 18 years old, have read the above information, and agree to participate.

Appendix C

DASS 21

(OFFICE USE) Participant #: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3

17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

Appendix D

Participant Data File Name: ___________________________ Date: ____________________

Sex (Circle one) Male Female Age: ___________________

Instructions

For the first 27 items, please circle the number next to each item below that best describes your behavior **DURING THE PAST SIX MONTHS.** Then answer the remaining three questions. If you are taking medication to treat ADHD (such as Ritalin) or have taken it in the past six months, please respond to these items based on your non-medicated behavior (i.e., how things are when you are "off-meds"). Please ignore the sections marked "Office Use Only."

	Never or rarely	Some-times	Often	Very often
1. Fail to give close attention to details or make careless mistakes in schoolwork, at work, or during other activities (e.g., overlook or miss details or work is inaccurate)	0	1	2	3
2. Have difficulty sustaining attention in tasks or play activities (e.g., have difficulty remaining focused during lectures, conversations, or lengthy reading)	0	1	2	3
3. Do not seem to listen when spoken to directly (e.g., mind seems elsewhere, even in the absence of any obvious distraction)	0	1	2	3
4. Do not follow through on instructions and fail to finish schoolwork, chores, or duties in the workplace (e.g., start tasks but quickly lose focus and am easily sidetracked)	0	1	2	3
5. Have difficulty organizing tasks and activities (e.g., difficulty managing sequential tasks; difficulty keeping materials and belongings in order; messy, disorganized work; have poor time management; fail to meet deadlines)	0	1	2	3
6. Avoid, dislike, or am reluctant to engage in tasks that require sustained mental effort (e.g., schoolwork or homework; for older adolescents and adults, preparing reports, completing forms, reviewing lengthy papers)	0	1	2	3
7. Lose things necessary for tasks or activities (e.g., school materials, pencils, books, tools, wallets, keys, paperwork, eyeglasses, mobile telephones)	0	1	2	3
8. Am easily distracted by extraneous stimuli (for older adolescents and adults, may include unrelated thoughts)	0	1	2	3
9. Am forgetful in daily activities (e.g., doing chores, running errands; for older adolescents and adults, returning calls, paying bills, keeping appointments)	0	1	2	3
10. Fidget with or tap hands or feet or squirms in seat	0	1	2	3
11. Leave seat in situations when remaining seated is expected (e.g., leaves his or her place in the classroom, in the office or other workplace, or in other situations that require remaining in place)	0	1	2	3
12. Run about or climb in situations where it is inappropriate. (Note: In adolescents or adults, may be limited to feeling restless.)	0	1	2	3
13. Unable to play or engage in leisure activities quietly	0	1	2	3
14. Am often "on the go," acting as if "driven by a motor" (e.g., is unable to be or uncomfortable being still for extended time, as in restaurants, meetings; may be experienced by others as being restless or difficult to keep up with)	0	1	2	3
15. Talk excessively	0	1	2	3

16. Blurt out an answer before a question has been completed (e.g., completes people's sentences; cannot wait for turn in conversation)	0	1	2	3
17. Have difficulty waiting for my turn (e.g., while waiting in line)	0	1	2	3
18. Interrupt or intrude on others (e.g., butts into conversations, games, or activities; may start using other people's things without asking or receiving permission; for adolescents and adults, may intrude into or take over what others are doing)	0	1	2	3

Section 3

19. Did you experience *any* of these 18 symptoms at least "Often" or more frequently (Did you circle a 3 or a 4 above)? **No** **Yes** (Circle one)

20. If so, how old were you when those symptoms began? (Fill in the blank)

    I was ____________ years old.

21. If so, in which of these settings did those symptoms impair your functioning? Place a *check mark* (√) next to all of the areas that apply to you.

_____________ School

_____________ Home

_____________ Work

_____________ Social Relationships

Appendix E

Participant Data File Name: ___________________________ Date: ____________________

Sex (Circle one) Male Female Age: ___________________

Instructions

For the first nine items, please circle the number next to each item below that best describes your behavior **DURING THE PAST SIX MONTHS.** Then answer the remaining three questions. If you are taking medication to treat ADHD (such as Ritalin) or have taken it in the past six months, please respond to these items based on your non-medicated behavior (i.e., how things are when you are "off-meds"). Please ignore the sections marked "Office Use Only."

Section 1 (Sluggish Cognitive Tempo)	Never or rarely	Some-times	Often	Very Often
1. Prone to daydreaming when I should be concentrating on something or working	1	2	3	4
2. Have trouble staying alert or awake in boring situations	1	2	3	4
3. Easily confused	1	2	3	4
4. Easily bored	1	2	3	4
5. Spacey or "in a fog"	1	2	3	4
6. Lethargic, more tired than others	1	2	3	4
7. Underactive or have less energy than others	1	2	3	4
8. Slow moving	1	2	3	4
9. I don't seem to process information as quickly or as accurately as others	1	2	3	4
Office Use Only (Section 1) Total Score Section 1 Symptom Count				

Vita

Zachery Mondlak was born in Columbus, Ohio, on April 5, 1994. He graduated from Marburn Academy in Columbus, Ohio in May 2013. The following August, he entered Bowling Green State University to study Psychology and in May 2017 he was awarded the Bachelor of Science degree. In the fall of 2018, he accepted a research assistantship in Experimental Psychology at Appalachian State University and began study towards a Master of Arts degree. He received a Master of Arts in Experimental Psychology in December 2020.