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Why Are Individuals With ADHD More Prone to Boredom? Examining Attention Control and Working Memory as Mediators of Boredom in Young Adults With ADHD Traits

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Abstract

Objective: Proneness to boredom has been reported in ADHD populations; however, no study to date has examined potential mediators of ADHD-related boredom. The current study investigated whether individuals with ADHD traits exhibit higher levels of boredom propensity relative to their peers without ADHD traits and explore if attention control and working memory mediate the relationship between ADHD and proneness to boredom. **Method:** Young adults (M_{age} = 19.1, *SD* = 1.3) with (*n* = 31) and without (*n* = 57) ADHD traits completed self-report measures (i.e., boredom proneness, current ADHD symptoms, and childhood indicators of ADHD) and six counterbalanced performance-based cognitive measures (i.e., three attention control and three working memory tasks). **Results:** Young adults with ADHD traits exhibited large magnitude effect size differences in proneness to boredom relative to their peers without ADHD traits (*d* = 2.09). In addition, proneness to boredom and ADHD trait group status were related to worse performance on attention control and working memory factors. Both attention control and working memory factors partially mediated the relation between ADHD and boredom, accounting for 5.8% and 6.4% of the variance in ADHD-related boredom, respectively. **Conclusion:** Executive attention processes related to difficulty controlling attention and using working memory may provide a partial explanation for why individuals with ADHD traits experience boredom. *(J. of Att. Dis. XXXX; XX(X) XX-XX)*

Keywords

ADHD, executive function deficits, working memory, attention control, boredom

Boredom is an emotional state defined as wanting to, but being unable to, find interest or enjoyment in a desired activity (Eastwood et al., 2012). While boredom may seem like a trivial experience, it has been linked with serious and even fatal outcomes. For example, boredom proneness is associated with severe mental health symptoms such as depression, anxiety, suicidal thoughts, and self-harm (Ben-Zeev et al., 2012; Goldberg et al., 2011; Nederkoorn et al., 2016; Newell et al., 2012). Boredom is also related to increased preventable accidents, injuries, and property loss in occupations that require sustained attention and monitoring (e.g., air traffic controllers, security guards; Kass et al., 2010; O'Hanlon, 1981). Finally, individuals with a high propensity to boredom demonstrate poor academic functioning, including lower GPAs and standardized test scores (Sharp et al., 2020; Tze et al., 2016), and difficulties with occupational functioning, such as job dissatisfaction and increased absenteeism (Kass et al., 2001; Watt & Hargis, 2010). Therefore, while boredom may seem like a minor unpleasant experience to many, empirical research identifies boredom as potentially problematic for certain individuals more than others.

Boredom is sometimes conceptualized as a trait-like characteristic that affects a person's tendency to feel bored in different situations. This trait-like characteristic is referred to as *trait boredom* or *boredom propensity* in the literature. Boredom has also been investigated as state-specific or situational and is commonly referred to as *state boredom*. State boredom was not tested in the current study (but see Hunter & Eastwood, 2018; Mercer-Lynn et al.,

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2014). Boredom propensity is often assessed using self-report measures such as the Boredom Proneness Scale (BPS; Farmer & Sundberg, 1986) and the Boredom Susceptibility subscale of the Sensation Seeking Scale (Zuckerman et al., 1964). The BPS has been more widely used, includes 28 items, and two factors characterizing boredom due to the lack of internal or external stimulation. While this measure has been useful in characterizing boredom propensity, it has been criticized by others for having an unstable factor structure and factors dependent on the wording of items (Struk et al., 2017). In an effort to correct for some of these short comings, Struk et al. (2017) developed the Short Boredom Proneness Scale (SBPS), an 8-item measure of boredom propensity reflecting a unidimensional construct of boredom with good construct validity and excellent internal consistency estimates.

Early theories (Berlyne, 1960) suggested that boredom results from an unstimulating and monotonous environment, situation, or stimulus (e.g., "this book is so boring!"), while other theories suggest that the propensity for boredom lies within the person. The *Cognitive Theory of Boredom* posits that boredom results from an individual's inability to sustain and carefully control their attention to a salient aspect of a situation or the environment (Eastwood et al., 2012; Fisher, 1993; Hamilton et al., 1984). According to this theory, a person is aware of their inability to successfully engage their attention to the task and becomes increasingly frustrated or engages in task unrelated thoughts (e.g., mind wandering). When the person is unable to engage their attention, they typically attribute the aversive state to the environment or stimulus, rather than their own difficulty attending to the task (Eastwood et al., 2012). For example, a student studying for an exam struggles to focus while reading a textbook. They repeatedly reread paragraphs without retaining the material and, frustrated, blame the content as boring rather than recognizing their own attention difficulties.

Eastwood et al. (2012) suggested that boredom might be caused by an attentional failure, such as failed efforts to engage executive control of attention. Executive attention is often called *attention control* in the literature. Attention control is involved in conflict resolution as well as the ability to focus attention on a relevant task while also resisting distractions (Burgoyne & Engle, 2020), either internal (e.g., thoughts and feelings) or external (e.g., noises in immediate environment and cell phone notifications). Attention control is critical for higher order thought and is involved in everyday behavior, such as self-control and emotion regulation (Broadway et al., 2010; Schmeichel & Demaree, 2010). Another cognitive ability that utilizes attention control processes is working memory. Working memory is defined as a limited capacity, multi-component system responsible for the temporary storage, rehearsal, processing, updating, and maintenance of information (Baddeley, 2007). Baddeley's (2007) multi-component model of working memory includes a higher order attention controller (i.e., central executive), two modality specific short term storage/rehearsal components (i.e., phonological loop and visuospatial sketchpad), and an episodic buffer for temporary storage of events. The central executive, reflecting the attention control component, has been shown to be involved in several academic and intellectual abilities, such as reading, math, and fluid reasoning (Swanson & Kim, 2007). Given that both attention control and working memory reflect higher order mental processing and are involved in several important behavioral and academic outcomes, their relation to boredom is worthy of investigation.

Empirical evidence indicates that high levels of boredom proneness are related to attentional failures (Hamilton et al., 1984; Hunter & Eastwood, 2018; Malkovsky et al., 2012; Sawin & Scerbo, 1995). These studies have used laboratory-based tasks (e.g., the Continuous Performance Test [CPT] or the Sustained Attention to Response Task [SART]) designed to measure sustained attention. In these tasks, participants are instructed to press a button (usually a space bar on a keyboard) in response to "Go" stimuli (e.g., numbers or letters) and withhold their response to certain "No-go" stimuli (e.g., the letter X or the number 3). These tasks are usually long, requiring between 10 and 20 min of sustained attention. Performance is typically measured by estimating the number of errors committed during the task. Omission errors occur when a person neglects to respond to Go stimuli and may reflect lapses in attention. Commission errors occur when a person presses the button when they should have withheld their response to No-go stimuli and may reflect impulsive responding due difficulties with cognitive control (i.e., executive attention). Post-error slowing is a behavior that occurs when a person slows their reaction times to the stimuli following a commission error. Post-error slowing is a normal response in most "healthy" individuals and reflects performance monitoring. In one study, high boredom proneness in adults was associated with increased omission and commission errors on the SART (Hunter & Eastwood, 2018); however, no significant relations were found between boredom propensity and post-error slowing. In contrast, another study reported that individuals with high levels of boredom proneness were less likely to demonstrate post-error slowing following commission errors, suggesting that boredom prone individuals are less likely to monitor their performance after making an error (Malkovsky et al., 2012). However, this study did not find associations between boredom proneness and commission errors. Given these conflicting findings, studies are needed to investigate the relationship between boredom and other measures of attention control. Measures like the SART ostensibly estimate attention control abilities related to behavioral inhibition, such as withholding or stopping an on-going motor response

(Schachar et al., 2000); however, no study to date has examined the extent to which other aspects of attention control, such as cognitive interference control, conflict resolution, and working memory maintenance, may be involved in proneness to boredom.

Given that inattention is one of the core symptoms of ADHD, if the Cognitive Theory of Boredom is correct then individuals with ADHD should have a higher propensity to experience boredom. While the research in this particular area is limited, the few studies examining the relationship between ADHD symptoms and boredom in non-clinical samples have reported moderate to strong correlations ($r = .52$–$.64$; Castens & Overby, 2009; Malkovsky et al., 2012). In addition, children diagnosed with ADHD were found to have higher levels of both trait and state boredom compared to children without ADHD (Hsu et al., 2020). Less research has examined relationships between cognition, boredom, and ADHD. One study found that children diagnosed with ADHD with a higher propensity to boredom exhibit slower reaction times and increased reaction time variability during a task designed to measure sustained attention compared to ADHD children with a lower propensity to boredom (Golubchik et al., 2021). In another study, state boredom was associated with inattention indices on the CPT in the group of children diagnosed with ADHD, but not children without ADHD (Hsu et al., 2020). In addition, psychopharmacological treatment with methylphenidate (e.g., Ritalin) was shown to reduce levels of boredom in children diagnosed with ADHD (Golubchik et al., 2020, 2021). Perhaps, reduced levels of boredom were found in children who were medicated because methylphenidate increases catecholamine (i.e., dopamine and norepinephrine) activity in the prefrontal cortex (Quintero et al., 2022), thereby upregulating cognitive functioning in brain areas ostensibly responsible for executive attention. No studies to date have examined other aspects of attention control, such as interference control and conflict management, in ADHD or potential mechanisms of ADHD-related boredom propensity.

Like individuals with a higher propensity for boredom, some individuals diagnosed with ADHD have deficits in the executive control of attention (Arora et al., 2020; Salmi et al., 2018). Weaknesses in executive attention are not surprising given neuroimaging evidence that individuals with ADHD experience dysregulation of the prefrontal cortex, the brain area ostensibly subserving executive control, including hypo- (Dickstein et al., 2006) and hyper- (Calub et al., 2022) activity in these regions, as well as delayed cortical development (Shaw et al., 2007). Furthermore, meta-analytic reviews are highly consistent in documenting working memory deficits in individuals diagnosed with ADHD, with more impairment found for central executive functioning (i.e., attention control), relative to storage and rehearsal abilities (Kasper et al., 2012; Martinussen et al., 2005). However, no study to date has explored ADHD-related weaknesses in attention control and working memory and their relation to proneness to boredom.

Given the links between ADHD and boredom, the present study investigates the extent to which executive attention is involved in ADHD-related boredom. Therefore, the purpose of the current study is to (1) determine if young adults with ADHD traits have a higher propensity to boredom than their peers without ADHD traits; (2) investigate the extent to which executive attention, namely attention control and working memory, are related to proneness to boredom; and (3) determine if attention control and working memory serve as mediators in the relationship between ADHD and boredom propensity. We expect that individuals with ADHD traits will self-report higher levels of boredom and perform worse on tasks of attention control and working memory relative to their peers without ADHD traits. We also expect that performance-based measures of attention control and working memory will be related to boredom propensity and will mediate the relationship between ADHD trait group status and propensity to boredom.

Methods

Participants

One hundred fifteen undergraduate students from a southeastern university in the United States participated in the current study. Participants were recruited using an undergraduate research participation pool and were compensated with partial course credit for their general psychology course. Students not participating in research studies were given alternative assignments for their psychology course. To be included in the final sample, the participants were required to meet criteria for the ADHD or control group based on the group assignment criteria described below. Therefore, the final sample consisted of 88 participants (70 females; *M* age = 19.1, *SD* age = 1.3; see Table 1). All participants provided their informed consent and the university's Institutional Review Board approved the study prior to the onset of data collection.

Group Assignment

Thirty-one participants were included in the ADHD trait group based on their self-report of (1) five or more symptoms on the Barkley Adult ADHD Rating Scale (BAARS-IV; Barkley, 2011) inattention or hyperactive/impulsive subscales as occurring "often" or "very often" OR[1] exceeding the threshold criteria on the Adult ADHD Self-Report Screening Scale for DSM-5 (ASRS-5; Ustun et al., 2017) of a total score of 14 or greater; and (2) exceeding the threshold criteria (ADHD score >35) on the Wender Utah Rating Scale (WURS; Ward, 1993), a retrospective measure of

Table 1. Means, Standard Deviations, and Between Group Differences.

	ADHD			Control			Group differences		
Variables	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*	*p*	*d*
Age	31	19.1	1.2	57	19.1	1.4	−0.09	.930	0.02
ASRS-5 total score	31	15.5	3.3	57	7.9	3.0	−10.93	<.001	2.44
BAARS-IV total score	31	48.3	8.5	57	29.1	5.1	−13.23	<.001	2.95
WURS total ADHD score	31	47.9	13.5	57	19.8	8.9	−11.74	<.001	2.62
SBPS total score	31	18.8	5.3	57	8.4	4.8	−9.35	<.001	2.09
Flanker deadline RT	30	702.0	237.1	57	640.5	154.3	−1.46	.148	0.33
SACT total correct	31	51.7	8.9	57	57.3	5.7	3.57	<.001	0.80
Visual arrays *k* score	31	1.3	1.1	57	1.5	1.0	0.61	.547	0.14
Operation span partial score	31	45.8	15.6	57	52.0	12.5	2.03	.046	0.45
Symmetry span partial score	31	23.0	8.3	56	28.4	7.8	2.99	.004	0.67
Rotation span partial score	30	21.6	7.4	57	25.6	8.8	2.11	.038	0.48
Attention control factor score	30	−0.4	1.2	57	0.2	0.8	2.90	.005	0.65
Working memory factor score	30	−0.4	1.0	56	0.3	0.9	3.09	.003	0.70
	n male	*n* female		*n* male	*n* female				
Gender	8	23		10	47				

Note. ASRS-5 = Adult ADHD Self-Report Rating Scale Fifth Edition; BAARS-IV = Barkley adult ADHD Rating Scale Fourth Edition; *k* = capacity; M = mean; RT = reaction time; SACT = sustained attention to cue task; *SD* = standard deviation; SBPS = Short Boredom Proneness Scale; WURS = Wender Utah Rating Scale.

childhood ADHD symptoms (see below for measure descriptions). This screening method was used to characterize our group of adults with ADHD traits because all three measures have good psychometric properties and are widely used measures for assessing ADHD symptomology in adults. Furthermore, we included both current (i.e., ASRS-5 and BAARS-IV) and retrospective (WURS) symptoms to identify only those individuals with elevated ADHD symptoms who also experienced these symptoms as children and to avoid selecting participants with more recent attention problems that might be unrelated to ADHD. In the ADHD trait group, 11 participants reported a prior diagnosis of ADHD, 12 participants reported a history of ADHD medication use, and 7 participants reported using ADHD medication currently, including 4 participants who used ADHD medication the morning of the research session. Fifty-seven participants were included in the control group based on (1) indicating four or fewer symptoms on the BAARS-IV inattention or hyperactive/impulsive subscales as occurring "often" or "very often;" (2) having a total score of 13 or less on the ASRS-5; (3) having a total ADHD score of 35 or less on the WURS; and (4) no self-report of ADHD diagnosis or past ADHD medication use. The grouping variable was dummy coded (1 = ADHD, 0 = Control) for all analyses. Of the original group of 115 who participated in the study, 14 participants failed to meet inclusion criteria because they did not reach threshold criteria on either of the ADHD measures but met WURS criteria or stated that they had been diagnosed with ADHD previously and 12 participants met ADHD criteria but did not meet the threshold criteria for the WURS. One participant in the control group became sick and left midway into the session. This participant was excluded from all analyses.

Measures

Self-Report Behavioral Measures

Short Boredom Proneness Scale. The Short Boredom Proneness Scale (SBPS; Struk et al., 2017) is an eight-item self-report measure that uses a 5-point Likert scale (0 = *never*, 4 = *very often*). The scale is designed to measure one's propensity to boredom (i.e., trait boredom) over the past six months. Example items on the scale include "I find it hard to entertain myself" and "In most situations, it is hard for me to find something to do or see to keep me interested." Higher scores reflect a higher propensity to boredom. The SBPS is a widely used shortened version of the original Boredom Proneness scale (BPS; Farmer & Sundberg, 1986) and has strong construct validity and internal consistency indices (Cronbach's alpha = .88; Struk et al., 2017).

Barkley Adult ADHD Rating Scale. The Barkley Adult ADHD Rating Scale (BAARS-IV; Barkley, 2011) is a 27-item self-report survey with a 4-point Likert scale (1 = *never or rarely*, 4 = *very often*) that measures ADHD symptoms in adults. Specifically, the BAARS-IV uses three subscales to measure overall ADHD symptoms as well as symptoms of inattention, hyperactivity/impulsivity, and sluggish cognitive tempo. While a total score can be computed by summing responses across the inattentive and hyperactive/impulsive subscale items, the current study used a count method as a criteria for group assignment as described above. Sample items from the measure include, "Difficulty sustaining my attention in tasks or fun activities," "Blurt out answers before questions have been completed, complete others' sentences, or jump the gun," and "Fidget with hands or feet or squirm in seat." The BAARS-IV is a widely used, psychometrically reliable and valid measure with excellent internal consistency (Cronbach's alpha = .914) and reliability between self- and other-reports (r = .67–.70; Barkley, 2011).

Adult ADHD Self-Report Screening Scale for DSM-5. The Adult ADHD Self-Report Screening Scale for DSM-5 (ASRS-5; Ustun et al., 2017) measures symptoms of ADHD in adults. Six items are rated on a 5-point Likert scale (0 = *never*, 4 = *very often*). The scale evaluates the frequency of reported ADHD symptoms over the last 6 months (e.g., "How often do you have difficulty concentrating on what people are saying to you even when they are speaking to you directly?"; "How often do you put things off until the last minute?"). Scores range between 0 and 24. Total scores ≥14 are suggestive of ADHD (91.4% sensitivity; 96.0% specificity; Ustun et al., 2017). Scores below 14 reflect normal functioning.

Wender Utah Rating Scale. The Wender Utah Rating Scale (WURS; Ward, 1993) is a 61-item self-report survey utilizing a 5-point Likert scale (0 = *not at all or very slightly*, 4 = *very much*) that assesses retrospective childhood ADHD symptoms via participant's recollection of the frequency and intensity of childhood ADHD symptoms and related experiences. Specifically, the WURS utilizes three sections that ask the participant to recall general behaviors from their childhood (e.g., "Concentration problems, easily distracted"; "Irritable"; and "Get in fights"), medical problems in childhood (e.g., "Headaches"; "Food allergies"; and "Bedwetting"), and childhood behaviors in a school setting (e.g., "Slow reader"; "Bad handwriting"; and "Did not achieve up to potential"). Twenty-five items are used to target childhood ADHD, and result in scores between 0 and 100. Scores ≥36 indicate childhood symptoms consistent with an adult diagnosis of ADHD (Ward, 1993). Good to excellent validity and reliability estimates have been reported for the WURS (Ward, 1993).

Demographic Questionnaire. A demographic questionnaire was administered to indicate the participant's age, gender, and history of current and past ADHD diagnosis and medication use.

Performance-based Cognitive Measures[2]

Attention Control. Attention control was measured using three tasks (described in more detail below) recently developed, validated, and distributed by Draheim et al. (2021). The attention control tasks selected for the study were shown to have higher reliabilities, stronger inter-correlations with other attention control measures, and higher loadings on a common factor than similar measures traditionally used in the literature. They were also selected because traditional attention control measures were shown to have poor psychometric properties at the individual difference level due to their reliance on computing difference scores (e.g., the difference in performance between congruent and incongruent trials on the Flanker task; see Draheim et al., 2021for an in-depth review). Therefore, we selected tasks that utilized accuracy, rather than difference, scores. The three attention control task that were selected were also found to fully mediate the relationship between working memory capacity and fluid intelligence, supporting the hypothesis that attention control is a domain general ability that underlies the relationship between working memory and fluid intelligence (Draheim et al., 2021).

Selective Visual Arrays. In the Selective Visual Arrays task participants were told to concentrate on either red or blue rectangles, indicated by a 300 ms flash of the word RED or BLUE. After a delay of 900 ms, an array of both red and blue rectangles was displayed for 250 ms, followed by the same display but with only the target rectangles (either red or blue). Among the target rectangles, a white dot appeared at the center of one of rectangles. On half of the trials, the rectangle with the white dot changes in orientation. The participant was asked to recall if the rectangle with the white dot is the same orientation from its original presentation by pressing the yes (i.e., "Y") or no (i.e., "N") buttons on a computer keyboard. Each array contains five or seven rectangles per color for a total of 10 to 14 rectangles, respectively. Forty trials per set size (set size 5 or set size 7) were presented for a total of 80 trials. A capacity score (k), reflecting the number of items the participant could retain in the array, was calculated for the dependent variable as recommended (see Draheim et al., 2021). This calculation is $N \times (\text{Hits} + \text{Correct Rejections} - 1)$, where N is the set-size for that array. Two separate k scores (one for set size 5 and one for set size 7) were calculated and averaged together to create a single score for the dependent variable for this task. Eight practice trials with feedback were administered to familiarize the participants with the task.

Flanker Deadline (DL). In this task, participants were told to indicate whether the target arrow (i.e., the middle arrow), surrounded by flanking arrows, was pointing either left or right. Flanking arrows either pointed in the same direction as the target arrow (i.e., congruent; < < < < <) or the opposite (i.e., incongruent; > > < > >). Participants used the computer keyboard to select either a right key or the left key to indicate which direction the target arrow was pointing. Three hundred twenty-four total trials were administered, consisting of 18 blocks of 18 trials. On each trial, a response deadline limited how long the participant had to respond before they heard a loud beep and were then unable to respond. The response deadline decreased (i.e., less time to respond) if the participant was accurate on at least 15 trials within each block or increased (i.e., more time to respond) if their accuracy was fewer than 15 correct trials within each block. There were 12 congruent and 6 incongruent trials in random order in each block with a randomized 400 to 700 ms ISI. The response deadline was the same for incongruent and congruent trials. Forty-four practice trials with feedback were administered to familiarize the participants with the task. The dependent variable was the response deadline after the final block of trials as recommended (Draheim et al., 2021).

Sustained Attention to Cue Task. The Sustained Attention to Cue Task (SACT) is a psychomotor vigilance task with a distractor component that assesses a participant's accuracy in detecting a target. In the task, a trial begins with a central fixation point (+) presented for 2 or 3 s that was distributed evenly throughout the task. Afterwards, a 300-ms tone sounded and a white circle appeared in a random location on the left or right side of the screen. The participant was instructed to focus their attention to the center of the circle. The center of the circle then shrunk in size resulting in the center of the circle becoming smaller and smaller. Once the center of the circle reached a set size, a wait time of 2, 4, 8, or 12 s (distributed evenly among trials) was presented. Following the wait time, a white asterisk (i.e., the distractor component) flashed at the center of the screen for 300 ms (i.e., 100 ms on, 100 ms off, and 100 ms back on). Then, a 3 × 3 array of letters was displayed at the center of the circle with the target letter in the center of the letter array. The target letter was presented in gray for 125 ms before being replaced by a "#," while the nontarget letters were presented in black and remained visible on the screen. After the "#" was displayed for 1,000 ms, a response screen appeared presenting the possible target letters (i.e., B, D, P, or R). Participants were instructed to use the mouse to select the correct target letter (i.e., the letter that appeared in the center of the circle). In this task, if the participants were distracted by the flashing asterisk, they would miss the target letter. Sixty-four total trials were administered. Six practice trials with feedback were administered to familiarize the participants with the task. Accuracy rate (i.e., number of correct trials out of 64) was used as the dependent variable as recommended (Draheim et al., 2021).

Working Memory. Working memory capacity was measured using three working memory complex span tasks (described in more below) developed, validated, and distributed by Foster et al. (2015). Complex span tasks require participants to alternate between a memory task (e.g., remembering letters) and a processing task (e.g., solving math problems). Participant's reaction time (+2.5 standard deviations) during only the practice trials of the processing task was recorded and was used as a time limit on the processing task during the real task. This was to ensure that participants were paying attention to the processing task and not rehearsing the information they were asked to remember. Furthermore, participants were asked to maintain at least 85% accuracy during the processing task. Their score on the processing task was presented in the upper-left hand corner of the screen during the entire task. For all three span tasks, participants first became familiar with memory task followed by the processing task separately, then three practice trials with feedback were administered to familiarize the participants with the real task.

Operation Span. In the Operation Span task, participants were asked to solve math problems (processing subtask) while also remembering a series of letters (memory subtask). Participants were first shown a math problem (e.g., $[4 \times 4] - 1 = 12$) and decided if the math problem with the solution was true or false. Then, they were shown a letter to remember. This was followed by another math problem and another letter to be remembered. At the end of each series of math problems and letters, the participant was asked to recall the letters in the order they were presented. Participants were presented with 15 trials divided into three blocks. Each trial varied in size from three to seven math problems and letters. The dependent variable for this task was a partial score, which was calculated by summing the number of letters correctly recalled in the correct order.

Rotation Span. In the Rotation Span task participants were asked to determine if a letter presented in the center of a screen was in the normal or mirror-reversed direction (processing subtask) while also remembering the order and position of arrows of varying size and direction (memory subtask). Participants were first shown a letter on the computer screen, which was rotated at an angle. The participant was instructed to mentally rotate the letter to its upright position and then decide if the letter was in a normal position or if the letter was in a mirror-reversed position. Once the participant made the decision about the letter orientation, they were shown an arrow. There were eight possible arrow directions (four ordinal and four cardinal directions) and two sizes for each direction (large or small). Then the participant was shown another letter and another arrow. At the completion of the letters and arrows, participants were asked to recall the arrows in the correct order they appeared on the screen. Participants were presented with 12 trials which were divided into three blocks. Each trial varied in size from two to five rotation problems and arrows. The dependent variable was the number of correctly recalled arrows in the correct order.

Symmetry Span. In the Symmetry Span task, participants were asked to determine if a shape displayed in an 8×8 black and white grid was symmetrical along its center vertical axis (processing subtask) while also remembering the locations of red squares in a 4×4 grid of potential locations (memory subtask). After remembering the location of the red square another symmetry item would appear, followed by another red square to remember. After a varying set size of symmetry images and squares to remember, participants were asked to recall the position of the red squares presented in the order they appeared on the screen. Participants were presented with 12 trials which were divided into three blocks. Each set varied in size from two to five symmetry problems and red square locations. The dependent variable was the total number of red square locations correctly recalled in the correct order.

Executive Function Dimension Reduction

No single executive function task can purely capture the construct it is purported to measure because the task will also be capturing motor and cognitive performance such as processing speed, motor response, and other aspects of task-specific attention. Therefore, to control for task impurity as recommended (Burgoyne & Engle, 2020; Draheim et al., 2021) we utilized a dimension reduction technique employed by others (see Kofler et al., 2017, 2019) that isolates reliable variance associated with each cognitive construct and removes random and task-specific error (Conway et al., 2005). Following these methods, Bartlett factor scores for attention control and working memory were created separately using a principal components factor analysis on two[3] attention control tasks and three working memory span tasks variables, respectively (attention control: 78.8% of the variance accounted for; component factor loadings = 0.89; working memory: 66.5% of the variance accounted for; component factor loadings = 0.78–0.84). The ratio of participants (88) to factors (2) was deemed acceptable (Hogarty et al., 2005) for the factor analyses. All continuous variable scores were converted to z scores prior to the factor analysis. In all but the Flanker task, higher scores reflect better performance; therefore, the z-score for the Flanker task was transformed to be consistent with this interpretation.

Procedure

All computerized tasks and self-report measures were completed in a single 2-hr session. Participants were seated in a small office alone in front of a desktop computer. The examiner, seated outside the participant's view, monitored the participant and their performance. After completing the informed consent form, the participant began the first computerized task. Computerized tasks were counterbalanced for each participant to minimize order effects. To minimize fatigue, participants completed paper and pencil self-report measures after the completion of two computerized tasks. The demographic questionnaires and adult ADHD self-report measures were given after completion of all computerized measures. After all tasks and measures were completed, participants were debriefed on the purpose of the study and were dismissed.

Statistical Analyses

Data were analyzed using SPSS Version 28. Before data analysis, outliers were windsorized if they were more than 3 standard deviations (*SD*) above/below the mean. This resulted in nine data points being replaced by the next highest value within 3 *SD*s (i.e., three Flanker, four SACT, one Visual Arrays, and one BAARS-IV). Computer errors occurred during administration of two tasks (i.e., Flanker and Rotation Span) for one participant and one task (Symmetry Span) for another participant. Therefore, these scores were removed from the data set. Independent measures t tests were first used to examine between group differences in proneness to boredom, attention control, and working memory. Next, relations among variables were examined using zero-order bivariate Pearson correlations. Then, exploratory mediation analyses were conducted using bias-corrected bootstrapping. Bias corrected bootstrapping was used to minimize Type II error (as recommended by Shrout & Bolger, 2002) and to establish the statistical significance of all total, direct, and indirect effects. The PROCESS script for SPSS (Hayes, 2017) was used for all analyses and 5,000 samples were derived from the original sample ($n = 88$) by a process of resampling with replacement (Hayes, 2017; Shrout & Bolger, 2002). Effect ratios (indirect effect divided by total effect) were calculated to estimate the proportion of each significant total effect that was attributable to the mediating pathway (indirect effect). Standardized beta values, standard errors, indirect

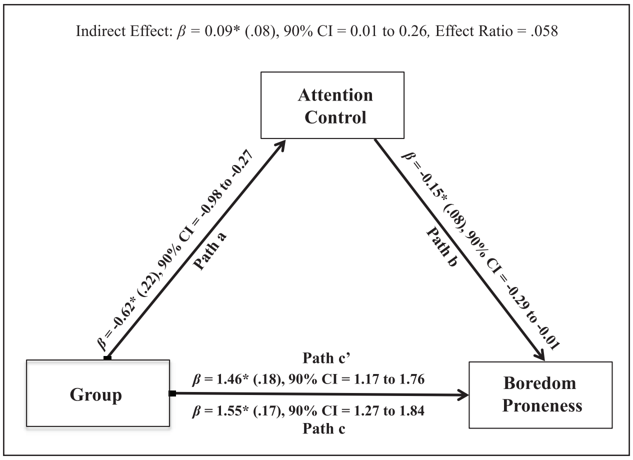

Figure 1. Attention control mediating the relationship between group and boredom proneness.
Note. Figure depicts β coefficients and standard errors of the total, direct, and indirect pathways for the mediating effect of attention control on the relationship between group and boredom proneness. β coefficients for the c and c′ pathways reflect the impact of Group (i.e., ADHD trait vs. Controls) on Boredom Proneness before (path c) and after (path c′) taking into account the mediating variable.
*β coefficient is significant based on 90% confidence intervals that do not include 0.0 (Shrout & Bolger, 2002).

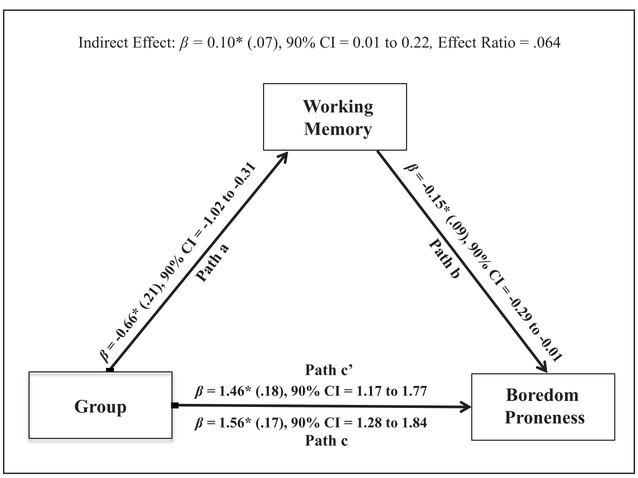

Figure 2. Working memory mediating the relationship between group and boredom proneness.
Note. Figure depicts β coefficients and standard errors of the total, direct, and indirect pathways for the mediating effect of working memory on the relationship between group and boredom proneness. β coefficients for the c and c′ pathways reflect the impact of Group (ADHD trait vs. control) on Boredom Proneness before (path c) and after (path c′) taking into account the mediating variable.
*β coefficient is significant based on 90% confidence intervals that do not include 0.0 (Shrout & Bolger, 2002).

effects, and effect ratios are shown in Figures 1 and 2. Ninety percent confidence intervals were selected over 95% confidence intervals because the former are more conservative for evaluating mediating effects (see Shrout & Bolger, 2002).

Results

Power Analysis

A sensitivity analysis using G*Power indicated that with our sample size of 88 an effect size of 0.63 and a correlation of ±.29 could be reliably detected with 0.80 power.

Between Group Differences

Individuals in the ADHD trait group reported significantly higher levels of boredom relative to individuals in the control group, $t(86) = -9.35$, $p < .001$, $d = 2.09$. The ADHD trait group also exhibited worse performance on attention control as measured by a latent variable, $t(85) = 2.90$, $p = .005$, $d = 0.65$. However, the three attention control measures yielded only one difference between the ADHD trait group and the control group. Specifically, the ADHD trait group performed worse than the control group on the SACT, $t(86) = 3.57$, $p < .001$, $d = 0.80$. Scores between the two groups were not significantly different on the Flanker ($t(85) = -1.46$, $p = .148$) or the Visual Arrays ($t(86) = 0.61$, $p = .547$) tasks. Individuals in the ADHD trait group also demonstrated worse working memory performance as measured by a latent variable, $t(84) = 3.09$, $p = .003$, $d = 0.70$ and on all three individual measures of working memory: Operation Span, $t(86) = 2.03$, $p = .046$, $d = 0.45$, Symmetry Span, $t(85) = 2.99$, $p = .004$, $d = 0.67$, and Rotation Span, $t(85) = 2.11$, $p = .038$, $d = 0.48$. Means and standard deviations for each group are presented in Table 1.

Zero-Order Bivariate Correlations

Boredom (SBPS) was positively correlated with ADHD scores on the ASRS-5 ($r = .717$) and the BAARS-IV ($r = .733$). The ASRS-5 and the BAARS-IV were highly correlated ($r = .801$). The ASRS-5 and BAARS-IV were also significantly correlated with performance on the Flanker and SACT, but not Visual Arrays, tasks. Specifically, performance on the Flanker task was positively correlated with the ASRS-5 ($r = .202$) and the BAARS-IV ($r = .226$), indicating that a slower RT deadline at the end of the task was associated with higher self-reported ADHD symptoms. Negative correlations were found between scores on the SACT and the self-report ratings on the ASRS-5 ($r = -.362$) and the BAARS-IV ($r = -.367$), indicating that worse performance on the SACT was associated with elevated ADHD symptoms. The ASRS-5 and BAARS-IV were also significantly correlated with the Rotation and Symmetry Span, but not Operation Span ($p > .158$), tasks. Specifically, Symmetry Span and Rotation Span were negatively correlated with the ASRS-5 ($r = -.187$ and $-.274$, respectively) and the BAARS-IV ($r = -.235$ and $-.230$, respectively), suggesting that worse performance on these tasks were related to

Table 2. Zero-Order Bivariate Correlations.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Group													
2. ASRS-5	.763**	—											
3. BAARS-IV	.819**	.801**	—										
4. WURS	.785**	.598**	.689**	—									
5. SBPS	.710**	.717**	.733**	.709**	—								
6. Flanker	.156	.202*	.226*	.170	.120	—							
7. SACT	−.360**	−.362**	−.367**	−.298**	−.267**	−.576**	—						
8. Visual Arrays	−.065	−.168	−.156	−.014	−.007	−.305**	.373**	—					
9. Operation Span	−.213*	−.063	−.133	−.163	−.163	−.142	.238*	.205*	—				
10. Symmetry Span	−.309*	−.187*	−.235*	−.287**	−.242**	−.039	.182	.041	.439**	—			
11. Rotation Span	−.223*	−.274**	−.230*	−.275**	−.198*	−.203*	.355**	.301**	.482**	.557**	—		
12. Attention Control Factor	−.300**	−.322**	−.335**	−.264*	−.219*	−.889**	.887**	.384**	.213*	.126	.314**	—	
13. Working Memory Factor	−.319**	−.224*	−.252**	−.304**	−.251**	−.155	.322**	.223*	.782**	.821**	.844**	.268**	—

Note. ASRS = adult ADHD Self-Report Rating Scale Fifth Edition; BAARS-IV = Barkley Adult ADHD Rating Scale Fourth Edition; SACT = sustained attention to cue task; SBPS = Short Boredom Proneness Scale; WURS = Wender Utah Rating Scale.
*$p < .05$. **$p < .01$.

elevated ADHD symptoms. Furthermore, both the ASRS-5 and BAARS-IV were negatively correlated with the Attention Control Factor (−.322 and −.335, respectively) and the Working Memory Factor (−.224 and −.252, respectively). Zero-order bivariate correlations for all variables are presented in Table 2.

Correlations between boredom and the performance-based cognitive measures were also examined. Self-report ratings on the SPBS were significantly negatively correlated with the SACT ($r = -.267$), Symmetry Span ($r = -.242$), and Rotation Span ($r = -.198$) suggesting the higher levels of boredom proneness was associated with worse performance on these tasks. Self-report ratings on the SPBS were also negatively correlated with Attention Control ($r = -.219$) and Working Memory ($r = -.251$) factors. Finally, SBPS scores were not correlated with the Flanker, Visual Arrays, or Operation Span tasks ($ps > .084$).

Exploratory Mediation Analyses

Group (i.e., ADHD trait vs. Control) predicted boredom proneness prior to considering the potential effects of attention control ($M_\beta = 1.55$, $SE = 0.17$, 90% CI [1.27, 1.84]; see Figure 1) and working memory ($M_\beta = 1.56$, $SE = 0.17$, 90% CI [1.28, 1.84]; see Figure 2). With regards to the attention control factor as a mediator of ADHD related proneness to boredom (see Figure 1), ADHD trait group status predicted attention control performance ($M_\beta = -0.62$, $SE = 0.22$, 90% CI [−0.98, −0.27]). In addition, attention control predicted proneness to boredom controlling for ADHD trait group status ($M_\beta = -0.15$, $SE = 0.08$, 90% CI [−0.29, −0.01]). The indirect effect was significant for the attention control factor ($M_\beta = 0.09$, $SE = 0.08$, 90% CI [0.01, 0.26]). The relation between ADHD trait group status and proneness to boredom remained significant after parsing out the effects of the attention control factor ($M_\beta = 1.46$, $SE = 0.18$, 90% CI [1.17, 1.76]), suggesting that attention control served as a partial mediator in ADHD-related proneness to boredom. The effect ratio indicated that 5.8% of ADHD-related proneness to boredom can be explained by weaknesses in attention control. With regards to the working memory factor as a mediator of ADHD related proneness to boredom (see Figure 2), ADHD trait group status predicted working memory performance ($M_\beta = -0.66$, $SE = 0.21$, 90% CI [−1.02, −0.31]). In addition, working memory predicted proneness to boredom controlling for ADHD trait group status ($M_\beta = -0.15$, $SE = 0.09$, 90% CI [−0.29, −0.01]). The indirect effect was significant for the working memory factor ($M_\beta = 0.10$, $SE = 0.07$, 90% CI [0.01, 0.22]). The relation between ADHD trait group status and proneness to boredom remained significant after parsing out the effects of the working memory factor ($M_\beta = 1.46$, $SE = 0.18$, 90% CI [1.17, 1.77]), suggesting that working memory served as a partial mediator in ADHD-related proneness to boredom. The effect ratio indicated that 6.4% of ADHD-related proneness to boredom can be explained by weaknesses in working memory performance.

Discussion

The current study found that adults with ADHD traits reported significantly higher boredom proneness than adults without ADHD traits, with a large effect size ($d = 2.09$). To examine the potential mechanisms of this observed difference, exploratory mediation analyses revealed that both attention control and working memory served as significant partial mediators in this relationship, accounting for 5.8% and 6.4% of the variance in ADHD-related boredom, respectively. This study is the first to examine whether performance-based measures of executive attention help explain the link between ADHD traits and boredom in young adults. These findings support the *Cognitive Theory of Boredom*, which posits that the experience of boredom manifests because of the inability to sustain or engage attention on a task at hand (Eastwood et al., 2012; Fisher, 1993; Hamilton et al., 1984). Therefore, part of the reason why individuals with ADHD often experience boredom, is due to difficulty controlling their attention and using their working memory effectively, leading to interpretations of that situation as boring. Our findings are consistent with prior studies that have examined correlational relationships between ADHD, performance-based measures of attention, and boredom. For example, one study reported that elevated state boredom was significantly associated with increased errors on a continuous performance test in children diagnosed with ADHD, but not healthy controls (Hsu et al., 2020). Another investigation found that increased reaction time variability and decreased response speed on the Tests of Variable Attention (TOVA) task were associated with elevated ratings of boredom in children diagnosed with ADHD (Golubchik et al., 2021). The cognitive tasks used in these prior studies are quite different than the tasks used in the current study. Most notably, prior studies have not examined other aspects of attention control, such as interference control and conflict management. Furthermore, no study to date has investigated working memory in ADHD-related boredom.

Neurological evidence suggests that the default mode network (DMN), a set of interconnected brain regions including the posterior cingulate cortex/precuneus and ventromedial prefrontal cortex (Buckner et al., 2008), is associated with feelings of boredom, related to errors during tasks of sustained attention (Christoff et al., 2009; Danckert & Merrifield, 2018) and implicated in the neuropathology of ADHD (Uddin et al., 2008). During an attention demanding task, the DMN is usually deactivated, and areas associated with executive control in the prefrontal cortex are active (Greicius et al., 2003; Raichle et al., 2001). When a person is resting or bored, the DMN exhibits increased activity, while pre-frontal networks decrease in activity (Danckert & Merrifield, 2018). Liddle et al. (2011) found that children with ADHD exhibit attenuated deactivation in the DMN compared to controls under low incentive conditions—conditions which are probably boring. Boredom may arise in ADHD populations as a result of difficulties engaging executive control networks (Calub et al., 2022; Dickstein et al., 2006; Salmi et al., 2018) and modulating activity of the DMN (Liddle et al., 2011; Uddin et al., 2008) during activities that require sustained attention and concentration. This may ultimately lead to the DMN remaining active during attention demanding tasks, resulting in performance decrements and feelings of boredom. However, these hypotheses were not tested in the current study and other brain regions may be associated with boredom propensity in ADHD populations.

Our findings are consistent with the extant literature that individuals with elevated ADHD symptoms self-report significantly higher level of boredom proneness relative their peers without ADHD symptoms. In the current study, strong correlations were found between boredom propensity and two different self-reported adult ADHD measures (rs = .71–.73). Furthermore, results revealed large magnitude effect size differences between adults with ADHD traits and controls for self-report ratings of boredom proneness (d = 2.09). Indeed, prior studies reveal moderate to strong relationships between ADHD total symptom scores and boredom proneness (r = .40–.65; Malkovsky et al., 2012) in non-clinical samples and medium to large (d = 0.48–1.01; Castens & Overby, 2009; Hsu et al., 2020) effect size differences in boredom proneness in individuals with diagnosed ADHD relative to controls. The larger group differences observed in the current study may be due to methodological differences between studies or the specific characteristics of our sample, which included young adult college students. Prior studies with children generally reported smaller, but significant, correlations between ADHD and boredom (d = 0.41 and r = .40; Golubchik et al., 2020; Hsu et al., 2020), whereas studies with adults have reported somewhat stronger associations (rs = .48–.65; Castens & Overby, 2009; Kass et al., 2003; Malkovsky et al., 2012) and effect size differences (d = 0.48; Castens & Overby, 2009). These differences may partially reflect developmental shifts or informant-related factors. For example, one study had parents complete the ADHD symptoms scale while children self-reported boredom propensity (Golubchik et al., 2020), potentially introducing discrepancies based on informant perception. In contrast, large magnitude effect sizes have been reported in studies using a single informant (Hsu et al., 2020). Furthermore, SBPS mean scores for the ADHD trait group (M = 18.8) were similar to scores reported by only one other study of boredom in ADHD with a child sample using the SBPS (M = 19.7; Golubchik et al., 2020). However, our control group reported somewhat higher levels of boredom propensity (M = 8.2) compared to groups of healthy adults in other studies (i.e., M = 2.72–2.88; Boylan et al., 2021; Yang et al., 2020). We believe differences in sample composition between studies might account for this discrepancy. However, it is also important to acknowledge that these observed patterns are consistent with the study's statistical power limitations, as our study was powered to detect medium-to-large effects. A post hoc sensitivity analyses using G*Power indicated that the current sample size (n = 88) was sufficient to detect correlations of approximately r = .29 and effect sizes of d = 0.63 or larger, assuming α = .05 with 0.80 power and a two-tailed test. This means that smaller, yet potentially meaningful, associations and effect sizes may have gone undetected. Therefore, the apparent differences in correlations and effect sizes could reflect not only methodological or sample-composition differences, but also the influence of power constraints on what effects are statistically observable in this study.

Attention control and working memory, as measured by latent variables, were negatively correlated with proneness to boredom, suggesting that individuals who have difficulty using executive attention also report experiencing higher levels of boredom. Attention control reflects one's ability to regulate attention in service of goal directed behavior (Burgoyne & Engle, 2020). This includes sustaining attention toward an important task while also minimizing distractions, either externally from our environment or internally from our thoughts. Indeed, individuals who experience difficulty sustaining their attention during a task, but are unaware of the source of distraction, often describe that task as boring (Damrad-Frye & Laird, 1989). Several studies have found that individuals who are more prone to boredom, perform worse on tasks that require sustained attention and vigilance (Hunter & Eastwood, 2018; Kass et al., 2001) and are less likely to modulate their performance when they make an error during an inhibitory control task (Malkovsky et al., 2012). This is the first study, however, to examine the association between working memory ability and boredom. Our findings revealed that individuals with worse working memory performance also self-reported more boredom. As reviewed earlier, working memory consists of a domain general attention controller, named the *central executive*, and two modality specific short term storage components (Baddeley, 2007). We believe that the central executive competent of working memory, reflecting a type of executive attention similar to attention control, is likely the factor that is associated with boredom. However, we did not specifically test the separate influence of working memory components in their relation to boredom.

Among the attention control tasks, worse performance on the SACT was related to increased proneness to boredom, suggesting it may capture aspects of attention control that are particularly relevant to boredom. In prior studies, the SACT has demonstrated higher intercorrelations with other attention control measures compared to the Flanker and Visual Arrays tasks (Draheim et al., 2021), indicating that it may be a more robust measure of attention control. In contrast, the Flanker and Visual Arrays tasks involve task-specific demands such as strategy implementation, reaction time, and motor coordination, which may be less directly linked to the experience of boredom. Furthermore, the SACT involves sustained attention over a longer period than the Flanker and Visual Arrays tasks (25 min compared to 13 and 11 min, respectively) and includes unpredictable, infrequent target presentations (ranging from 2 to 12 s; Draheim et al., 2021). This may suggest that boredom is related to attention control under conditions of sustained performance greater than 20 min and when the time to identify a target is infrequent, unpredictable, and long. This is often the case for individuals who work in occupations susceptible to boredom such as security guards, radar controllers, and medical monitors. However, these hypotheses have not been specifically tested. It is also possible that the non-significant correlations reflect limited statistical power rather than the true absence of an effect. As stated earlier, a post hoc sensitivity analyses indicated that the current sample size was sufficient to detect correlations of approximately $r = .29$ or larger. Therefore, smaller associations, such as the associations between boredom and the Flanker and Visual Arrays tasks, may have gone undetected. Future studies with larger samples may be better positioned to detect significant correlations between these variables.

With regards to the individual working memory tasks, both Symmetry Span and Rotation Span showed associations with boredom proneness; however, the relation between boredom proneness and Operation Span was not significant. One possible explanation for this pattern may lie in task-specific variance. Operation Span is a verbal working memory task, whereas the Rotation Span and Symmetry Span tasks tap visuospatial working memory. Although direct comparisons between verbal and visuospatial working memory in relation to boredom are lacking, prior research suggests that individuals with ADHD tend to show greater deficits in visuospatial than verbal working memory (Rapport et al., 2008). Alternatively, as noted earlier, the current study may have lacked sufficient power to detect smaller correlations which could explain the non-significant findings for the Operation Span task. Future studies could examine the extent to which boredom is related to different working memory modalities using a larger sample of participants. Finally, from an anecdotal perspective, the participants noted that the Operations Span task was challenging yet rewarding. Perhaps, the Operation Span task provided enough of a challenge that performance on this task was not impacted by boredom proneness. Indeed, studies have shown that participants engaged in a challenging arithmetic task demonstrated reduced activity in the DMN (Ulrich et al., 2014), the area that is typically active during states of boredom (Danckert & Merrifield, 2018).

At the group level, individuals assigned to the ADHD trait group exhibited worse attention control and working memory performance compared to participants assigned to the control group. This is consistent with prior studies of adults with ADHD who perform worse on measures of attention control (Antshel et al., 2010; Boonstra et al., 2005) and working memory (Alderson et al., 2013) compared to adults without ADHD. In addition, individuals in the ADHD trait group exhibited decreased performance in most, but not all, executive function tasks compared to their peers without ADHD traits. Specifically, there were no significant between group differences in performance on the Flanker and Visual Arrays tasks. As stated earlier, power limitations in the current study may have prevented the detection of these smaller effects. Further inspection of the group means reveals that adults with ADHD traits exhibited slightly longer, but non-significant, reaction times and more variable performance on the Flanker task. Variability in performance is often found in ADHD populations (Kofler et al., 2013), and may account for the non-significant between group differences in this task. It is also possible that non-significant group differences on the Visual Arrays task may reflect a floor effect of performance, as both the ADHD trait and control groups could only retain about one item in the array. This task may have been too difficult for our participants; therefore, group differences did not emerge. This may also explain why the Visual Arrays task had lower component factor loadings on the Attention Control factor relative to the other two attention control measures.

While this was the first study to provide insight into the potential mechanisms of ADHD-related boredom, there were some limitations worth noting. First, our modest sample size can only reliably detect moderate-large effect sizes and correlations. Therefore, our study cannot conclude whether the non-significant findings reflect a true absence of an effect or simply an effect too small to be detected given the study's power. Although exploratory, the results of the mediation analyses should be interpreted with caution due to the relatively small sample and limitations in power to detect small effects. Effects observed in small samples can be unstable and are more susceptible to over- or underestimation due to sampling variability (Funder & Ozer, 2019; Gelman & Carlin, 2014). Replication with a well-powered sample is therefore necessary to determine if the observed patterns represent robust effects or statistical artifacts. In addition, for the self-report measures in our study, the results could be impacted by rater-bias (e.g., social desirability bias). The strong correlations found between ADHD and boredom could also reflect a mono-rater/mono-method bias where single measures tend to correlate strongly with one another when they are completed by the same informant at the same time point. Future studies could examine boredom using objective means, such as whether experimentally inducing boredom exacerbates cognitive and affective symptoms in ADHD populations. Furthermore, the sample was rather homogenous, comprised of mostly young adult women recruited from a southeastern university in the United States. Therefore, the results may not generalize to all individuals with ADHD across more diverse populations. Moreover, while the current study used psychometrically validated diagnostic measures with empirically derived thresholds to categorize ADHD participants with consideration of symptom severity, symptom count, and evidence of childhood symptoms, it did not assess cross-setting impairment—a criteria for DSM-5 ADHD diagnoses, or rule out the possibility of other clinical syndromes, such as depressive or anxiety disorders. In addition, the use of an "OR" method to identify threshold levels of ADHD symptoms using two different self-report measures might have increased the likelihood of false positives in the ADHD trait group. Therefore, the study may not generalize to young adults diagnosed with ADHD using gold standard methods, such as clinical interviews and multi-informant ratings of ADHD. We also recognize that the underlying mechanisms of ADHD-related boredom may not be the same for every person. Future studies could examine the extent to which other measures of cognitive control (e.g., cognitive flexibility) as well as affective states (e.g., depression, apathy) may contribute to the relationship between boredom and ADHD. Lastly, the study's cross-sectional design cannot infer potential cause-and-effect relationships between ADHD symptoms, executive attention, and boredom.

Despite these limitations, our findings make important contributions to the understanding of boredom in individuals with ADHD traits. These findings will ultimately help to inform intervention strategies for young adults with ADHD and others who are more prone to boredom, particularly boredom related to academic settings. For example, emotion recognition techniques could be used to identify feelings of boredom as a signal for attention difficulties and then employ methods to re-engage in the task at hand, such as scheduling short breaks or studying with a partner. Another method to counteract boredom and boost performance during attention demanding tasks is to reduce the attention load, such as breaking challenging assignments into smaller, more manageable chunks, using multiple study sessions in shorter intervals (e.g., 30 min), and introducing incentives for completing assigned tasks. Furthermore, studies have shown that boredom is often associated with mundane, meaningless experiences or activities (Danckert & Merrifield, 2018; Mercer-Lynn et al., 2014). Therefore, the extent to which a person can modify tasks to become more personally meaningful or add an element of challenge to their activity, may help to alleviate boredom and attention difficulties in individuals with ADHD. Lastly, future studies could explore alternative questions, such as whether elevated ADHD symptoms help to explain why boredom-prone individuals perform poorly on measures of executive attention, and alternatively, that boredom propensity might, in part, explain executive attention impairments in children and adults with ADHD. In addition, well-powered studies could explore more complex mediation designs (e.g., parallel mediation) to determine if working memory, attention control, or their collective effects mediate the relation between ADHD and boredom. Testing these models through robust statistical techniques, such as structural equation modeling, would provide valuable insights into other causal relationships between these constructs.

Declaration of Conflicting Interests

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Notes

1. An "OR" method was used to increase the sensitivity in identifying individuals with elevated ADHD symptoms who also reported having experienced ADHD symptoms as children.
2. All performance-based cognitive measures were created, validated, and distributed by Draheim et al. (2021) and Foster et al. (2015) available at englelab.gatech.edu. Additional details for these measures, including visual depictions and psychometric properties, can be found in these publications.
3. A factor analysis was conducted initially with all three attention control tasks, but the Visual Arrays task had a lower component factor loading (0.67) compared to the SACT (0.85) and Flanker Tasks (0.82). Therefore, we eliminated the Visual Arrays task from the Attention Control Factor.

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