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Examining the Effects of Frustration on Working Memory Capacity in an Emerging Adult Sample

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I am submitting herewith a thesis written by Jonathan Parks Fillauer entitled "Examining the Effects of Frustration on Working Memory Capacity in an Emerging Adult Sample." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Psychology.

Jennifer Bolden, Major Professor

We have read this thesis and recommend its acceptance:

Todd Moore, Erin Hardin

Accepted for the Council:

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

**Examining the Effects of Frustration on Working Memory Capacity in an Emerging Adult
Sample**

A Thesis Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Jonathan Parks Fillauer

August 2017

Abstract

Attention-Deficit/Hyperactivity Disorder (ADHD) is associated with numerous pejorative outcomes in adults such as low frustration tolerance and deficits in central executive functioning. The present study aims to examine (1) the effect of induced frustration on working memory capacity (WMC) and (2) the unique contribution of ADHD symptoms and other commonly comorbid disorders (i.e., anxiety/depression and alcohol use) to frustration. Participants (N=66) were randomly assigned to either the control group (n=32) or the experimental group (n=34). The Frustration Induction Procedure (FIP) was administered to participants in the experimental group and a neutral, non-frustrating task was administered to a control group. A factor-analytic framework was utilized to assess WMC based on performance on three computerized tasks. WMC and baseline frustration levels were assessed both prior to and after inducing frustration. Participants provided four subjective ratings of frustration and blood pressure was assessed at four time points to assess changes in baseline frustration ratings and blood pressure. Results suggest that we were able to systematically induce subjective frustration for participants in the experimental group relative to the control group. WMC, however, was not associated with induced frustration in the present study, highlighting a need to examine the extent to which additional working memory-related performance variables (i.e., reaction time, latency to first response) are related to frustration. Finally, results indicate that ADHD symptoms, rather than anxiety/depression symptoms and hazardous drinking behavior, predict baseline frustration levels.

Keywords: ADHD, frustration, working memory, central executive functioning

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Chapter One: Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a prominent neurodevelopmental disorder that affects approximately 3-7% of school-age children (American Psychiatric Association, 2013) and 4.4% of adults in the United States (Kessler et al., 2006). Hallmark ADHD symptoms include persistent and developmentally inappropriate inattention and/or hyperactivity/impulsivity levels displayed prior to age 12 (American Psychiatric Association, 2013). The disorder is associated with low frustration tolerance (Bitsakou, Antrop, Wiersema, & Sonuga-Barke, 2006; Scime & Norvilitis, 2006), diminished overall adaptive functioning (Shawzirt & Chaplin, 2005), academic impairments (Billingslea & Bloom, 1950; Heiligenstein, Guenther, Levy, Savino, & Fulwiler, 1999), problematic driving behavior (Groom, Van Loon, Daley, Chapman, & Hollis, 2015), interpersonal difficulties, and significant cognitive impairments. Working memory deficits, for example, are noted in both pediatric (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005) and adult ADHD samples (Alderson et al., 2013; Mark Rapport et al., 2008; Cutt et al., 2005). Understanding the continued manifestation of the associated features of ADHD into adulthood, specifically working memory impairments, is particularly important as 90% of adults diagnosed with ADHD during childhood continue to experience ADHD symptoms and/or ADHD-related impairments despite a 60% symptomatic ADHD remission rate by the age of 20 (Biederman, Mick, & Faraone, 2000).

ADHD and Working Memory Impairments

Working memory is a limited-capacity system that is responsible for storing and processing verbal and visuospatial information. Although there are multiple models of working memory (cf. Baddeley, 2003), Alan Baddeley's Multi-component Working Memory Model has been used extensively to understand ADHD-related working memory functioning in pediatric (R

Barkley, 1997; Martinussen et al., 2005) and adult (Alderson et al., 2013) samples (Baddeley, 2012). Components in Baddeley's working memory model include the central executive (CE) and two modality-specific subsystems for storing and processing phonological and visuospatial information (Baddeley, 2012). The domain-general CE (i.e., the attention controller) interacts with the two subsidiary systems (i.e., the phonological short-term store and visuospatial sketchpad) and is responsible for focusing attention, dividing attention between two or more tasks, and interacting with long-term memory stores (Baddeley, 2003, 2012). The CE is associated with everyday problem solving abilities and abstract reasoning. Impaired CE functioning is also linked to problems with listening, understanding directions, and inhibiting impulsive behavior (Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Gropper & Tannock, 2009).

ADHD-related CE deficits are consistent with dysfunctional attention networks, namely the anterior cingulate, orbital frontal, and dorsolateral prefrontal cortices as well as both the basal ganglion and thalamic regions (Ehlis, Bähne, Jacob, Herrmann, & Fallgatter, 2008; Emond, Joyal, & Poissant, 2009; Sergeant, Geurts, Huijbregts, Scheres, & Oosterlaan, 2003). Further, studies document medium to large between-group effect sizes for verbal storage/rehearsal ($d = .43-.71$), visuospatial storage/rehearsal ($d = .55-1.06$), and the domain-general central executive ($d = 2.84$; Alderson, Rapport, Hudec, Sarver, & Kofler, 2010; Martinussen et al., 2005; Mark Rapport et al., 2008; Cutt et al., 2005) in pediatric and adult ADHD samples.

Researchers have started to evaluate the contribution of motivation and sensitivity to both reward and punishment to ADHD-related working memory deficits (Shiels et al., 2008). Findings document a direct relationship between motivational factors and working memory performance. For example, incentives administered during a working memory task are associated

with a 50% increase in working memory performance variables (Shiels et al., 2008). This finding highlights the relationship between motivation and ADHD-related working memory impairments and is consistent with work examining the role of motivation and sensitivity to reinforcement and punishment in ADHD (Douglas & Parry, 1994; Haenlein & Caul, 1987; Quay, 1988). Shiels and colleagues, however, attempted to “control for frustration effects”, by not removing the participants from “enjoyable activities” before starting the working memory assessment. Moreover, they posited that rewards or goal attainment may be necessary to avoid frustration and regulate working memory processes (Shiels et al., 2008).

The present study attempts to expand our understanding of frustration and working memory by examining the unique contribution of frustration (i.e., the reactive cognitive and/or emotional state precipitated by an unforeseen circumstance or event interfering or thwarting a desired or planned goal) to working memory performance. Clinically, this work may inform current etiological models of ADHD, particularly models emphasizing the timing of reinforcement and cognitive performance (Sagvolden, Johanssen, Aase, & Russell, 2005; Sonuga-Barke, 2003). For example, the Dual Pathway Model of ADHD proposed by Sonuga-Barke (2003) posits that delayed and inconsistent rewards result in decreased performance. Frustration and ADHD symptoms are associated with a steepened delay-of-reinforcement gradient or heightened aversion to delay (Amsel & Roussel, 1952; Bitsakou et al., 2006; Bitsakou, Psychogiou, Thompson, & Sonuga-Barke, 2009; M. Rapport, Tucker, DuPaul, Merlo, & Stoner, 1986). Additionally, Walter Mischel demonstrated that children with ADHD become frustrated quickly and have low delay intolerance when placed in in his delay of gratification paradigm (i.e., children are asked to decide if they want an immediate smaller reward or a larger reward after waiting for an unidentified amount of time; Douglas & Parry, 1994; Mischel,

Ebbesen, & Zeiss, 1972; M. Rapport et al., 1986). Accordingly, cognitive deficits observed in children with ADHD are expected to ameliorate when powerful, frequent, and relatively immediate reinforcers are utilized (Sagvolden et al., 2005). Individuals with ADHD may be particularly sensitive to the removal of rewards, resulting in a performance decrement, possibly due to frustration (Douglas & Parry, 1994).

Historical Review/Account of Frustration

Low frustration tolerance is associated with multiple pejorative outcomes including interpersonal interaction deficits (e.g. hostility and complaining; Berkowitz, 1989), increased driving impairments (e.g. a 80% increase running of stop signs and collisions; Oliver, Nigg, Cassavaugh, & Backs, 2012), decreased workplace productivity (Maier, 1973; Spector, 1978), as well as headache pain, stress intolerance, and decreased coping skills (J. Beck, 2013; Massey, Garnefski, Gebhardt, & van der Leeden, 2009). Further, both impaired academic functioning and cognitive deficits are associated with low frustration tolerance (Abram Amsel, 1992; Barker, 1938; Scime & Norvilitis, 2006). Students with ADHD and low frustration tolerance, for example, perform poorly in educational situations above and beyond what is accounted for by ADHD symptoms alone. Children with ADHD and low frustration tolerance tended to score less accurately on arithmetic problems as well as word puzzles, and stop persisting on academic tasks (Hoza, Pelham, Waschbusch, Kipp, & Owens, 2001; Scime & Norvilitis, 2006). Moreover, after experiencing an academic set back (e.g. failing a test), students with low frustration tolerance exhibit decreased academic success (operationalized as decreased class discussion, note taking, and desire for success) for a period of 48 hours post-frustration (Billingslea & Bloom, 1950).

Limited research regarding frustration and cognitive performance in an adult sample may be due to a number of methodological issues. While multiple methods of inducing frustration

have been created, it has been difficult to design a reliable procedure for evoking frustration in adults. Some research teams have attempted to target delay intolerance to evoke a frustration response (Bitsakou et al., 2006; M. Rapport et al., 1986). For example, while delay intolerance tasks are largely effective with children (i.e., asking participants to wait before providing a response), research suggests that delay intolerance may decrease with age (Green, Fry, & Myerson, 1994). Other research teams have attempted to induce frustration by asking participants to complete a fifteen-piece puzzle while blindfolded (Scime & Norvilitis, 2006). This method is inherently unreliable and difficult to measure.

Recently, researchers have attempted to induce frustration with a frustrating driving simulation where participants are placed in virtual environments where they must interact with poor drivers and hazardous road conditions (Oliver et al., 2012). To date, card sorting tasks are the most reliable tasks for inducing frustration in adults (Henna, Zilberman, Gentil, & Gorenstein, 2008; Lindzey & Riecken, 1951). Early card sorting tasks were disguised as a test of cooperation. In general, vague task instructions were provided quickly and frustration was associated with group-related pressure/stress to sort the cards correctly (Lindzey & Riecken, 1951). More recently, researchers have created the Frustration Induction Procedure (FIP), a promising frustration-provoking task with both moderate reliability and validity in inducing frustration in adults (Henna et al., 2008). The FIP is based on the Wisconsin Card Sorting Task, a clinical assessment used for assessing perseveration and cognitive flexibility. During the FIP, participants are told they “win” if they correctly sort ten cards in a row. While the first nine attempts are always indicated as correct the tenth attempt is always indicated as incorrect; which prevents achievement of the goal and therefore induces frustration.

Study Aims

The present study examines the relationship between frustration and working memory capacity (WMC) in a college student sample. This work may bridge existing research on both frustration and cognitive processes as well as inform current theoretical models of ADHD. Participants were randomly assigned to either the control group or experimental group. We attempted to induce frustration for individuals assigned to the experimental group by administering a modified version of the FIP. Participants in the control group were administered a similar task that was neutral and non-frustrating. Based on previous research linking frustration and working memory performance (Barker, 1938; Maier, 1966; Shiels et al., 2008), we expected to find a significant decrease in WMC for the experimental group relative to the control group after controlling for any between-group differences in baseline frustration levels (i.e., individual differences in frustration prior to the FIP). We then examined the unique contribution of ADHD symptoms to reported frustration. ADHD symptom severity was expected to predict baseline frustration levels.

Finally, due to previous research suggesting a relationship among WMC and clinical symptoms such as anxiety, depression, and substance use/abuse in emerging adults (cf., Channon, 1996; Eysenck, MacLeod, & Mathews, 1987; Giancola & Moss, 1998; McNaughton, 1997; Micco et al., 2009; Murrough, Iacoviello, Neumeister, Charney, & Iosifescu, 2011), we examined the unique contribution of depression severity, anxiety severity, and hazardous alcohol use to baseline frustration. These clinical symptoms are also frequently comorbid with ADHD (Kessler et al., 2006; Piñeiro-Dieguez, Balanzá-Martínez, García-García, & Soler-López, 2014; Spencer, Biederman, & Wilens, 1999) and may help further explain the relationship between

ADHD, WMC, and Frustration. Because these analyses are explorative in nature, no hypotheses are provided.

Chapter Two: Method

Participants

Eighty-one participants (at least 18 years of age) were recruited by or referred to the Behavior and Learning Lab at the University of Tennessee (BALL@UT) through the university's SONA Research Participant Recruitment System. Students recruited through the SONA system received 2.5 research participation credits for their course grade corresponding to the 2.5-hour lab-based research appointment. Individuals with gross neurological, sensory or serious motor impairment, an IQ score of less than 85 on the WASI-II, or a history of seizure disorder or psychosis were excluded due to the task demands of the study. Individuals were excluded if they are prescribed/using psychotropic medication or using medications that might affect blood pressure/pulse measurement (e.g., benzodiazepines, beta blockers). Individuals who report suicidal ideations on the BDI-II excluded. Individuals with a systolic blood pressure (BP) of greater than 140 and a diastolic blood pressure of 95 or higher were excluded as BP at these levels or above is considered hypertensive by the American Heart Association (McLaughlin,2009). After removal of excluded participants and one outlier, a total of 66 participants were analyzed (see Figure 2).

Measures

Participants completed a demographic questionnaire to assess basic demographic information including age, handedness, gender, sex, ethnic category, educational history, health (physical and psychological) history, family history, and social history.

Measured Intelligence

Wechsler Abbreviated Scale of Intelligence (WASI-II). The WASI-II is an abbreviated intelligence battery consisting of subtests similar to those on the Wechsler Adult and Child

Intelligence Scales. The 2-subtest format (vocabulary and matrix reasoning) has an excellent internal consistency ($\alpha = .94$) and is correlated with the Wechsler Adult Intelligence Scale, 4th edition (McCrimmon & Smith, 2013). Higher Full Scale IQ-2 scores reflect greater intellectual capacity/functioning.

Working Memory Capacity

The following three computer-based tasks were used to assess working memory capacity:

Operation Span Task (Ospan). Ospan is a measure of working memory for numerical stimuli. Participants were shown a set of mathematical operations (e.g., $4+4=2$) and asked to judge whether each equation is true or false (note: about half of the problems were true). A letter was presented after each equation was shown on the computer screen. After the presentation of all operations within a set, participants were asked to recall the letters in order (Oswald, McAbee, Redick, & Hambrick, 2015). A longer version of this task has demonstrated good internal consistency ($\alpha = .80$; Engle, Tuholski, Laughlin, & Conway, 1999; Kane et al., 2004) and test-retest reliability ($r = .77-.83$; Redick et al., 2012). The version used in the current study also has demonstrated good internal consistency ($\alpha = .86$) and maintained high discrimination ability without significant decrement to model fit (Oswald et al., 2015). Participants completed three blocks of 3-7 sets. Variables generated by this task include working memory span in a numerical domain, time errors, and accuracy errors. The present study utilized the working memory span variable.

Reading Span (Rspan). Rspan is a measure of working memory for verbal stimuli. Participants were presented a set of sentences between 10-15 words long (e.g., “We were fifty lawns out at sea before we lost sight of land”) and were asked to judge whether the sentence is semantically sensible (note: about half were sensible). Following each sentence, participants

viewed a single letter, which they were asked to remember. After the presentation of all sentences within a set, participants were asked to recall the letters in order (Kane et al., 2004; Oswald et al., 2015). A longer version of this task has demonstrated good internal consistency ($\alpha = .78$; Engle et al., 1999; Kane et al., 2004) and test-retest reliability ($r = .76-.82$; Redick et al., 2012). The version used in the current study also has demonstrated good internal consistency ($\alpha = .89$) and maintained high discrimination ability without significant decrement to model fit (Oswald et al., 2015). Participants completed three blocks of 3-7 sets. Variables generated by this task include working memory span in a verbal domain, time errors, and accuracy errors. The working memory span variable was used in the present study.

Symmetry Span (Symspan). Symspan is a measure of working memory for spatial stimuli. Participants were presented with a set of 8x8 matrices of black and white squares and asked to judge whether the matrices are symmetrical down the vertical axis (note: about half were symmetrical). After each matrix participants were shown a red square positioned in a 4x4 matrix for recall at the end of the set (Oswald et al., 2015). A longer version of this task has demonstrated good internal consistency ($\alpha = .86$; Engle et al., 1999; Kane et al., 2004) and test-retest reliability ($r = .62-.77$; Redick et al., 2012). The version used in the current study also has demonstrated good internal consistency ($\alpha = .80$) and maintained high discrimination ability without significant decrement to model fit (Oswald et al., 2015). Participants completed three blocks of 2-5 sets of this task. Variables generated by this task include working memory span in a visuospatial domain, time errors, and accuracy errors. The present study utilized the working memory span variable.

Working Memory Capacity Composite (WMC). A principle components factor analysis using an oblique promax rotation was utilized to assess the shared variance among the three

Working Memory Capacity (WMC) tasks. This procedure was recommended by Conway and colleagues (2005). Results indicated that the Operation Span Task accounted for more than half of the variance in WMC (time administration: 52.2%, second administration: 61.8%) whereas Symspan and Rspan each accounted for approximately a quarter of the variance (Symspan first administration: 22.1%, second administration: 13.4%; Rspan first administration: 25.7%, second administration: 24.7%).

Frustration

Frustration Induction Procedure (FIP). Henna and colleagues developed the FIP in 2008 at the University of Sao Paulo, Brazil Medical School. The procedure was first published in the *Revista Brasileira de Psiquiatria*, the official publication of the Brazilian Psychiatric Association. Henna and colleagues noted that the FIP created frustration in 80% of their participants (Henna, Zilberman, Gentil, & Gorenstein, 2008). Based on the concept of the Wisconsin Card Sort Task, participants are shown one card from a set of 64. Cards are numbered 1 to 4, have 4 suits (i.e., spades, clubs, diamonds, and hearts), and have 4 colors (i.e., red, green, blue, and black). In the present study, participants were presented with the following instructions: “You will be shown a series of cards, with five cards in each group. Match the card on the top of the screen with one of the four cards on the bottom of the screen that is most similar. If you get ten in a row correct, you will win (most people are able to win).” The first nine attempts were designated as correct (regardless of accuracy), and participants saw a green screen with the word “correct.” The tenth attempt is always designated as incorrect (i.e., therefore preventing achievement of the goal) and participants saw a red screen with the word “incorrect” following the tenth attempt. Participants completed sixty sorts/trials.

Frustration Discomfort Scale (FDS). The FDS was developed based on Rational-Emotive-Behavior-Therapy theory (Harrington, 2005). The FDS contains 47 items that are rated on a 5-point Likert scale ranging from 1 (*Absent*) to 5 (*Very Strong*). The FDS has excellent internal reliability with an alpha of .96 (Harrington, 2005). The FDS was used to assess baseline levels of frustration intolerance. Higher total scores on the FDS denote lower frustration tolerance.

Frustrative Non-reward Scale (FNRS). The FNRS is a brief five-question self-report measure that uses a 4-point Likert scale ranging from 1 (*very true for me*) to 4 (*very false for me*). The measure assesses individuals' responses to goal and achievement blocking. The scale has excellent internal validity ($\alpha=.72$) and strong reliability with the intra-class correlation coefficient value at .75 (Wright, Lam, & Brown, 2009). Elevated FNRS scores reflect a greater frustration tendency following non-reward.

Academic Motivation

School Motivation and Learning Strategies Inventory- College Form (SMALSI-C). The SMALSI-C is a 164 item self-report inventory developed by Stroud and Reynolds (2006) that assesses ineffective learning strategies, low academic motivation, attention and concentration problems, difficulties with test taking, or test anxiety. The SMALSI provides standardized scores for each subscale and an indication of inconsistent responding. The SMALSI was designed to assess the following subscales: study strategies, note taking/listening skills, reading/comprehension strategies, writing/research skills, test-taking skills, organization, time management, academic motivation, test anxiety, and attention/concentration difficulties in an academic context. Subscales are internally consistent (Cronbach's alphas ranged from .77 to .86; Stroud & Reynolds, 2006). Only the academic motivation subscale was utilized in the present

study due to time constraints. Participants evaluated statements with a 4-point Likert scale ranging from 1 (*Never*) to 4 (*Always*).

Clinical Symptoms

ADHD Assessment

Barkley Adult ADHD Rating Scale-Fourth Edition: Current Symptoms (BAARS-IV: Current). The BAARS-IV assesses current ADHD symptoms and functioning. The form uses a 4-point Likert scale that ranges from 1 (*Never or Rarely*) to 4 (*Very Often*). The BAARS-IV assesses the following five domains (inattention, hyperactivity, impulsivity, sluggish cognitive tempo, and frequency/onset of symptoms). The internal consistency, using Cronbach's alpha, is satisfactory: ADHD inattention = .902; ADHD hyperactivity = .776; ADHD impulsivity = .807; ADHD total score = .914 (All *F*-tests significant at $p < .001$). The test-retest reliability of the BAARS-IV is satisfactory as well: ADHD inattention = .66; ADHD hyperactivity = .72; ADHD impulsivity = .76; and ADHD total score = .75. A total ADHD symptom count at the 93rd percentile rank and above falls in the clinically significant range. Elevated BAARS-IV scores indicate inattention and hyperactive-impulsive problems (Barkley, 2011).

BAARS-IV Current Symptoms Interview (BAARS-IV: Interview). The BAARS-IV: Interview is a structured clinical interview of the following four factors: Inattention, Hyperactivity, Impulsivity, and Sluggish Cognitive Tempo. Participants are instructed to answer questions by responding: "*No this does not occur often*" or "*Yes this occurs often.*" The BAARS-IV interview is a companion to the BAARS-IV rating scale. The interview does not have normative data; however there are high correlations between the interview scores and the current symptoms rating scale: Inattention = .87, Impulsivity/Hyperactivity = .85, and total number of

symptoms = .89. Positive endorsements indicate a higher likelihood of ADHD symptoms (Barkley, 2011).

Affective Symptom and Alcohol-related Problems Assessment

Beck Depression Inventory-Second Edition (BDI-II). The BDI-II is a self-report measure of depressive symptoms (Sundberg, 1987). The measure contains 21 items using a 4-point Likert scale. BDI-II items assess depressive symptoms over the past two weeks. The BDI-II has a Cronbach's alpha of .92 (A. Beck, Steer, Ball, & Ranieri, 1996). The BDI-II has strong test-retest reliability with clinical samples of .96 (Sprinkle et al., 2002). Elevated scores on the BDI-II indicate increased depression severity (Steer, Ball, & Ranieri, 1999). The current study used a participant's total score as an estimate of current depression severity.

Beck Anxiety Inventory (BAI). The BAI measures current anxiety severity for individuals between the ages of 17 and 80. The measure uses a 4-point Likert scale ranging from 0 (*Not at All*) to 4 (*Severely*). Participants are instructed to rate the occurrence of common anxiety symptoms experienced over the past week. Using Cronbach's alpha, the internal consistency ranges from .92 to .94. The test-retest reliability is .75. Elevated BAI scores indicate increased current anxiety severity (A. Beck, Epstein, Brown, & Steer, 1988). The total score was used to estimate current anxiety severity.

Alcohol Use Disorders Identification Test (AUDIT). The AUDIT is a 10-item self-report screening tool for alcohol-related problems. The screener measures frequency, amount of alcohol consumed, problems due to consumption, and potential alcohol dependency. Questions are rated from 0-4 for a total score range of 0-40 with higher scores indicating an increased need for intervention. Overall, the AUDIT has an internal consistency of $\alpha = 0.80$ (De Meneses-Gaya, Zuardi, Loureiro, & Crippa, 2009). Test-retest reliability was strong over a one-month span ($r =$

.84 De Meneses-Gaya et al, 2009). Elevated scores indicate a higher-likelihood of alcohol related problems. The AUDIT total score was used to estimate hazardous drinking behavior.

Manipulation Checks

National Aeronautics and Space Administration – Task Load Index (NASA-TLX). The NASA-TLX is a subjective scale developed by the National Aeronautics and Space Administration, to evaluate the subjective response to workload based on the following six variables: Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. A scale questioning the participant's motivation to complete the task was added to the standard battery. Participants rate the six factors with a visual analog scale ranging from *Very Low (Perfect for Own Performance Factor)* to *Very High (Failure for Own Performance Factor)*. The scales are subsequently quantified using scores of 0 (*Very Low/Perfect*) to 100 (*Very High/Failure*). The NASA-TLX has been used frequently and has been cited in over 300 publications (S. G. Hart, 2006; S. Hart & Staveland, 1988). The NASA-TLX has split-half reliability and Cronbach's alpha of more than .80. The test-retest reliability has been shown to be between .516 and .753 (Xiao, Wang, Wang, & Lan, 2005). The NASA-TLX Frustration Factor was used to assess subjective frustration throughout the research appointment.

Blood Pressure. Blood pressure was recorded using a GoWISE USA[®] Advanced Control Upper Arm Blood Pressure Monitor. The monitor is automated so only the necessary pressure is applied to the individual's arm. The monitor uses a large adjustable plastic cuff and protective barrier sleeves were used to maintain hygiene. Blood pressure was assessed in the present study as an indication of vascular response to frustration. Previous research has indicated a relationship between frustration and certain health problems; in particular, blood pressure has been indicated (Berkowitz, 1989; Fox & Spector, 1999; Hokanson & Burgess, 1962; Oliver et al., 2012).

Previous research has indicated that blood pressure increases as a result of frustration induced from emotional stimuli, but should not change or decrease as a result of frustration from cognitive stimuli (Farmer et al., 1987). As the FIP is expected to create cognitive frustration, therefore blood pressure should remain constant across time points. Systolic blood pressure was used due to research indicating a stronger link between systolic blood pressure (compared to diastolic blood pressure) and frustration (Gentry, 1970). Therefore, the physiological response of systolic blood pressure to frustration induction was assessed.

Procedure

Participants signed up for an available timeslot for the 2.5-hour research appointment on the university's SONA Research Participant Recruitment website. Participants then reviewed the intent of the study, general procedures, time involvement, potential benefits of participation, potential risks of participating, limits of confidentiality, and the right to cease participating in the study at any time without penalty or consequence. Participants were assessed individually.

Once in the research lab, the research assistants reviewed the consent form, and provided opportunities for participants to ask questions regarding the study. Participants were asked to review and sign the consent form. Participants then completed the following questionnaires via computer: Demographics Questionnaire, FDS, FNRS, SMALSI (low academic motivation subscale), BAARS-IV: Current Rating Scale, BDI-II, BAI, and AUDIT. Participants were then administered the BAARS-IV: Interview and the WASI-II Two-Subtest Form (i.e., Vocabulary and Matrix Reasoning subtests). Participants completed the NASA-Task Load Index (NASA-TLX) to determine their baseline level of frustration and had their blood pressure assessed to establish baseline BP. Individuals were assigned to one of two groups using a random number generator. The computer-generated list assigned participants to the experimental or

control group. Permuted block randomization (i.e., 26, 12, 10) was used to keep the numbers of subjects in the groups closely balanced at all times and keep research assistants blind to group allocation (i.e., prevent research assistants from determining when a particular block of assignments is completed). Next, all participants completed the following three computerized tasks (using E-Prime 2 psychological research software) in counterbalanced order to evaluate their central executive functioning: OSpan, RSpan, and SymSpan tasks. Participants then completed the NASA-TLX and had their blood pressure evaluated for a second time.

Participants in the experimental group completed an adaptation of the FIP, programmed using SuperLab-Pro Psychological Research Software. Participants were asked to complete 60 sorts/trials. Participants in the control group completed a card-sorting task similar to the FIP, however their responses would always be indicated as correct. All participants were then asked to complete the NASA-TLX and had their blood pressure assessed for a third time. Next, all participants completed the computerized working memory battery (Operation, Reading, and Symmetry Spans) again. Finally all participants completed the NASA-TLX and had their blood pressure assessed for a fourth time. Following all research protocols participants reviewed a debriefing document explaining the intent and goals of the study. A list of community resources was provided. Refer to Figure 1 in Appendix B for a visual representation of procedures.

Chapter Three: Results

Dependent Variables

FDS and FNRS total scores were used to assess baseline frustration levels. The FDS evaluates emotional frustration while the FNRS assesses cognitive frustration. The NASA-TLX-frustration factor was used to measure subjective experience of frustration at four time points (i.e., before the first WMC battery, after the first WMC battery, after the FIP or control, and after the second WMC battery). Systolic blood pressure was used as a physiological indicator of experienced frustration at four time points (i.e., before the first WMC battery, after the first WMC battery, after the FIP or control, and after the second WMC battery). As potential covariates, the BAARS-IV: Current total score was used to assess total ADHD symptom severity. Additionally, the BAI total score and BDI-II total score, and AUDIT total score were used to measure current anxiety severity, depression severity, and hazardous alcohol use, respectively. The Academic Motivation subscale from the SMALSI was administered to assess for potential between-group differences in academic motivation.

Data Screening

Group Assignment and Participant Exclusion. Eighty-one participants were recruited for the study and a total of fourteen met exclusion criteria. Nine participants were excluded due to reporting past suicidal ideations on the BDI-II and were provided with a list of mental health services. Two participants were excluded for having an FSIQ-2 score below 85 on the WASI-2. Two participants were excluded as they reported taking medication that would interfere with physiological measurement (i.e. beta blockers). Finally, one participant was excluded due to a technological difficulty during administration of the Rspan task (i.e., computer program ended mid-administration). Refer to Figure 2 for a visual schematic of participant exclusion. After

random assignment, 34 participants were assigned to the experimental group and 32 were assigned to the control group.

Preliminary Results

Power Analysis. An 80% *a priori* power analysis was conducted using a medium effect size as suggested by Kazdin (2016) and indicated that 64 participants would be sufficient to detect an effect. This sample contains 66 participants.

Distribution Analysis. Data were first analyzed for outliers. One significant outlier, for age, was detected and excluded; this did not significantly affect results. Analysis of skewness and kurtosis revealed elevated kurtosis for age (Skewness=1.89, Kurtosis=4.035; Kim, 2013); therefore the nonparametric Spearman's correlation coefficient was utilized for correlational analysis that included age. There were no distributional concerns regarding other measures.

Preliminary Analyses

The sample had a mean age of 19.09. Sample ethnic category was mixed with 80.3% Caucasian (n=53), 2.9% Hispanic (n=2), 13.6% African American (n=9), 2.9% Asian (n=1), and 1.4% Other/Multiracial (n=1). Sample sex distribution was 33.3% male (n=22) and 66.7% female (n=44). Independent samples *t*-tests for equality of means for age and the FSIQ-2 indicated that the mean age ($p=.607$) and FSIQ -2 scores ($p=.210$) were comparable for the experimental and control groups. Pearson Chi-Square Tests were conducted for categorical variables (i.e., sex and race/ethnicity) to evaluate whether demographic variables differ between the experimental and control groups. No significant difference in sex ($p=.728$) or race/ethnicity ($p=.723$) was observed. Consequently, these variables will not be used as covariates in subsequent analyses. Demographic data are displayed in Table 1.

Statistical Analyses

Tier I: Baseline Functioning

Univariate ANOVAs were conducted to evaluate between-group differences in baseline frustration levels (FDS and FNRS total scores). No significant group differences in baseline frustration (FDS: $p=.189$, FNRS: $p=.315$) were detected. Tier 1 statistics are presented in Table 2.

Tier II: Frustration (Manipulation Check)

NASA-TLX. To evaluate subjective changes in frustration across time, a 2 (control group vs experimental group) x 4 (NASA-TLX-Frustration Factor-Time 1, NASA-TLX-Frustration Factor-Time 2, NASA-TLX-Frustration Factor-Time 3, and NASA-TLX-Frustration Factor-Time 4) repeated-measures ANOVA was conducted. Results indicated that there was a significant main effect ($p<.001$). The group by time interaction was significant ($p <.001$), using a Greenhouse-Geisser correction. The between-group effect was significant ($p=.008$). The significant interaction suggests that subjective frustration ratings varied as a function of group membership. A Fisher's LSD post-hoc analysis indicated that groups were comparable at times 1 ($p=.963$), 2 ($p=.687$), and 4 ($p=.883$), but significantly different at time point 3 ($p<.001$). The experimental group reported higher subjective frustration ratings after the FIP was administered relative to the control group. Thus, we can conclude that the FIP successfully induced frustration for study participants as the groups were significantly different after administration of the FIP.

Systolic Blood Pressure. To evaluate physiological changes in frustration across time, a 2 (control group vs experimental group) x 4 (Systolic Blood Pressure Time 1, Systolic Blood Pressure Time 2, Systolic Blood Pressure Time 3, and Systolic Blood Pressure Time 4) repeated-measures ANOVA was conducted to evaluate changes in systolic blood pressure. Results

indicated that there was non-significant main effect ($p=.119$) and non-significant group by time interaction for systolic blood pressure ($p=.975$), using a Greenhouse-Geisser correction. The between-group effect was not significant ($p=.964$). These results suggest that blood pressure did not vary across the four time points and comparable blood pressure values were obtained for the control and experimental groups. Tier II statistical data is presented in Table 3.

Tier III: Frustration and WMC

Next, a 2 (control group vs. experimental group) x 2 (Pre-WMC Score vs. Post-WMC) repeated-measures ANOVA was conducted to evaluate within- and between-group differences in central executive functioning, across the two time points. Results indicated a non-significant main effect ($p=.994$) and a non-significant group by time point interaction effect for WMC ($p=.814$). The between-group effect was significant ($p=.035$). These results suggest that the groups yielded comparable WMC performance values across the two time points. The significant between-group effect suggests that across the two time points, the experimental group exhibited higher WMC scores relative to the control group. Tier III statistical data is presented in Table 4.

Tier IV: Contributions of Clinical Symptoms to Baseline Frustration Levels

Finally, a stepwise regression was conducted to evaluate the unique contribution of ADHD symptoms (i.e., total score on the BAARS-IV: Current) to baseline levels of frustration (i.e. total score on the FDS and FNRS). After accounting for ADHD symptom severity (block 1), we evaluated the unique contributions of hazardous drinking (AUDIT total score) and current anxiety/depression severity (BAI and BDI-II total scores) to baseline frustration and WMC (block 2). Results indicated that high ADHD symptom severity significantly predicted higher rates of baseline frustration. The BAARS-IV: Self accounted for approximately 22.1% of the variance in the FDS total score ($p < .001$) and 23.3% of the variance in the FNRS total score ($p <$

.001). We did not detect a significant relationship between the AUDIT, BDI-II, and BAI scores to baseline levels of frustration. Tier IV statistical data is presented in Tables 5 and 6.

Chapter Four: Discussion

To inform clinical science regarding the relationship between motivational processes and cognitive performance, the current study examined the association between frustration and working memory capacity in an emerging adult sample. Historically, inducing frustration in a laboratory is difficult, due to reliability and validity concerns of frustration induction tasks (Lindzey & Riecken, 1951; Oliver et al., 2012; Scime & Norvilitis, 2006). However, in the current study participants in the experimental group reliably reported significantly higher subjective frustration ratings relative to individuals in the control condition without being promised a tangible reward for completing the frustration task. To our knowledge, this is the first study to date to systematically induce subjective frustration ratings without an immediate reward.

Consistent with existing research, systolic blood pressure did not change across the four time points as a function of induced frustration. This suggests that we were able to isolate cognitive frustration, as previous research has suggested that blood pressure changes are related to changes in response to emotional frustration (e.g., frustration in response to not meeting a social goal), and not cognitive (e.g., frustration stemming from difficulty with cognitive tasks; Farmer et al., 1987; Oliver et al., 2012). In the present study, we attempted to induce cognitive frustration and hypothesized that blood pressure measurements would not vary across the two time points.

To understand the relationship between frustration and WMC, the current study utilized a factor analytic framework developed by Conway and colleagues (2005) to isolate and examine WMC. Theoretical accounts (Abram Amsel, 1992; Barker, 1938; Maier, 1966) and animal studies (A Amsel & Hancock, 1957; A Amsel & Ward, 1954; Amsel & Roussel, 1952; Maier, 1966) have suggested a negative relationship between cognitive performance and frustration. To

our knowledge this is the first study to examine a relationship between frustration and WMC. In the present study, WMC had a positive relationship with FSIQ-2 and the vocabulary subtest of the WASI-2. This is consistent with previous research that documents a relationship between measured intelligence and WMC (Alloway, 2010; Martinussen et al., 2005), and provides further support for the construct validity of the Oswald (2015) tasks. Moreover, this finding could guide future research on WMC and intellectual functioning

WMC was not associated with induced frustration in the present study. However, this finding is consistent with previous research suggesting that WMC is a stable construct and difficult to influence (Tracy, Packiam, Alloway & Alloway, 2010; Cowan, 2010). As such, future research should examine the extent to which additional working memory-related performance variables (i.e., reaction time, latency to first response) are related to frustration. For example, Shiels and colleagues (2008) were able to document a relationship between storage-rehearsal processes, rather than WMC, of visuospatial-working memory and an environmental influence (i.e., motivation). Given this finding, researchers could examine if frustration is related to storage-rehearsal processes rather than the domain general central executive component of working memory. Additionally, given our finding that the Operation Span Task contributed the most variance to WMC, future research should examine the extent to which specific CE-processes (i.e., focused attention, divided attention, interaction with long-term memory stores) are related to frustration. Additionally, further research may wish to continue to explore the factor structure of WMC using the Oswald (2015) span tasks.

The current study also has potential clinical implications. Our results extend previous research suggesting a relationship between ADHD and frustration (Bitsakou et al., 2006, 2009; Scime & Norvilitis, 2006), by demonstrating that ADHD symptoms contributed uniquely to both

the FDS and FNRS. This finding is consistent with previous research that has documented a relationship between ADHD and frustration intolerance (Bitsakou et al., 2006, 2009; Scime & Norvilitis, 2006). The BAI, BDI-II, and AUDIT, however, did not account for a significant portion of variance in either measure. This suggests that ADHD symptoms rather than anxiety/depression severity and alcohol use/abuse contributes uniquely to frustration. Our results, however, are incongruent with previous research that has documented a relationship between frustration and anxiety, depression (Chang & D’Zurilla, 1996; Klinger, 1975; Mahon, Yarcheski, Yarcheski, & Hanks, 2007), and alcohol use (Cox & Klinger, 1988; Finch, Catalano, Novaco, & Vega, 2003). Future research should attempt to replicate these effects on pure ADHD, depressive, anxious, and alcohol-abusing samples to further clarify frustration’s relationship to clinical symptomatology. An additional avenue future clinical studies may wish to follow is to study if interventions targeting frustration and/or delay intolerance help to reduce ADHD related symptomology.

A number of limiting caveats must be considered. First, this study relied on self-report ratings of both frustration and clinical symptoms. Although self-report offers advantages in terms of assessing the subjective experience of frustration and clinical symptoms, behavioral observation data would be a valuable next step. Behavioral observations would allow qualitative validation of participants experiencing a frustration response as well as allowing researchers to identify a direct antecedent to the response. Additionally, a relatively homogenous group of college students constituted the sample, and the sample had twice as many women, both factors limit the findings generalizability. Finally, there is no available data on the immediate test-retest reliability of the WMC span tasks. As the task sessions were administered within 15-20 minutes of each other, results could be skewed by recall or practice effects. Limitations notwithstanding

the current study offers novel insight and guides future directions into the effects of frustration on cognitive factors; as well as providing evidence that it is possible to induce frustration in a laboratory setting. Furthermore, given that our baseline measures of frustration were correlated negatively, future research should examine the concurrent validity of the measures in a young adult sample. While the developers of the FNRS compared their measure toward low approach motivation, they did not compare the assessment to a pure frustration measure; therefore it is unknown how the factor structures of the FDS and FNRS compare. Furthermore, the current study only looked at total scores on the measures. Future research may wish to use the subscales on the FDS to understand the relationship between emotional and behavioral process of frustration and how they map on to cognitive factors.

Future exploration of this data set should include controlling for effects of ADHD symptomology on the relationship between frustration and WMC. Given the documented associations between ADHD and Frustration (Bitsakou et al., 2009; M. Rapport et al., 1986; Scime & Norvilitis, 2006; Wilbertz et al., 2013) as well as ADHD and WMC (Alderson et al., 2013; Martinussen et al., 2005; Mark Rapport et al., 2008; Valera, Faraone, Biederman, Poldrack, & Seidman, 2005), ADHD symptoms may play a significant role in the relationship between frustration and WMC. Additionally, given the effects of motivation on Visuospatial Working Memory documented by Shiels (2008), future research should control for individual differences in motivation. Finally, an exploration of the relationship between domain-specific WM processes and frustration may improve our understanding of frustration and both storage and rehearsal processes and inform the development of potential interventions for college students.

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Appendices

Appendix A: Tables

Table 1. Demographic Data

Variable	Control (n=32)		Experimental (n=34)		<i>F</i>
	\bar{x}	<i>SD</i>	\bar{x}	<i>SD</i>	
Age	18.66	.937	18.74	1.19	.268
FSIQ-2	103.81	8.84	100.41	7.33	1.607
	N	%	N	%	χ^2
Sex					.121
Male	10	31.3	12	35.3	
Female	22	68.8	22	64.7	
Ethnic Category					2.07
Caucasian	26	81.3	27	79.4	
Hispanic	1	3.1	1	2.9	
African American	4	12.5	5	14.7	
Asian	-	-	1	2.9	
Other	1	3.1	-	-	

Table 2. Tier I. Baseline Frustration ANOVA Summary

Variable	Control		Experimental		<i>F</i>	<i>p</i>
	\bar{x}	SD	\bar{x}	SD		
FDS	99.22	18.24	92.56	22.17	1.76	.189
FNRS	14.31	2.48	13.56	3.46	1.02	.315

Note: FDS=Frustration Discomfort Scale and FNRS=Frustrative Non-Reward Scale

Table 3. Tier II. Repeated Measures ANOVA Summary – Manipulation Checks

Variable	Control					Experimental					Total	
	Administration Time					Administration Time					Group Composite	<i>F</i> <i>p</i>
	1	2	3	4	Group Composite	1	2	3	4	Group Composite		
\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SE)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SE)		
NTF	24.90 (30.99)	43.31 (24.42)	9.72 (19.06)	41.78 (28.96)	29.93 (3.71)	34.08 (28.33)	42.38 (26.46)	54.88 (34.32)	44.97 (28.40)	44.08 (3.60)	16.04	<.001
Group F	20.66*	100.6*	8.32**	66.6*	24.43*	49.24*	87.23*	86.93*	85.26*	30.38*	7.87	<.001
Effect Size	.31	.04	1.61	.73		.31	.04	1.61	.73			
SBP	124.00 (15.01)	122.00 (15.18)	121.22 (14.49)	121.03 (12.38)	122.06 (2.14)	124.50 (14.15)	121.79 (15.87)	120.50 (12.33)	120.94 (17.49)	121.93 (2.07)	.047	.975
Group F	2184.61*	2221.3*	2239.2*	3057.3*	762.31*	2631.6*	2003.4*	3243.5*	1625.7*	912.02*	2.27	.119
Effect Size	.03	.01	.05	.28		.03	.01	.05	.28			

Note: NTF = NASA-TLX: Frustration; SBP = Systolic Blood Pressure; Effect size measured in Cohen's *d*; *Significant at $p < .0005$; **Significant at $p < .01$

Table 4. Tier III. Repeated Measures ANOVA Summary - WMC

Variable	Control			Experimental			Total	
	Administration Time		Group Composite	Administration Time		Group Composite	<i>F</i>	<i>p</i>
	1	2		1	2			
\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SE)	\bar{X} (SD)	\bar{X} (SD)	\bar{X} (SE)			
WMC	-.258 (.887)	-.235 (.881)	-.246 (.159)	.243 (1.05)	.221 (1.06)	.232 (.154)	.056	.814
Group F	2.70	2.27	.094	1.81	1.46	.909	.000	.994
Effect Size	.51	.47		.51	.47			

Note: WMC=Working Memory Capacity; Effect Size measured in Cohen's *d*

Table 5. Tier IV Regression Analysis Summary: FDS

Model	Variable	FDS			β	t	p
		R	R Square	Std. Error			
1. ^a		.470	.221	18.36			
	(Constant)					6.32	<.001
	BAARS-IV				.470	4.228	<.001
2. ^b		.583	.339	17.32			
	(Constant)					6.87	<.001
	BAARS-IV				.241	1.71	.093
	BDI-II				.023	.137	.892
	BAI				.365	2.72	.080
	AUDIT				.090	.724	.472

a. Predictors: (Constant), BAARS-IV

b. Predictors: (Constant), BAARS-IV, BDI-II, BAI, AUDIT

Table 6. Tier IV Regression Analysis Summary: FNRS

Model	Variable	FNRS			β	t	p
		R	R Square	Std. Error			
1. ^a		.482	.233	2.69			
	(Constant)					14.57	<.001
	BAARS-IV				-.482	-4.37	<.001
2. ^b		.530	.281	2.67			
	(Constant)					12.26	<.001
	BAARS-IV				-.284	-1.92	.059
	BDI-II				-.228	-1.31	.129
	BAI				-.073	-.525	.601
	AUDIT				-.034	-.260	.796

a. Predictors: (Constant), BAARS-IV

b. Predictors: (Constant), BAARS-IV, BDI-II, BAI, AUDIT

Appendix B: Figures

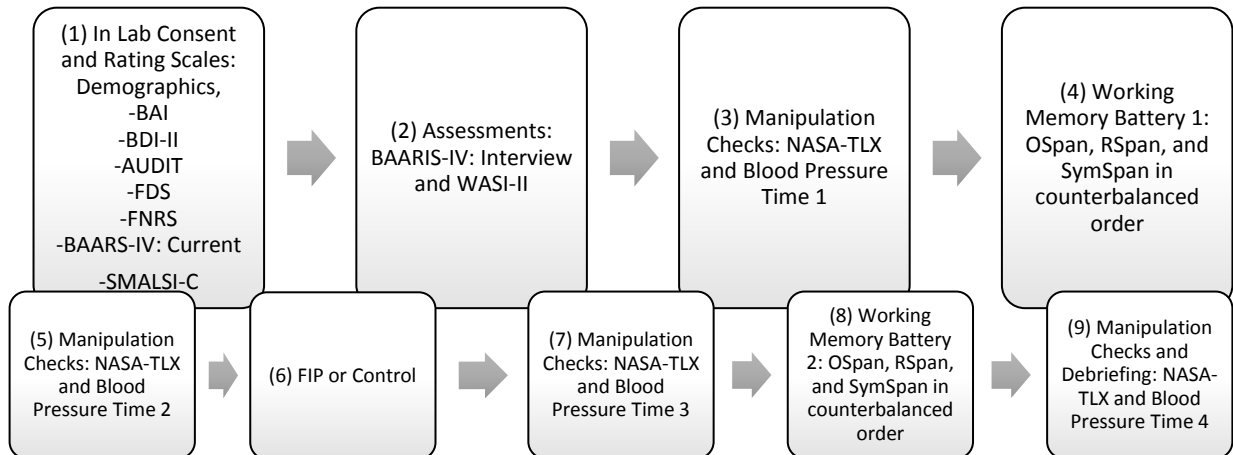


Figure 1: Visual Schematic of Procedures

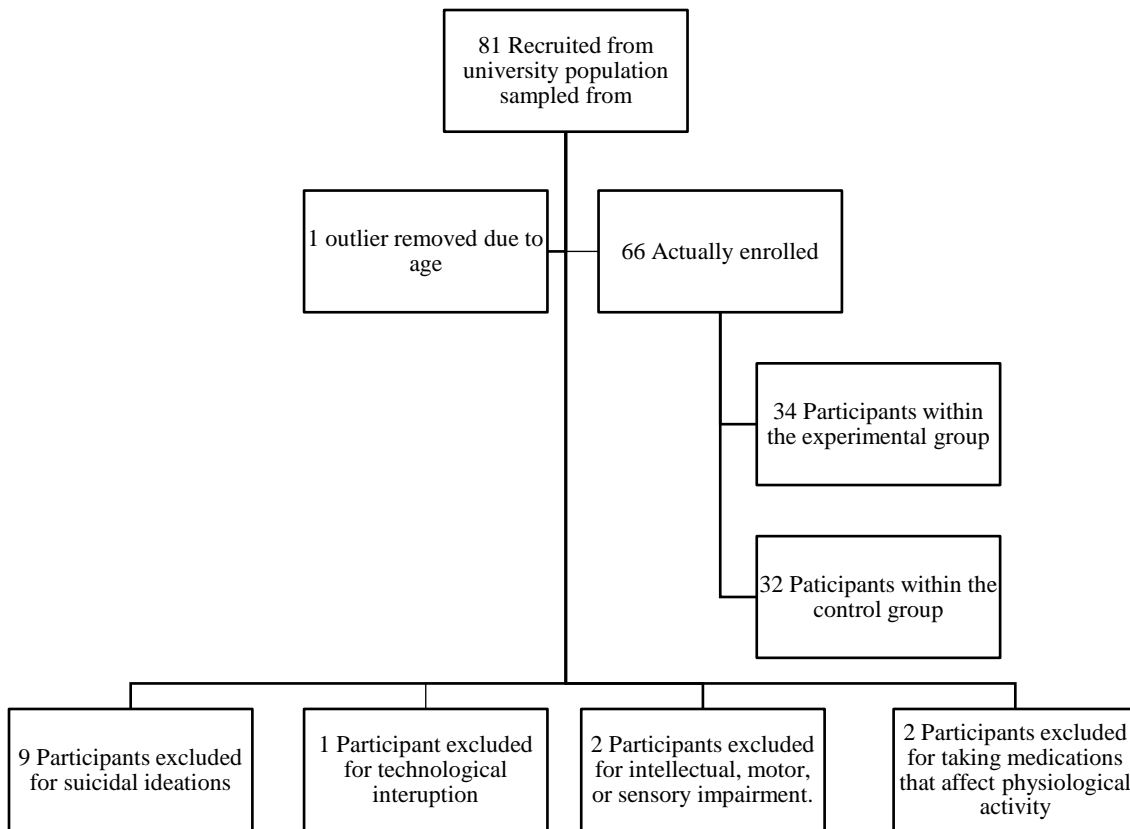


Figure 2: Participant Exclusion Schematic

Vita

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