Florida State University Libraries

Electronic Theses, Treatises and Dissertations

2017

Reading Comprehension Ability among College Students with ADHD

Jennifer L. B. Coleman

Follow this and additional works at the DigiNole: FSU’s Digital Repository. For more information, please contact lib-ir@fsu.edu
FLORIDA STATE UNIVERSITY
COLLEGE OF EDUCATION

READING COMPREHENSION ABILITY
AMONG COLLEGE STUDENTS WITH ADHD

By

JENNIFER L.B. COLEMAN

A Dissertation submitted to the
Department of Educational Psychology and Learning Systems
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

2017
Jennifer L.B. Coleman defended this dissertation on May 1, 2017

The members of the supervisory committee were:

Frances Prevatt
Professor Directing Dissertation

Christopher Schatschneider
University Representative

Steven Pfeiffer
Committee Member

Beth Phillips
Committee Member

The Graduate School has verified and approved the above-named committee members, and certifies that the dissertation has been approved in accordance with university requirements.
I dedicate this work and degree to my children. I hope that you try something difficult, challenge yourself beyond what you believe you can accomplish, and then when you think you cannot go any further, have the courage to ask for help to reach your goal. We do nothing alone, and the wonders of science, like the beauty of humanity are built on the hard work and ideas of many, not just one.
ACKNOWLEDGEMENTS

Embarking on this project was not one I believed I could accomplish. This experience has taught me that even the most daunting of tasks can be accomplished the support of those around you. I thank with sincerity my major professor, Frances Prevatt. Thank you for opening so many doors and helping me have the courage to walk through them. Thank you to my committee members who have helped me along the way and to all if my professors and mentors who have guided and tutored me in the art and science of psychology.
# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................................ vii

LIST OF FIGURES ..................................................................................................................... viii

ABSTRACT ................................................................................................................................... ix

CHAPTER 1: INTRODUCTION ................................................................................................... 1

CHAPTER 2: REVIEW OF LITERATURE .................................................................................. 5

  A Brief History of ADHD and Diagnostic Criteria ................................................................. 5

  Etiology of ADHD ...................................................................................................................... 7

  Treatment for ADHD .................................................................................................................. 9

  ADHD Development and Prevalence ....................................................................................... 10

  ADHD Consequences ............................................................................................................... 11

College Students with ADHD ................................................................................................... 13

Reading and Comprehension ..................................................................................................... 16

The Simple View of Reading and ADHD ................................................................................ 21

Comparing Reading Abilities ................................................................................................... 23

Working Memory, Attention, and Reading ............................................................................... 26

Research Questions ................................................................................................................... 30

CHAPTER 3: METHODOLOGY ................................................................................................ 32

  Introduction ............................................................................................................................... 32

  Research Design ........................................................................................................................ 32

  Participants and Data Collection ............................................................................................... 32

  Measures ................................................................................................................................... 36

  Research Questions ................................................................................................................... 38

CHAPTER 4: DATA ANALYSIS ............................................................................................... 40

  Research Questions 1 and 2 ...................................................................................................... 40

  Research Questions 3 and 4 ...................................................................................................... 42

  Results for Question 3a: Working Memory through Silent Reading Fluency on Reading
  Comprehension—Simple Mediation Model ............................................................................. 45

  Results for Question 3b: Working Memory through Language Comprehension on Reading
  Comprehension—Simple Mediation Model ............................................................................. 46

  Results for Question 3c: Working Memory Multiple Mediating Model ................................. 47

  Results for Question 4a: Attention through Silent Reading Fluency on Reading
  comprehension—Simple Mediation ......................................................................................... 50

  Results for Question 4b: Attention through Language Comprehension on Reading
  comprehension—Simple Mediation ......................................................................................... 51

  Results for Question 4c: Attention Multiple Mediating Model .............................................. 52
LIST OF TABLES

Table 1. Definitions of constructions and measures used to evaluate ADHD symptoms and components of the SVR .......................................................................................................................... 3

Table 2. Symptoms of Inattention and Hyperactivity/Impulsivity ................................................. 7

Table 3. Descriptive Statistics for the Study Measures ................................................................. 40
LIST OF FIGURES

Figure 1. Simple Mediation Model ................................................................. 44

Figure 2. Model 2: Parallel Multiple Mediation Model .............................. 45

Figure 3. Regression coefficients for the relationship between working memory and reading comprehension as mediated by silent reading fluency ......................................................... 48

Figure 4. Regression coefficients for the relationship between working memory and reading comprehension as mediated by language comprehension ........................................ 49

Figure 5. Regression coefficients for the relationship between working memory and reading comprehension as mediated by language comprehension and silent reading fluency .......... 49

Figure 6. Regression coefficients for the relationship between attention and reading comprehension as mediated by silent reading fluency ......................................................... 51

Figure 7. Regression coefficients for the relationship between attention and reading comprehension as mediated by language comprehension ............................................. 52

Figure 8. Regression coefficients for the relationship between attention and reading comprehension as mediated by language comprehension and silent reading fluency .......... 53
ABSTRACT

College students with ADHD are an understudied population. Reading comprehension difficulties are common among those with ADHD. Research that addresses reading comprehension abilities among college students is limited. This study compares college students with ADHD to a national sample of college students to determine differences between groups on variables associated with reading comprehension. Furthermore, the study addresses reading comprehension ability among college students with ADHD to determine if components of the simple view of reading (SVR) mediate the relationship between ADHD symptoms and reading comprehension. Understanding how college students with ADHD compare to a national sample of college students without ADHD may provide information useful in determining the focus of interventions and support for college students with ADHD.

Objective: This study examines four questions. Do college students with ADHD perform below average compared to national college norms on measures of silent reading fluency, language comprehension, and reading comprehension? Do college students with ADHD perform below average compared to national college norms on measures of working memory? Is the relationship between working memory and reading comprehension partially mediated by silent reading fluency and language comprehension? Is the relationship between attention and reading comprehension partially mediated by silent reading fluency and language comprehension?

Methods: A total of 370 college students diagnosed with ADHD completed measures of working memory, attention, language comprehension, reading fluency, and reading comprehension. The sample consisted of 14% freshman, 18% sophomores, 24% juniors, 24% seniors, and 19% graduate students. The self-identified gender composition was 46% female and 54% male. The self-identified ethnic composition is 65% Caucasian, 18% Hispanic, 10% African
American, 2% Asian, and 5% identified as ‘other.’ Researchers diagnosed 52% of the sample as ADHD-PI (Primarily Inattentive Type) and 47% ADHD-C (Combined Hyperactive and Inattentive Type).

Results: The analyses revealed that college students with ADHD perform as well or better on all measures than their non-ADHD peers from a national sample. The mediation models that included working memory were significant, but the mediation models including inattention were not significant. Conclusion: College student with ADHD may be a unique population in that they experience reduced reading comprehension difficulties as compared to their ADHD peers who do not attend post-secondary education. The mediating models, while significant, do not suggest that improvement in working memory contributes to meaningful gains in reading comprehension. Intervention design may be more successful if directed toward component reading skills and environmental cues that can assist with reducing the effects of ADHD symptoms on reading behavior at a university level.
CHAPTER 1
INTRODUCTION

College students with ADHD experience increased risks of academic failure (American Psychological Association [APA], 2013a; Melara, 2012; Murray, 2000), and fail to progress through their post-secondary education settings at the same rate as their nondisabled peers (Melara, 2012; Murray, 2000). The National Center for Education Statistics (2009) reports that fewer high school students with Other Health Impairments (including ADHD) attend college than those without disabilities and that college students with ADHD and/or learning disabilities “are less likely to graduate, take longer to do so, and as compared with nondisabled peers, they have lower GPAs and higher rates of withdrawals, ineligibilities, and course under loads” (Richman, 2013, p. 4).

ADHD symptoms include working memory and attention deficits that are associated with poor academic and reading performance (American Psychiatric Association, 2013a; Barkley, Murphy, & Fischer, 2008; Mahone, 2011; Martinussen & Mackenzie, 2015; Tripp & Wickens, 2009). In particular, many college students and adults with ADHD struggle with reading comprehension (Levrini & Prevatt, 2012). In a college setting, reading for understanding is additionally difficult due to the complexity of text presented. College-level text requires readers to draw upon working memory and attentional skills that challenge average and even highly literate readers (Bauerlein, 2011).

The ADHD reading literature uses the terms reading disorder, reading disability, and reading difficulties to describe similar reading comprehension limitations. This paper uses the term reading difficulty to describe broad reading comprehension problems. The term reading comprehension refers to a complex, hierarchical, and active process where a reader interprets the
text, its context, and its meaning through interaction with learned language (Chall, 1987; National Institute of Child Health and Human Development [NICHHD], 2000).

Childhood, adolescent, and adult studies suggest that deficits contributing to reading comprehension difficulties differ between those with ADHD and those with traditional reading disorders (Barkley et al., 2008; Brock & Knapp, 1996; Hatcher, Snowling, & Griffiths, 2002; Purvis & Tannock, 2000; Wilson & Lesaux, 2001). Children and adults with reading disorders generally experience difficulty with component reading comprehension skills related to decoding text, whereas children and adults with ADHD generally show average performance in these areas (Barkley et al., 2008; Kroese, Hynd, Knight, Hiemenz, & Hall, 2000; Samuelsson, Lundberg, & Herkner, 2004; Wilson & Lesaux, 2001). Some authors suggest that children and adults with ADHD experience reading comprehension difficulties due to ADHD symptoms associated with poor attentional control and working memory ability rather than decoding limitations (Barkley et al., 2008; Hervey, Epstein, & Curry, 2004; Locascio, Mahone, Eason, & Cutting, 2010; Mahone, 2011; Marzocchi et al., 2008; McInnes, Humphries, Hogg-Johnson, & Tannock, 2003; Purvis & Tannock, 2000; Sesma, Mahone, Levine, Eason, & Cutting, 2009; Snow, Burns, & Griffin, 1998). However, applying findings from childhood, adolescent, and adult reading research to college students with ADHD is problematic due to the developmental nature of reading ability, maturation of cognitive abilities, the evolving nature of ADHD symptom presentation, self-selection characteristics of college students with ADHD, and varied evaluation and measurement practices (APA, 2013a; Barkley et al., 2008; Dally, 2006; DuPaul, Weyandt, O'Dell, & Varejao, 2009; Green & Rabiner, 2012; Sergeant, Geurts, & Oosterlaan, 2002; van der Sluis, de Jong, & van der Leij, 2007). Thus, it is not clear how college students with ADHD are performing on measures of reading compared to their peers without ADHD.
Table 1

Definitions of constructions and measures used to evaluate ADHD symptoms and components of the SVR.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Measure/Variable Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Memory</td>
<td>Woodcock-Johnson III Tests of Cognitive Abilities, Normative Update (WJ III COG NU). This cluster score includes subtests: Numbers Reversed and Auditory Working Memory. <em>Working Memory</em></td>
</tr>
<tr>
<td>Attention</td>
<td>The Barkley Adult ADHD-IV Rating Scale (BAARS-IV). This self-rating scale measures inattention severity. <em>Attention</em></td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>Woodcock-Johnson III Tests of Achievement, Normative Update (WJ III ACH NU). The subtest Passage Comprehension requires the participant to read a small paragraph with a blank space. The participant is asked to read the passage and provide the missing word. <em>Passage Comprehension</em></td>
</tr>
<tr>
<td>Language Comprehension</td>
<td>WJ III ACH NU. Understanding Directions is a listening comprehension task that requires the participant to listen, give attention to a sequence of auditory cues, and then follow directions provided within the cues. It is a measure of listening abilities and language development. <em>Understanding Directions</em></td>
</tr>
<tr>
<td>Decoding</td>
<td>WJ III ACH NU. The subtest Fluency is a silent reading task that asks the participant to read printed statements rapidly and respond true or false to each statement. <em>Fluency</em></td>
</tr>
</tbody>
</table>

Despite the limits of generalizability, prior studies among children and adolescents provide methodological guides for college student ADHD reading research. Those who study reading comprehension among children and adolescents (García & Cain, 2014) often employ the simple view of reading (Gough & Tunmer, 1986). Its use among adult populations is growing (Tighe & Schatschneider, 2014). The simple view of reading (SVR) posits that reading comprehension is mainly composed of decoding and language comprehension abilities. Martinussen & Mackenzie (2015) expanded the SVR to account for ADHD symptoms associated with ADHD symptom severity. They found that decoding and language comprehension measures “were significant mediators of the effects of ADHD symptoms on reading comprehension” (p.
These recent findings provide evidence for the potential of increasing decoding and language comprehension skills to increase reading comprehension; and they provide additional support for the SVR among a childhood population with ADHD.

This exploratory study examines whether the relationships between ADHD symptoms and reading comprehension observed in childhood and adolescent studies also occur among college students with ADHD. Furthermore, it seeks to determine if decoding and language comprehension skills mediate the relationship between ADHD symptoms and reading comprehension. Table 1 provides an explanation for the constructs and measures used in this study.

Insight about how ADHD symptoms contribute to reading ability among college students may help direct and support research-based interventions (Trammell, 2003). This study therefore uses data collected from a college student population evaluated and diagnosed with ADHD to address the following research questions:

1. Do college students with ADHD perform below average compared to national college norms on measures of silent reading fluency, language comprehension, and reading comprehension?

2. Do college students with ADHD perform below average compared to national college norms on measures of working memory?

3. Is the relationship between working memory and reading comprehension partially mediated by silent reading fluency and language comprehension?

4. Is the relationship between attention and reading comprehension partially mediated by silent reading fluency and language comprehension?
CHAPTER 2

REVIEW OF LITERATURE

To examine the proposed research questions, this literature review addresses findings from both ADHD and reading comprehension research. The review first addresses ADHD’s history, etiology, negative impact on multiple life domains (including academics), working memory and attentional control deficits, and treatment options. Second, the review discusses the components of reading comprehension. Third, the review examines the limited research that uses the simple view of reading among populations with ADHD. These sections provide support for the research questions and methodological approaches addressed in Chapter 3.

A Brief History of ADHD and Diagnostic Criteria

The history of ADHD focuses mainly on research among children. Only in the last 25 years has ADHD research begun to emphasize studies of adults with the disorder (Barkley et al., 2008). Among adults, research among college students with ADHD is even more limited (DuPaul et al., 2009). For almost 200 years many practitioners believed that symptoms of ADHD only occurred among children and symptoms diminished through maturation (APA, 1968; Lange, Reichl, Lange, Tucha, & Tucha, 2010). As knowledge about this disorder has increased over time, its name and diagnostic criteria have evolved. ADHD has experienced various name changes through this 200-year process, including: Minimal Brain Damage, Minimal Brain Dysfunction, Hyperkinetic Reaction of Childhood, Hyperkinetic Reaction of Childhood with Attention Deficit Disorder, and Attention Deficit Disorder (with and without hyperactivity). Currently, the disorder is labeled Attention-Deficit/Hyperactivity-Impulsivity Disorder (ADHD) and has the following specifiers: combined presentation, predominantly inattentive presentation, and predominantly hyperactive/impulsive presentation (APA, 1968; 1980; 1994; 2013a; Clements, 1966; Lange et al., 2010). The progress of ADHD research has clarified symptoms
and identified genetic patterns. More recently, neuroimaging of brain abnormalities has enabled researchers to establish the developmental path of ADHD into adulthood. Current diagnoses identify three subtypes of the disorder: inattentive, hyperactive and combined. (APA, 1994; 2013a; Lange et al., 2010). It was not until 1972 that Shelley and Reister produced the first paper involving adults with symptoms of ADHD (Barkley et al., 2008). Only within the last 25 years has research begun to emphasize adults with ADHD, and even less research focuses on college students (Barkley et al., 2008; DuPaul et al., 2009).

Presently, the DSM-5 (APA, 2013a) categorizes ADHD as a neurodevelopmental disorder with an age of onset of 12 or younger. The essential feature of ADHD is “a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development as characterized by” (p. 59) six or more behavioral symptoms of inattention and/or six or more behavioral symptoms of hyperactivity and impulsivity (see Table 2). Adult diagnosis (age 17 and older) is less stringent than childhood diagnosis, requiring a history of symptoms and present manifestation of five or more symptoms. ADHD is a neurodevelopmental disorder that interferes with executive functioning (APA, 2013). Russell Barkley (1997) argues that ADHD is a disorder of executive functioning with strong impairments in attentional control, inhibition, nonverbal working memory, verbal working memory, emotional self-regulation (including motivation), and planning/generativity.

In sum, the majority of ADHD research has focused on children due to the belief that symptoms did not persist into adulthood. The current state of the literature instead concludes that ADHD symptoms persist into adulthood. Research of adults with ADHD is growing. ADHD is seen as a disorder that negatively affects executive domains including working memory and attentional control.
Table 2.

Symptoms of Inattention and Hyperactivity/Impulsivity.

<table>
<thead>
<tr>
<th>Inattention</th>
<th>Hyperactivity/Impulsivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to give close attention to detail</td>
<td>Fidgets, taps with hands or feet, squirms</td>
</tr>
<tr>
<td>Difficulty sustaining attention in play activities</td>
<td>Leaves seat when remaining seated is expected</td>
</tr>
<tr>
<td>Does not seem to listen when spoken to directly</td>
<td>Runs or climbs about when it is inappropriate to do so/restlessness</td>
</tr>
<tr>
<td>Fails to follow through or finish schoolwork, chores or other assigned tasks</td>
<td>Unable to engage in leisure/play activities quietly</td>
</tr>
<tr>
<td>Difficulty with organization</td>
<td>Is often “on the go” and is uncomfortable being still for long periods</td>
</tr>
<tr>
<td>Avoids tasks that require sustained mental effort</td>
<td>Talks excessively</td>
</tr>
<tr>
<td>Loses things necessary for activities or tasks</td>
<td>Blurs out answers before a question has been completed</td>
</tr>
<tr>
<td>Easily distracted by external stimuli</td>
<td>Difficulty waiting/turn taking</td>
</tr>
<tr>
<td>Forgetful in daily activities</td>
<td>Interrupts or intrudes on others</td>
</tr>
</tbody>
</table>

*Note.* Adapted from the “Diagnostic and Statistical Manual of Mental Disorders, 5th Edition” by American Psychological Association, 2013.

**Etiology of ADHD**

The cause of ADHD is not yet known and specific genetic markers or a cure for ADHD have not yet been identified. Neuroimaging studies have found associations with “various structural, functional, electrical activity, and chemical correlates with ADHD in children, adolescents and adults” (ADHD Institute, 2015, p. 1). These studies observe structural and developmental differences in the cortex, specifically the frontal and temporal lobe regions of children with ADHD compared to normal controls (Shaw et al., 2007). The areas identified are associated with memory, controlled behavior, attention, thought process, and language (Mehta, 2013; Shaw et al., 2007). Research among children with ADHD has shown that these areas of the
brain develop at a slower rate and with less mass than their peers without the disorder (Ellison-Wright, Ellison-Wright, & Bullmore, 2008; Mehta, 2013).

The frontal lobe works to coordinate different networks in the brain to accomplish varied tasks. Neuroimaging studies of children and adults with ADHD have shown that activation of these networks does not function as efficiently as those found among normal controls (ADHD Institute, 2015; Morein-Zamir et al., 2014; Volkow et al., 2009). The dopamine hypothesis of ADHD suggests that the disruption of the frontal temporal lobe’s ability to regulate brain networks may be due to irregular levels of dopamine and noradrenaline. These chemicals are associated with inattention and impulsivity (Cubillo, Halari, Smith, Taylor, & Rubia, 2012; Economidou, Theobald, Robbins, Everitt, & Dalley, 2012; Rubia, Smith, Brammer, Toone, & Taylor, 2014; Volkow et al., 2009). Recently, Tomasi and Volkow (2014) observed that development of dopaminergic neural pathways was delayed in children with ADHD compared to normal controls, further supporting this theory. These findings provide insight into potential structural and chemical abnormalities associated with ADHD; however, brain imaging techniques are not sufficiently advanced to fully diagnose ADHD, or reveal the source of the disorder (APA, 2005; Mehta, 2013).

Research has found strong genetic patterns among family, twin, and adoption studies that suggest ADHD symptoms are related to heritability and environmental factors (Khan & Faraone, 2006). Symptom presentation has been associated with fetal prenatal stress and exposure to alcohol and tobacco, but this does not account for all cases of ADHD (Department of Health and Human Services, 1999; Faraone & Biderman, 2002). Post-natal environmental exposures in the form of food additives have been researched as potential causes of ADHD. One meta-analysis performed found that some children may benefit from a restriction diet, but research in this area
is not sufficient to draw strong conclusions (Nigg, Lewis, Edinger, & Falk, 2012). ADHD type (inattentive or hyperactive) appears to be influenced by different factors. Nikolas and Burt (2010) found that in twin studies the ADHD inattentive type was associated with a stronger genetic presentation than they hyperactive subtype. Although this area of research is promising, there is still no known environmental or genetic cause to this neurodevelopmental disorder.

**Treatment for ADHD**

Psychostimulants are the most common form of treatment for children with ADHD and have been prescribed for over 50 years (Woo & Keatinge, 2008). Psychostimulant medications, such as methylphenidate (i.e., Ritalin) and mixed salts of a single-entity amphetamine product (i.e., Adderall) have been shown to reduce ADHD symptoms (Lange et al., 2010; Woo & Keatinge, 2008). These medications affect how dopamine and norepinephrine are released in the brain and how long they remain available for the receptors in the brain. Dopamine and norepinephrine occur naturally in the body and assist with concentration, impulsivity, sustained attention, motivation and working memory, which are components of executive functioning (Faraone & Biderman, 2002; National Resource Center on ADHD, 2008). Improved outcomes for treatment among children and adolescents with ADHD include incorporating psychological therapy, psychoeducation, tutoring, and social skills training alongside psychostimulant medications (Jensen et al., 2001; MTA Cooperative Group, 1999; Woo & Keatinge, 2008).

In sum, while the exact cause of ADHD is not yet known, neuroimaging and genetic research studies are finding structural and familial links to the disorder. The most common treatment for ADHD symptom reduction among children is stimulant medication, which is more effective among children and adolescents when paired with multimodal treatments like therapy, psychoeducation, and social skills training.
ADHD Development and Prevalence

ADHD symptoms manifest differently as children mature into adulthood. This may be due to learned coping abilities that mask obvious hyperactive and inattentive symptoms (Adler, 2004; APA, 2013; Loe & Feldman, 2007). For example, an adult who experiences hyperactive symptoms may not run or climb about inappropriately, as seen in children with ADHD. Instead, an adult may constantly feel restless or hemmed in when required to sit, concentrate, or maintain focus. Inattention among adults may manifest in actions not applicable to children, such as frequently forgetting to pay bills on time, forgetting appointments, and manifestations of ineffective time management and organizational skills (APA, 2013; Barkley, 2011b). As symptom manifestations change over time, so do identified prevalence rates and gender distributions.

The prevalence rate of ADHD in most cultures is about 5% of children and 2.5% of adults, and is reported more frequently in males than in females (APA, 2013a). In childhood, the ratio of males to females diagnosed with ADHD is 2:1. Among adults, the ratio between males and females with ADHD reduces to 1.6:1 (APA, 2013a). The change in the ratio over time is likely due to multiple factors, including the following: (a) females are not identified as readily in childhood because their symptoms are often misdiagnosed as learning disorders and emotional difficulties; (b) hyperactivity manifests differently between genders in childhood and diagnosis favors predominantly male displays of hyperactivity; (c) female conformity to social pressures to perform well in academic settings promotes the development of early coping skills among females, which further mask symptoms in childhood and adolescence (Kessler et al., 2006; Quinn, 2005).

ADHD symptoms persist into adulthood for many diagnosed in childhood, and it is likely that those who outgrow their symptoms are not the majority (APA, 2013a). Research
suggests that symptom prevalence in adulthood persists for 16-66% of children. The large range of persisting symptoms is likely due to methodological limitations, including: restricted sampling, small sample sizes, and varied diagnostic criteria (APA, 2013a; Barbaresi et al., 2013; Barkley et al., 2008; Faraone & Biederman, 2005; Newlove-Delgado & Stein, 2012; Woo & Keatinge, 2008). These same limitations also make it difficult to conclude what percentage of the adult population was diagnosed during childhood.

In sum, ADHD symptoms manifest differently among children and adults. Males are diagnosed at a higher rate than females in childhood, which may be due to multiple factors impeding earlier diagnosis. ADHD symptoms are believed to persist into adulthood for a majority of children. Studies of ADHD have been strained by methodological limitations. ADHD researchers suggest that studies should employ broader sampling, larger sample sizes, and consistent and accurate diagnostic criteria.

ADHD Consequences

Children with ADHD experience impairment in multiple life domains including: home, social, community, school, sports, self-care, and chore performance—with school performance often being the most severely affected (Barkley et al., 2008). Those with ADHD are also more likely to experience co-morbid disorders including conduct disorders, disruptive mood dysregulation disorder, specific learning disorders, anxiety and depressive disorders, substance use disorders, and personality disorders (Adler, 2004; APA, 2013a; Sobanski et al., 2007). Adults with ADHD also experience impairment in multiple life domains including educational performance, occupational functioning, and money management (Barkley et al., 2008). They are also likelier to have lower levels of education and employment status (Biederman, Petty et al., 2008).
Reading disorders are significantly co-morbid among populations with ADHD. Estimates of co-morbidity among children and adolescents range from 25-40%, compared to five percent of the general population (APA, 2013a; August & Garfinkel, 1990; Willcutt & Pennington, 2000). Diagnosing reading disorders among children with ADHD can be challenging because ADHD and reading disorders can present with similar initial symptoms, including inattention and off-task behavior (Mahone, 2011). It has been observed that children and adolescents who experience both ADHD and reading disorders display symptoms of both disorders and are at a higher risk of experiencing mental health problems and academic underachievement (Ghelani et al., 2004; Mahone, 2011; Willcutt & Pennington, 2000). Co-morbid reading disorders among adults with ADHD are also statistically higher than adults without ADHD. Barkley et al. (2008) finds that, in two adult ADHD studies, co-morbid reading disorders occurred among 15-20% of adults with ADHD, and 3-5% among control groups without ADHD.

Research suggests that reading difficulties among children and adolescents with ADHD who do not have a reading disorder may be due to ADHD symptoms interfering with the reading process, rather than symptoms congruent with a reading disorder (Aaron, Joshi, Palmer, Smith, & Kirby, 2002; Frazier, Youngstrom, Glutting, & Watkins, 2007; Ghelani, Sidhu, Jain, & Tannock, 2004; Mahone, 2011; Purvis & Tannock, 2000; Smith, 1971). Misdiagnosis of the source of reading problems among children with ADHD can lead to incorrect interventions, further hindering academic success of the student (Loe & Feldman, 2007).

Academic underachievement is found among children and adults with ADHD (Frazier et al., 2007; Woo & Keatinge, 2008). Students with ADHD perform poorly on standardized assessments and experience a higher risk of failing grades, retention, school-reassignment, and learning disabilities (Biederman et al., 2004; M. Wagner, 1991; Young, 2000). A meta-analysis
conducted by Frazier, Youngstrom, Glutting and Watkins (2007) found that children and adolescents with ADHD experience significant difficulties in areas of academic performance when compared to their peers who do not have ADHD (weighted effect size of $d = .71$).

Specifically, children with ADHD often have trouble with reading, math and spelling compared to their peers without the disorder (Barkley, 2005; Doggett, 2004; Frazier et al., 2007; Mahone, 2011). ADHD symptoms hindering academic success, including poor reading ability, which likely persist throughout adolescence and adulthood and can affect academic performance in college settings (Adler, 2004; Woo & Keatinge, 2008). Barkley, Murphy and Fischer’s (2008) review of two adult ADHD studies found that both clinic-referred adults and adults diagnosed with ADHD underperform controls on measures of reading, spelling, and math.

In sum, children and adults with ADHD experience increased risk of academic underachievement and reading difficulties compared to their peers without the disorder.

Understanding the root cause of reading difficulties among children with ADHD is difficult due to the affect ADHD symptoms can have on reading ability. Misidentification of the source of reading impairment can further hinder academic achievement. Studies of adults with ADHD find that both clinic-referred adults and adults diagnosed in childhood experience hindered academic achievement compared to their peers.

**College Students with ADHD**

Since the passing of the Individuals with Disabilities Education Act (IDEA) of 1975, Section 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act (ADA) in 1990, individuals with ADHD who attend college have been identified as a population warranting additional support. Even with increased resources supporting their educational experience, college students with ADHD do not progress through their post-secondary education settings at the same rate as their peers who do not have a disability (Murray, 2000).
College students with ADHD experience increased risks of academic failure and progress through college at a slower rate than their peers without the disorder (American Psychological Association [APA], 2013a; Melara, 2012; Murray, 2000). The National Center for Education Statistics (2009) reports that fewer high school students with Other Health Impairments (including ADHD) attend college than those without disabilities and that college students with ADHD and/or learning disabilities and “have lower GPAs and higher rates of withdrawals, ineligibilities, and course under loads” (Richman, 2013, p. 4). Little research exists that examines intervention effectiveness for this population (Green & Rabiner, 2012; Trammell, 2003).

Additional research addressing how symptoms of ADHD contribute to reading comprehension abilities of college students with ADHD may contribute to the development of ADHD specific research based reading interventions for this population. DuPaul, Weyandt, O'Dell and Varejao’s (2009) review of the literature regarding college students with ADHD reports that little is known about what specific life domains are affected by the disorder. Further, they observe that “no controlled studies of psychopharmacological, psychosocial, or educational interventions have been completed in samples of college students with ADHD. Comprehensive and methodologically sound investigations are needed, especially regarding treatment, to promote the success of students with ADHD in higher education settings” (DuPaul et al., 2009, p. 234).

The percentage of college students with ADHD is difficult to discern due to varied methodologies and small sample sizes used in studies examining this population (Green & Rabiner, 2012). However, present statistics suggest that approximately 25% of college students with disabilities have ADHD, and that students with ADHD make up 2-8% of college populations (DuPaul et al., 2009). College students with ADHD appear to differ from the larger adult population with ADHD. A meta-analysis performed by Frazier, Youngstrom, Glutting, and
Watkins (2007) found that college students with ADHD experience “(a) higher ability levels, (b) greater academic success during primary and secondary school, and (c) better compensatory skills than individuals with ADHD from the general population” (p. 55). Despite these relative strengths, college students with ADHD are at a disadvantage when compared to their non-disabled peers. College students with ADHD are more likely to experience lower self-esteem, poor social skills, increased mental health problems, lower quality of life, stressed family relationships, lower adjustment ability, increased difficulty with academics (including reading comprehension), lower levels of educational and employment status, and poorer work performance than their college peers (Adler, 2004; APA, 2013a; Faraone & Biderman, 2002; Frazier et al., 2007; Green & Rabiner, 2012; Mahone, 2011; Shifrin, Proctor, & Prevatt, 2010; Sobanski et al., 2007). These characteristics of college students with ADHD set them apart from their peers without ADHD, and the larger adult ADHD population.

College students with ADHD, like children and other adults with ADHD, may have specific problems with reading comprehension. There is limited research that investigates college students with ADHD regarding ability, treatment, intervention, and academic performance (DuPaul et al., 2009; Green & Rabiner, 2012). DuPaul, Weyandt, O’Dell and Varejao (2009) reported that, “The empirical study of ADHD in the college student population is in its infancy compared to the vast body of literature concerning ADHD in children and adolescents” (p. 246). It is likely that children with ADHD who experience reading difficulties mature into adults with ADHD who experience reading difficulties (Barkley et al., 2008; Biederman et al., 2004; DuPaul et al., 2009; Ghelani et al., 2004; Green & Rabiner, 2012; Mahone, 2011).

Studies of reading performance among children and adolescents with ADHD may not generalize to college students with ADHD due to the way ADHD symptoms and reading ability
develop over time. Generalizability may also be hindered by unique population differences that are characteristics of college students with ADHD (DuPaul et al., 2009; Green & Rabiner, 2012; Hervey et al., 2004; Kim, Wagner, & Lopez, 2012; Weyandt & DuPaul, 2006).

College students with ADHD are not specifically studied in these adult studies, making it difficult to determine if college students share similar academic difficulties as other adult populations with ADHD, or if college students with ADHD perform below average compared to their college peers without ADHD. One preliminary study by Coleman and Prevatt (2014) found that college students performed in the average range on measures of reading comprehension and working memory, suggesting that college student with ADHD are not as impaired as their non-college peers with the disorder, and are performing similarly to national norms.

In sum, college students with ADHD likely account for 25% of students with disabilities on college campuses. College students with ADHD are a distinctive population among adults with ADHD. Generalization of reading research conducted among children and adults with ADHD to college students with ADHD is limited due to the developmental nature of ADHD symptom presentation and reading development over time, and potentially unique self-selection qualities. Legislation has provided increased resources for students with disabilities in post-secondary education; however, research examining specific needs and interventions for college students is limited. Further research addressing academic domains, including reading comprehension, may improve understanding of what college students with ADHD need in order to progress through higher education at a similar rate as their peers without the disorder.

**Reading and Comprehension**

“Reading is essential to success in our society. The ability to read is highly valued and important for and social and economic advancement...In a technological society, the demands
for higher literacy are ever increasing, creating more grievous consequences for those who fall short” (Snow et al., 1998, p. 1).

The term *reading difficulty* was addressed in the introduction of this paper as a way to capture the reading problems observed among children and adults with ADHD that often manifest as comprehension difficulties. In reference to the college student population with ADHD and other adults, it refers to a limited age-appropriate reading and comprehension ability as compared to normal controls that has persisted throughout childhood and adulthood and is not the result of a brain injury or restricted access to reading instruction. The specific components of reading and comprehension will be addressed further in the paper. This approach is an attempt to consolidate the variety of terms (i.e., dyslexia; reading disorder; specific learning disorder, with impairment in reading) that often appear in the literature and vary in diagnostic criteria. For more information regarding the variety of terms used describing reading difficulties and the history of dyslexia, please see the works of Guardiola (2001), Lichtenstein and Klotz (2007), and the American Psychiatric Association’s (2013b) *Specific Learning Disorder Fact Sheet*. The following sections address developmental components of reading comprehension, basic models of reading comprehension, and reading research among children and adults with ADHD.

Reading comprehension is a complex construct affected by a child’s level of development, cognitive ability, and exposure to instruction (McCardle & Chhabra, 2004). Theoretical disputes among models and theories spurred national debate among educators, researchers and policy makers. In 1997, the United States Congress asked the National Institute of Child Health and Human Development (NICHHD) to commission a National Reading Panel (NRP) to review research in the field to determine evidence-based factors necessary for
successful reading instruction. The NRP’s (2000) review of over 100,000 articles from a variety of models and perspectives found the following elements necessary to the reading process:

- **Phonemic awareness**: listening comprehension skills that allow the listener to hear smaller sounds in within words.
- **Phonics**: an understanding that letters in the alphabet represent phonemes and those phonemes blend to form words.
- **Fluency**: the ability to recognize words with speed and efficiency to allow for greater comprehension capacity.
- **Vocabulary development**: acquisition of new words to improve understanding of text.
- **Comprehension strategies**: the ability to read text and understand the meaning of text.

**Phonemic Awareness.** In order to read English and other alphabetic writing systems successfully, early instruction needs to include instruction in phonemic awareness. Phonemes are the smallest units of spoken language. Phonemic awareness instruction focuses on analyzing and manipulating phonemes in speech, for example, “how to break the spoken word *teach* into three phonemes…or how to blend these phonemes to say the whole word” (Ehri, 2004, p. 154). Phonemic instruction is generally introduced during preschool instruction and continues throughout third grade (Moats & Tolman, 2009). Types of phonemic awareness instruction include (1) phoneme isolation, (2) phoneme identity, (3) phoneme categorization, (4) phoneme blending, (5) phoneme segmentation, (6) phoneme deletion, and (7) onset-rime manipulation. (Ehri, 2004).

**Phonics.** As a beginning reader is able to understand how to break down spoken words into phonemes, instruction incorporates letter-sound correspondence. Phonetic instruction teaches beginning readers to connect sounds of words to alphabetic symbols permitting word
reading and spelling (Ehri, 2004). The repeated experience of sounding out words contributes to automaticity and fluency, and learned words are stored in memory. Successful sight word reading requires knowledge of (1) phonemic segmentation, (2) letter-sound correspondences, and (3) spelling patterns as they relate to specific words, pronunciations and meanings (Ehri, 2004, p. 155). In the U.S., phonics instruction traditionally occurs in the first grade or earlier (Ehri, 2004, p. 175).

**Fluency.** Fluency of word recognition includes accuracy, appropriate speed, and proper expression (NICHHD, 2000, Chapter 3). Fluency allows a reader to focus on the meaning of words, rather than decoding the word, allowing for comprehension of text. Fluency measures often include measures of oral reading accuracy and rate. The relationship between oral reading accuracy and comprehension is strongest in first and second grades; however, by third grade other factors including comprehension strategies and vocabulary show greater relationships with comprehension (Kim et al., 2012; S. A. Stahl & Hiebert, 2005). Fluency is a vital comprehension tool for children as they shift from learning to read—to reading to learn, which generally occurs in the fourth grade (Chall, 1987; Kuhn & Stahl, 2003). Working memory and processing speed strongly predict oral and silent reading fluency ability among children with ADHD compared to normal controls (Jacobson et al., 2011). Among younger readers, oral reading fluency assessment measures are utilized to measure fluency development. As readers mature into higher grades, the majority of their reading occurs silently. Assessment addressing silent reading fluency include timed sentence verification tasks, where a student reads a sentence and determines if the statement is true or false (Denton et al., 2011).

**Vocabulary.** Vocabulary refers to meaning associated with individual words. Vocabulary types vary and are broadly categorized into two groups: receptive (i.e., what can be understood
when a person is presented text or oral communication) and productive (i.e., vocabulary used to produce speech or written text). Vocabulary grows and develops throughout the lifetime and plays a central role in reading development and comprehension (Kamil, 2004; NICHHD, 2000). Good readers in third through ninth grade read an estimated 1,000,000 words per year (Nagy & Anderson, 1984). Readers increase their vocabulary by exposure to new words through the text they read, direct instruction, and word exposure from other sources (Kamil, 2004; NICHHD, 2000).

**Comprehension.** Comprehension is a complex and active process where a reader interprets a text, its context, and its meaning through interaction with learned language. It is the result of accumulated knowledge and hierarchal reading skills. Comprehension is essential for successful reading and learning from print (Chall, 1987; NICHHD 2000). Comprehension is more successful when readers employ strategies, such as self-monitoring, in addition to their foundational knowledge of reading (NICHHD, 2000; S. A. Stahl, 2004). Reading comprehension also draws upon working memory and attentional control to allow the reader to construct meaning while reading (McVay, 2012; Unsworth & McMillan, 2013). McVay and Kane’s (2012) study reviews the literature and explains that working memory allows a reader to draw from old information while acquiring new information to integrate the meaning of a text. Attentional control allows a reader to resist distraction from external stimuli and internal stimuli to maintain focus on the act of reading and the topic of the material. Thus, attentional control and working memory ability both play an important role in comprehension. Readers with and without ADHD who experience reduced attentional control and/or working memory limitations experience difficulty with reading comprehension (Cain, Oakhill, & Bryant, 2004; Mahone, 2011; Sesma et al., 2009).
“Readers normally acquire strategies for active comprehension informally. Comprehension strategies are specific procedures that guide students to become aware of how well they comprehend what they read. It allows a reader to learn independently from text” (NICHHD, 2000, p. 232). Comprehension assessment includes a wide variety of measures that reflect a reader’s proficiency level. A common assessment method, cloze, presents the reader with a passage where a content word is intentionally left blank, and the reader is asked to determine the missing word (K. A. Stahl, 2009).

The Simple View of Reading and ADHD

The components of comprehension previously discussed are derived from reading research employing a variety of reading models. Historically, models of reading instruction in the United States fall into three categories: top-down, bottom-up, and integrative. Top-down models draw from a constructivist paradigm, which suggests that the reader processes text by obtaining cues and meanings from supportive text and referencing their own experiences (Goodman, 1988; Smith, 1971). Bottom-up models draw from a behavioral paradigm, which emphasizes a hierarchal learning process where the initial focus is placed on learning sounds, then words, and eventually skills necessary to comprehend larger text (Gough, 1972; LaBerge & Samuels, 1974). Criticism of both top-down and bottom-up models led to the development of interactive models, which seek to include components of both perspectives. The interactive models argue that readers engage in both top-down and bottom-up processes to derive meaning from text (Rosenblatt, 1994; Rumelhart, 1994).

Among childhood and adolescent reading research the simple view of reading (SVR) proposed by (Gough & Tunmer, 1986) has become a widely used and highly cited model employed in the United States, United Kingdom and other countries (García & Cain, 2014; Hoffman, 2009; Rose, 2005; Tighe & Schatschneider, 2014). The simple view of reading
employs top-down and bottom-up elements in reading. Their model argues that reading ability “equals the product of decoding and listening comprehension or \( R = D \times L\ C \), where each variable ranges from 0 (nullity) to 1 (perfection)” (Gough & Tunmer, 1986, p. 7). Decoding in this model is observed by measures that incorporate knowledge of the spelling-sound correspondence rules of English. Comprehension, or “knowing a language” (p.7) is represented by measures of listening comprehension. Under this model, reading difficulties are due to deficits in decoding (dyslexia), a lack of comprehension despite strong decoding skills (hyperlexia), or deficits in both resulting in “garden variety reading disability” (p.7). The SVR is supported by research showing that the combination of decoding and language comprehension accounts for a large portion of the variance in reading comprehension. “Estimates range from 45 to 85% across studies using a variety of samples and measures and using both concurrent and longitudinal analyses” (Conners, 2009, p. 592).

Some argue that the SVR is not a sufficient model for older readers who have sufficient decoding skills (Hoffman, 2009; Paris, Hamilton, Israel, & Duffy, 2009). This is because once decoding is successfully acquired, the model asserts that successful reading is then the singular result of listening comprehension and fails to account for other contributors to comprehension. Expanding the SVR to include additional variables such as attentional control and working memory has provided additional insight regarding the comprehension process by explaining additional variances of reading comprehension (Conners, 2009; Gremillion & Martel, 2012; Martinussen & Mackenzie, 2015).

The SVR has been utilized in reading research among adult populations; however, this research is limited (Tighe & Schatschneider, 2014). Two studies investigating the model among adults with low-literacy levels found that measures of decoding and language comprehension
accounted for 64% to 76% of the variance of reading comprehension (Braze, Tabor, Shankweiler, & Mencl, 2007; Sabatini, Sawaki, Shore, & Scarborough, 2010). A meta-analysis of adult literacy studies by Tighe and Schatschneider (2014) evaluated component reading skills to reading comprehension among adult readers with reading difficulties. In support of the SVR, it was observed that measures of “decoding (real word and pseudoword) and language comprehension emerged as important component reading skills” (p. 10) by exhibiting a strong relationship with reading comprehension. However, other components outside of SVR showed strong and moderate relationships with reading comprehension (morphological awareness, fluency, oral vocabulary knowledge, pseudoword decoding, and working memory, pseudoword decoding, orthographic knowledge, and phonological awareness). Expanding the SVR to address ADHD symptoms (working memory and attentional control) may provide insight into the mechanisms involved with how college students with ADHD comprehend text.

**Comparing Reading Abilities**

It is important to note here the differences in comprehension profiles between those with ADHD and those with a reading disability. The literature shows that reading performance among children with ADHD is generally lower than their peers without ADHD, and their reading profile does not fit that of a specific reading disorder (Brock & Knapp, 1996; Purvis & Tannock, 2000; Sesma et al., 2009). Children with a reading disorder generally experience difficulty with phonological processing or word recognition skills; children with ADHD often present with average word recognition skills and demonstrate fewer phonetic errors than students with reading disabilities (Kroese et al., 2000). It is thought that students with ADHD may experience reading difficulties due to deficits of associated with ADHD symptoms, rather than phonological limitations (Locascio et al., 2010; Mahone, 2011; Marzocchi et al., 2008; McInnes et al., 2003;
Purvis & Tannock, 2000; Sesma et al., 2009; Snow et al., 1998). Similar findings are reported in adolescent and adult studies.

Samuelson, Lundberg, and Herkner’s (2004) reading study among adolescent and adult males with and without ADHD found no differences between groups on measures of phonological processing and word decoding. Differences were observed on a measure of comprehension, where those with ADHD demonstrated weaker abilities, despite having intact phonological processing and word decoding skills. Adult ADHD reading studies also found similar results with differences observed on measures of comprehension but not on decoding measures (Barkley, 2008). These findings suggest that children, adolescents, and adults with ADHD experience comprehension difficulties despite having intact decoding skills, a different profile from those with reading disorders (Martinussen & Mackenzie, 2015).

This paper seeks to address ADHD symptoms (working memory and attention deficits) as they relate to reading comprehension among college students with ADHD and determine if component reading skills as suggested by the SVR (language comprehension and fluency) serve as mediators. This study does not address the component comprehension skills associated with decoding, such as phonological processing. This is because prior research shows that adolescents and adults with ADHD without comorbid reading disorders do not demonstrate deficits in areas of phonemic awareness (Barkley et al., 2008; Samuelsson et al., 2004; Willcutt et al., 2001).

Interventions addressing reading ability are prevalent among child-focused reading research (Galuschka, Ise, Krick, & Schulte-Körne, 2014; O'Connor & Vadasy, 2013). However, “there is a surprising lack of research on the effectiveness of the various instructional practices for adults seeking to improve their literacy skills. The lack of relevant research is especially striking given the long history of federal funding for adult education programs, albeit stretched
thin, and reliance on developmental education courses to remediate college student’s skills. Few studies of adult literacy focus on the development of reading and writing skills. There is also inadequate knowledge about assessment and ongoing monitoring of adult student’s proficiencies, weaknesses, instructional environments, and progress, which might guide instructional planning” (Lesgold, & Welch-Ross, 2012, p. 237). Major research efforts launched by the U.S. Department of Education, the National Institute of Child Health and Human Development, and others on the development of literacy in adolescence and adulthood are too new to have produced numerous peer-reviewed publications. “More research is needed with adolescent and adult populations to evaluate the effectiveness of instructional practices and specifically learning trajectories and the interaction of factors—cognitive, social, linguistic, economic, neurobiological—that may affect literacy development in subpopulations” (Lesgold & Welch-Ross, 2012, p. 237).

The lack of intervention effectiveness for college-students with ADHD and the limited knowledge about adult reading interventions provides a unique area to study. Addressing both of these areas of concern can lead to intervention design and evaluation directed at improving reading ability for adults with and without-ADHD.

In sum, successful reading comprehension builds off of foundational skills including phonetic awareness, phonics, fluency, vocabulary, and language comprehension. According to the SVR those with reading disorders do not demonstrate sufficient decoding skills and may not demonstrate sufficient language compression skills, which manifest as comprehension deficits. Children, adolescents, and adults with ADHD do not demonstrate the same decoding limitations as those with reading disorders. It is believed that cognitive domains associated with ADHD symptoms (working memory and attentional control) are related to poor comprehension ability. This paper seeks to determine if component reading skills mediate the relationship between
ADHD symptoms and reading comprehension as has been demonstrated in child and adolescent studies with the intent of further supporting intervention research.

**Working Memory, Attention, and Reading**

As noted in the introduction, the constructs being evaluated in this paper include components of reading comprehension (specifically decoding and language comprehension) and cognitive domains associated with ADHD (working memory and attention). This section addresses working memory, attention, and relevant ADHD reading research. Research suggests that weaknesses in working memory and attention associated with ADHD symptoms contribute to poor academic performance, and reading ability (APA, 2013a; Barkley et al., 2008; Mahone, 2011; Tripp & Wickens, 2009). Working memory and attention deficits are found among child, adolescent and adult populations with ADHD (Barkley et al., 2008; Karatekin, 2004; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Tripp & Wickens, 2009). Working memory and attention are necessary for successful reading comprehension (McVay, 2012; Unsworth & McMillan, 2013).

Working memory is described in multiple theoretical models (Baddeley & Hitch, 1974; Cowan, 1988; Engle, Kane, & Tuholski, 1999). Three popular working memory models include the work of Baddeley and Hitch (1974), Cowan (1988; 1995; 2005) and Engle, Kane and Tuholski (1999; 2002). Baddeley and Hitch’s model of working memory, with revisions, is the most empirically verified and researched of working memory models (Baddeley, 2003; Henry, 2012; Kintsch, Healy, Hegarty, Pennington, & Salthouse, 1999). A meta-analysis of working memory studies among children and adolescents with ADHD drew upon multiple models and found that working memory constructs could be categorized into four domains: verbal and spatial storage, and verbal and spatial storage with manipulation (Martinussen et al., 2005). Verbal storage and spatial storage draw upon the ability to hold information (maintenance) for
immediate recall. Participants with ADHD in this study were found to have the greatest working memory impairment with tasks that involved maintenance and manipulation over basic maintenance tasks. Assessments that address maintenance and manipulation include arithmetic operations, and ordering and updating presented information (Wager & Smith, 2003).

A consensus regarding the specific definition of attention is difficult to find in the literature, as it mingles with multiple research domains and scientific perspectives, not the least of which is the broad topic of executive functions (Cain, 2006; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Rucklidge & Tannock, 2002; Sesma et al., 2009; Shankweiler et al., 1999; van der Sluis et al., 2007; Whitney, Arnett, Driver, & Budd, 2001). According to ADHD research and theory, poor attentional control is due to executive functioning deficits that support and sustain goal related behaviors (Barkley, 1997). Thus, a student with ADHD may not be able to prohibit intrusive and distracting thoughts in order to maintain focus on the task at hand. Common inattentive behaviors among this population include failure to give close attention to detail, difficulty with organization, easily distracted by external stimuli, etc. (see Table 1 for additional examples; APA, 2013).

Common attention measures used in ADHD research and diagnostic practices include continuous performance tests, where a subject’s omission errors reflect attentional capacity (Riccio, Reynolds, & Lowe, 2001). Such neurocognitive measures designed to focus on very narrow cognitive abilities are helpful to research, but they are not always practical or helpful to those diagnosing or experiencing ADHD because they do not reflect impairment in relevant daily tasks (Barkley, 2011b). Thus diagnosis of ADHD does not depend on specific neurocognitive assessment results, instead it is grounded on behaviors and reports of behaviors that can be captured more accurately by using behavioral surveys and rating scales that measure ADHD.
symptom severity, such as the Barkley Adult ADHD-IV Rating Scale (Barkley, 2011a; Barkley et al., 2008; Martinussen & Mackenzie, 2015).

Working memory and attention share relationships with reading comprehension ability (McNamara, O'Reilly, Best, & Ozuru, 2006). This relationship is found among child, adolescent and adult populations with and without ADHD (Dally, 2006; Gremillion & Martel, 2012; Martinussen & Mackenzie, 2015). Samuelsson et al. (2004) argue that the severity of these deficits in working memory and attention control associated with ADHD are a contributing factor in the comprehension process. This is because “working memory serves as a buffer for the most recently read propositions in a text, enabling their integration to establish coherence, and holds information retrieved from long-term memory to facilitate its integration with the currently active text” (Cain et al., 2004, p. 31).

Mediation models have been employed to address how working memory and other cognitive processes interact with component reading skills and comprehension (Cain et al., 2004; Cromley & Azevedo, 2007; Gremillion & Martel, 2012; Martinussen & Mackenzie, 2015). They have also been used to address how component reading skills work directly and indirectly to facilitate comprehension (Cromley & Azevedo, 2007). Cromley and Azevedo’s (2007) study of normal ninth grade students model addresses “relationships among background knowledge, inferences, reading comprehension strategies, vocabulary, and word reading” (p. 311) and their direct and indirect effects on comprehension. Their findings “suggest that vocabulary and background knowledge interventions might be the best way to begin improving the academic reading comprehension of students like those in the sample” (p. 311). Their work provides a model to understand how many components of comprehension work together and separately in the reading process. However, Cromley and Azevedo express concern that their model does not
include cognitive variable (i.e., working memory) that may account for more variance in reading comprehension than those included in their study (p. 322).

McVay and Kane (2012) address the relationships among working memory tasks and attention tasks on reading comprehension. In their study of college students, they found that attention (mind wandering) partially mediated the relationship between working memory and comprehension. They found that students with weaker performance on working memory tasks also performed poorly on attentional control measures, and on reading comprehension tasks. They argue that both attentional control and working memory are necessary for successful comprehension and interventions focused on improving attentional control and working memory can be beneficial for improving comprehension among adult readers with reading comprehension difficulties. Given that these findings occurred among students without ADHD or diagnosed deficits in working memory and attentional control, it is likely that observations among those with ADHD would likely show a similar pattern.

In sum, mediation models have been helpful in conceptualizing how component reading skills and cognitive abilities influence reading comprehension skills. Gremillion and Martel (2012) and Martinussen and Mackenzie (2015) expanded the SVR via mediating models and found that decoding and language comprehension measures mediated the relationship between ADHD symptoms and comprehension among children and adolescents. The same may be true for college students with ADHD on measures of decoding and language comprehension. If the same pattern is found among college students with ADHD, the model may provide further support for an expanded SVR and to theoretically determine where interventions for reading comprehension should be focused.
Research Questions

ADHD literature has predominantly focused on children with the disorder. Growing literature addressing adults with ADHD has contributed to changes in the DSM-5, which addresses symptoms relevant to adults with the disorder. Despite being a focus of research for over 100 years, the cause of ADHD is still unknown. However, use of psychostimulant medications and multimodal approaches show successful symptom reduction among children and adults. Literature regarding treatment of adults is developing. College students represent a unique subset of the adult population with ADHD, and research among this population is limited.

Reading ability represents a specific area of limitation for those with ADHD. Children, adolescents, and adults with ADHD experience a higher rate of reading difficulties than the general population despite intact phonological abilities. It is likely that deficits in working memory and attention associated with ADHD negatively impact reading comprehension ability. ADHD reading studies focus mainly on children and adolescents. Generalizability of ADHD reading research to college students with ADHD is limited due to the developmental aspects of ADHD and reading ability as well as possible self-selection characteristics of college students with ADHD. Research investigating the nature of reading difficulties among college students with ADHD may support further development and implementation of appropriate reading interventions to help students with ADHD achieve in a university setting. Thus, this paper proposes the following questions regarding college students with ADHD:

1. Do college students with ADHD perform below average compared to national college norms on measures of silent reading fluency, language comprehension, and reading comprehension?

2. Do college students with ADHD perform below average compared to national college norms on measures of working memory?
3. Is the relationship between working memory and reading comprehension partially mediated by silent reading fluency and language comprehension?

4. Is the relationship between attention and reading comprehension partially mediated by silent reading fluency and language comprehension?
CHAPTER 3
METHODOLOGY

Introduction

The literature review addresses the limits of applying insights from reading/ADHD studies conducted with children and adults to college students. It also addresses relationships between symptoms of ADHD and reading comprehension difficulties. This chapter describes the features of the empirical analysis in this dissertation, including: participant characteristics, data collection protocols, measures, hypotheses, and data analysis.

Research Design

This study compares college students with ADHD to a national sample of college students to determine differences between groups on variables associated with reading comprehension. Further, the study addresses reading comprehension ability among college students with ADHD to determine if components of the simple view of reading mediate the relationship between ADHD symptoms and reading comprehension. Understanding how college students with ADHD compare to a national sample of college students may provide information useful in determining the focus of interventions and support for college students with ADHD.

Participants and Data Collection

This study uses archival data. The sample consists of college students assessed and diagnosed with ADHD at a university-based assessment clinic in the south eastern United States. All participant data was obtained with informed consent using protocols approved by the university’s Institutional Review Board (HSC No. 2015.16015; See Appendix A and B). A research team at the university collected data from the spring of 2010 to the spring of 2015. Enrolled college students who obtained an ADHD assessment, evaluation, and diagnosis comprise the study sample. The evaluation process addressed multiple life domains and used
multiple methods to determine accurate diagnosis. Participants completed forms addressing employment history and performance, social history, health history, driving behavior and history, and symptom severity during childhood and adulthood (Barkley, 2011). Each participant sat for a standard clinical interview to obtain further personal anecdotes supporting symptom presentation. Researchers also used other-informant information to supplement the diagnosis. Finally, researchers used psychometric testing to evaluate cognitive and academic abilities.

Diagnostic criteria comprise those found in the DSM-IV-TR (APA, 2000) and DSM-5 (APA, 2013) as well as criteria established by Barkley (2011b). Specifically, the research protocols use the following criteria: 1) Evidence that the client experienced symptoms of ADHD in childhood, 2) Onset of symptoms occurred no later than middle-school and impaired functioning in multiple settings, 3) Present symptom presentation impaired functioning across multiple settings, 4) No other explanation other than ADHD better accounted for symptom presentation. Graduate-level students pursuing a master’s degree in School Psychology or doctoral degree in Combined Counseling Psychology and School Psychology evaluated the study participants. Diagnosis of ADHD required consensus between the evaluator and the supervising licensed psychologist. Data collection occurred during the normal course of the evaluation and was coded systematically.

A priori power analysis was performed for question 1 using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). To obtain power of .80, while detecting an effect size of .5 (moderate effect) with an alpha of .01 (adjusted using Bonferroni’s correction), required 96 observations from each sample. A priori power analysis for question 2 was conducted using G*Power (Faul et al., 2007). To obtain power of .80, while detecting an effect size of .5 (moderate effect) with an alpha of .05, required 64 observations from each sample.
Preliminary power analysis was conducted for research question 3a using STATA, version 14 (StataCorp, 2015). Correlations among variables were derived from an available sample size of 230. The Monte Carlo Method was utilized to simulate the model for 1000 iterations with a sample of 395 participants (MacKinnon, Lockwood, & Williams, 2004; Preacher & Selig, 2012; Thoemmes, MacKinnon, & Reiser, 2010). The Monte Carlo estimates “power as the percentage of cases in which an estimate of interest is significantly different from zero” (Thoemmes et al., 2010, p. 510). This analysis found with a sample size of 395 that the model was significant 80% of the time at an alpha level of .05. This result is equal to the .80 level considered appropriate to reduce the risk of a Type II error, suggesting that sufficient power to detect an indirect affect can be obtained with approximately 395 participants (Cohen, 1992).

Due to a change in assessments used in the diagnosis process (DSM-IV to DSM-5 criteria) only 370 cases could be coded for analysis. The sample consists of 370 college students. Nine cases were removed from the study because those participants were older or younger than the normed, college-aged comparison group used. Of the final 361 college students included in this study, 14% were freshman, 18% sophomores, 24% juniors, 24% seniors, and 19% graduate students. The self-identified gender composition was 46% female and 54% male. The self-identified ethnic composition is 65% Caucasian, 18% Hispanic, 10% African American, 2% Asian, and 5% identified as ‘other’. Researches diagnosed 52% of the sample as ADHD-PI (Primarily Inattentive Type) and 47% ADHD-C (Combined Hyperactive and Inattentive Type). They identified learning disabilities among 9% of the sample. Of that 9%, reading disorders accounted for 2%, math disorders 2%, writing disorders 1%, and multiple learning disorders 4%. Depression was diagnosed in 21% of the sample, and anxiety disorders were diagnosed in 24%. The mean age of participants was 23 (SD = 5.14, range 18-43, median 21, mode 19). Specific information
regarding GPA, SAT and ACT scores was not gathered on this sample; however, all participants in the study students at a competitive top-tier school. Admission criteria as of 2017 included “graduating from a regionally accredited high school (or the equivalent) with specific academic courses, a cumulative grade point average based on these courses, and test scores. Additional factors include the rigor and quality of courses and curriculum taken, strength of senior schedule, math level in senior year, number of years in a sequential world language, and the written essay” (Florida State University, 2017).

I use the WJ III COG NU and WJ III ACH NU data to reference a comparison sample (Schrank et al., 2001). The full sample from Schrank et al. (2001) uses 8,818 subjects. I compare the data from this study to the subsample of college/university students from their research—1,165 undergraduate and graduate students attending 2-year (190 subjects) and 4-year institutions (975 subjects). The ethnic composition of the WJ college sample is 83% Caucasian, 8% African American, 13% American Indian and 4% Asian and Pacific Islander. Of the total college/university sample, 8% identified as Hispanic (McGrew, & Woodcock, 2001). Schrank et al. (2001) collected measures for both the WJ-III tests of Achievement and WJ-III Test of Cognitive abilities. The ADHD college students who participated in this study also completed those tests, thus allowing for direct comparison.

To determine if the age range of college students with ADHD was comparable to the WJ-III college subsample I consulted multiple technical manuals (McGrew & Woodcock, 2001; Schrank, McGrew, & Woodcock, 2001) and contacted Houghton Mifflin Harcourt, the publishing company of the WJ-III. Despite these efforts, I could not identify the specific age range of the college student subsample used in the norming process. I consulted data from the U.S. Department of Education’s National Center for Education Statistics (2009) National Post-Secondary Student Aid Survey to
determine a reasonable age range for this comparison group. For students in graduate school (masters level and doctoral level combined) in 2000, the average age was 33. This report lacked information providing the range of ages of graduate students. I reviewed the age distribution of participants in the study and chose to remove students over the age of 45. See Appendix C for age distribution before and after case removal.

Measures

Working Memory. Working memory scores for the normed comparison sample are measured using the Woodcock-Johnson III Tests of Cognitive Abilities, Normative Update (WJ III COG NU). The WJ COG III NU is an individually administered assessment of cognitive abilities that has been normed on a large national sample of college students (Schrank et al., 2001). The WJ III COG NU provides a variety of subtests for the examiner to use to address areas of cognitive functioning. The Working Memory cluster score includes two subtests: Numbers Reversed and Auditory Working Memory. During test development and norming, the subtests demonstrate high validity and reliability (2001). Both subtests were the product of years of research utilizing the Cattell-Horn-Carroll theory of cognitive abilities (CHC theory) and are calculated by confirmatory factor analysis. To establish reliability, Schrank et al. (2001) analyzed the subtests using the split-half method. Numbers Reversed yielded a median reliable score of .87 with a standard error of the mean (SEM) ranging from 4.63 to 5.66 for ages 18-39; and Auditory Working Memory yielded a median reliably score of .97 with a SEM ranging 5.11-6.76 for subjects ages 18 through 29. Overall, the cluster score for Working Memory (WM) achieved a reliability score of .91 with a SEM across the sample of 4.5. The standard error for Working Memory ranged from 4.24 to 4.74 for subjects ages 18-39 (McGrew & Woodcock, 2001; Schrank et al., 2001).
**Reading Comprehension, Language Comprehension, and Fluency.** The Woodcock-Johnson III Tests of Achievement, Normative Update (WJ III ACH NU) captures three constructs: reading comprehension, language comprehension and fluency. Reading comprehension was measured using the subtest Passage Comprehension (PC). Language comprehension was measured using the subtest Listening Comprehension (LC). Fluency was measured by the subtest Reading Fluency. The WJ III ACH NU is an individually administered assessment of achievement that has been normed on a large national sample of college students (Schrank et al., 2001). The assessment includes 12 subtests in the standard battery. The WJ III ACH NU demonstrates high factorial validity based upon the Cattel-Horn-Carroll factor model supported by a confirmatory factor analysis and good convergent validity with the Wechsler Individual Achievement Test’s Reading Comprehension subtest at .79. Test-retest reliability for Passage Comprehension was .92 with a standard error of measure ranging from 4.63 to 7.44 for ages subjects age 18 through 39 (McGrew & Woodcock, 2001). The Passage Comprehension test measures the individual’s capacity to create the mental representations provided by the text while reading (Wendling, Schrank, & Schmitt, 2007). It requires the participant to read a small paragraph with a blank space. The participant is asked to read the passage and provide the missing word. Listening comprehension is measured using the subtest Understanding Directions. This assessment’s test-retest median reliability is .83 with a standard error of 6.20 for the entire normed sample (Woodcock & McGrew, 2001). This listening comprehension task requires the participant to listen and give attention to a sequence of auditory cues then follow directions provided within the cues. It is a measure of listening abilities and language development. The silent reading fluency task evaluates reading and semantic processing speed. Participants are
asked to read printed statements rapidly and respond true or false to each statement. The median test-retest reliability is .90 with a standard error of 4.79 for the entire normed sample.

Attention. The Barkley Adult ADHD-IV Rating Scale (BAARS-IV) is a self-report “empirically developed scale, based on both the diagnostic criteria for ADHD in the fourth edition (text revision) of the Diagnostic and Statistical Manual of Mental Disorders” and historical research (Barkley, 2011a, p. 5). It is designed and normed for adults ages 18-81. Participants are asked to rank their level of severity on a variety of examples that address multiple domains of ADHD including: inattention, hyperactivity, impulsivity and sluggish-cognitive tempo. Each example allows the participant to select the following: never or rarely, sometimes, often, and very often. When scoring the BAARS-IV, never or rarely is observed as 0, sometimes as 1, often as 2, and very often as 3. Scores of 2 and 3 are considered symptomatic of abnormal behavior compared to normal controls. Inattention severity, observed as the ADHD Inattention scale on the BAARS-IV, includes statements such as: Have difficulty sustaining my attention on tasks or fun activities, avoid dislike or am reluctant to engage in tasks that require sustained mental effort, and I am easily distracted by external stimuli or irrelevant thoughts. As a measure of inattention, scores from the nine inattentive factors were totaled, with a possible range of 0 to 27, with higher scores representing more impairment. In this capacity, this measure addresses inattention severity as it relates to ADHD inattentive symptoms not ADHD severity specifically.

Research Questions

Given the previous literature on childhood and adult populations with ADHD and their reading abilities and the limited information available addressing college students with ADHD on this topic, this study poses the following research questions:
1. Do college students with ADHD perform below average compared to national college norms on measures of silent reading fluency, language comprehension, and reading comprehension?

2. Do college students with ADHD perform below average compared to national college norms on measures of working memory?

3. Is the relationship between working memory and reading comprehension partially mediated by silent reading fluency and language comprehension?

4. Is the relationship between attention and reading comprehension partially mediated by silent reading fluency and language comprehension?
CHAPTER 4
DATA ANALYSIS

The archival data set was coded into Stata, version 14 (StataCorp, 2015). I evaluated the data for outliers and missing observations. I corrected missing or inaccurate data by re-evaluating the participants’ original hand-written file. I did not use any missing variables or inaccurate data that could not be corrected in this way. I used a total of 361 cases. The sample size used to address each question varies from 317-358, where observations with missing data relevant to the research question were omitted from the analysis. I note the sample sizes for each question in the results section for each question. See Table 3 for descriptive statistics for the study measures.

Table 3

Descriptive Statistics for the Study Measures

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>M(SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Comprehension</td>
<td>342</td>
<td>104.42 (9.28)</td>
<td>68-133</td>
</tr>
<tr>
<td>Working Memory</td>
<td>326</td>
<td>105.25 (13.76)</td>
<td>61-144</td>
</tr>
<tr>
<td>Reading Fluency</td>
<td>345</td>
<td>100.31 (12.77)</td>
<td>68-142</td>
</tr>
<tr>
<td>Language Comprehension</td>
<td>340</td>
<td>99.26 (12.01)</td>
<td>61-127</td>
</tr>
<tr>
<td>Attention</td>
<td>357</td>
<td>18.29 (5.39)</td>
<td>9-36</td>
</tr>
</tbody>
</table>

Research Questions 1 and 2

Research Question 1. Do college students with ADHD perform below average compared to national college norms on measures of reading fluency, language comprehension, and reading comprehension?

Research Question 2. Do college students with ADHD perform below average compared to national college norms on measures of working memory?
To address questions 1 and 2 a one-sided independent-samples t-test was run to determine if there were differences in silent reading fluency, language comprehension, reading comprehension and working memory. The sample size of college students with ADHD for each variable ranged from 326 to 345. The national college student data sample size for each variable was 1,165. The mean for the national sample on each variable is 100 with a standard deviation of 15. There were no significant outliers in the data, as assessed by inspection of a boxplot. Assessment scores for each variable were normally distributed (See Appendix C for histograms of variable distribution). GraphPad (2017) and Social Science Statistics (Stangroom, 2017) online statistical calculators were used to calculate the results. Welches t-test statistic was not utilized to account for the unbalanced sample sizes and between the college ADHD sample and the national normative sample because it was determined that the sample sizes were sufficiently large to protect against a type 1 error. However, these results can be viewed in Appendix G.

The results of the one-sided independent-samples t-test show that assessment scores from college students with ADHD were not significantly lower on silent reading fluency compared to the national norm \((n = 345, M = 100.31, SD = 12.77)\). The ADHD sample scored .31 points greater than the national norm \(t(1517) = .53, p = .30\). College students with ADHD did not score significantly lower on language comprehension compared to the national norm \((n = 340, M = 99.26, SD = 12.09)\). The ADHD sample scored .74 points less than the national norm \(t(1511) = .61, p = .27\). College students with ADHD did not score significantly lower on reading comprehension compared to the national norm \((n = 342, M = 104.42, SD = 9.28)\). In fact, the ADHD sample scored 4.42 points greater than the national norm \(t(1514) = 5.26, p < .001\). College Students with ADHD did not score significantly lower on working memory compared to the national norm \((n = 326, M = 105.25, SD = 13.76)\). In fact, the ADHD sample scored 5.25 points
greater than the national norm $t(1499) = 5.56, p < .001$. To determine if the differences seen with reading comprehension and working memory were significantly higher than the national norm, a two-tailed test was subsequently performed. Results show that college students with ADHD performed significantly higher on reading comprehension ($p < .001$, 95% CI, 2.788 to 6.11) and working memory ($p < .001$, 95% CI, 3.27 to 6.85). Sample size for questions 1 and 2 were both greater than those stated in the a priori power analysis. Power achieved utilizing the larger sample populations is >.99 detecting an effect size of .5 with an alpha of .01 for the analyses performed for question 1 and 2.

**Research Questions 3 and 4**

Research Question 3. Is the relationship between working memory and reading comprehension partially mediated by silent reading fluency and language comprehension?

Research Question 4. Is the relationship between attention and reading comprehension partially mediated by silent reading fluency and language comprehension?

Participant scores on working memory, attention, listening comprehension, reading comprehension, and fluency were evaluated using mediating models. Simple mediation was initially selected to determine if silent reading fluency and/or language comprehension were playing a mediation role in the relationship between ADHD symptoms and reading comprehension. A limitation to simple mediation is that a direct comparison of the mediators cannot be observed. To obtain a direct comparison of the mediating models, parallel multiple mediation was introduced. Parallel multiple mediation was selected over other mediation models because it is not assumed that the mediators causally influence each other in this study.

---

1 Because simple mediation was originally proposed and accepted in the dissertation prospectus, it was decided to keep that in the dissertation for the purposes of training, with the understanding that it was not necessary given that multiple mediation was also performed. That analysis will be deleted when the dissertation is converted to a manuscript.
and it provides a formal comparison of the size of the indirect effects from the mediators (Hayes, 2013, Chapter 5). Thus, research questions three and four are examined first with simple mediation and then with parallel multiple mediation. Analyses were initially completed using a macro designed to run mediating analysis in SPSS called PROCESS version 2.13 (Hayes, 2013). However, due to remote access limitations to SPSS, final model and post-hoc power analysis was completed using STATA, release 14 (StataCorp, 2015). Post hoc power analysis for questions 1 and 2 were completed using G*Power (Faul et al., 2007).

To complete the simple mediation analyses in questions 3 and 4, assumptions specific to linear regression were evaluated among participating variables including: normal distribution, linearity, independence, normality of the observed scores, normal distribution of residuals, and homoscedasticity (see Appendices C, D and E). The Bruesch-Pagan test was run to analyze heteroscedasticity for variables included in the mediation models ($p = .111$). The results were not significant at the .05 level, meaning I fail to reject the null hypothesis, and that the data reflects homoscedasticity.

To evaluate the simple mediation model used in questions 3 and 4 (Figure 1) I performed the following steps: (1) Estimate the total effect (C) of X on Y using linear regression; (2) Estimate the indirect effect (ab) of X on Y by regressing $M_1$ on X to obtain $a_1$, and Y on $M_1$ to obtain $b_1$ and then multiplying $a_1$ by $b_1$; (3) Calculate the direct effect of X ($c'$) by regressing Y on X controlling for the indirect effect of $M_1$; (4) The total effect is obtained by adding the indirect effect of $M_1$ ($a_1 \cdot b_1$) and the direct effect of Y on X ($c'$). In this simple mediation model the total effect (C) is equal to the regression coefficient of X on Y performed in step 1. (5) Confidence intervals are used to make inferences about each of the observed effects; (6) Post-hoc power analysis are used on each model via the Monte Carlo Method (MacKinnon et al., 2004) to
provide additional information regarding risk of type II error (incorrectly retaining a false null hypothesis).

To evaluate the multiple mediation model (Figure 2) I performed the following steps: (1) Estimate the total effect (C) of X on Y using linear regression; (2) Estimate the indirect effect ($a_1 \cdot b_1 + a_2 \cdot b_2$) of X on Y by regressing $M_1$ on X to obtain $a_1$, and Y on $M_1$ to obtain $b_1$ and then multiply $a_1$ and $b_1$. I then estimate the indirect effect of $M_2$ by regressing $M_2$ on X to obtain $a_2$, and Y on $M_2$ to obtain $b_2$, then multiply $a_2$ and $b_2$; (3) Calculate the direct effect of X ($c'$) by regressing Y on X controlling for the indirect effect of $M_1$ and $M_2$; (4) The total effect is obtained by adding the indirect of effect of $M_1$ and $M_2$ ($a_1 \cdot b_1 + a_2 \cdot b_2$) and the total direct effect of Y on X ($c'$); (5) Confidence intervals are used to make inferences about each of the observed effects; (6) Post-hoc power analysis are used on each model via the Monte Carlo Method (MacKinnon et al., 2004) to provide additional information regarding risk of type II error (incorrectly retaining a false null hypothesis).

Figure 1. Simple Mediation Model. Taken from “Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-based Approach,” by A. Hayes, 2013, pg. 91. Copyright 2013 by Guilford Press.
Question 3

The results for question 3 are described in three parts, 1) the results of the simple mediation model with silent reading fluency as the mediating variable, 2) the results of the simple mediation model with language comprehension as the mediating variable, and 3) the results of the multiple mediating model with language comprehension and fluency as mediating variables.

Results for Question 3a: Working Memory through Silent Reading Fluency on Reading Comprehension—Simple Mediation Model

The simple mediation model was employed to show how silent reading fluency \( (n = 315) \) mediates the relationship between working memory and reading comprehension. As Figure 3 illustrates, the regression coefficient \( (C) \) between working memory and reading comprehension is statistically significant \( (.257, p < .001) \), as is the regression coefficient \( (a_1) \) between working
memory and silent reading fluency (.359, p < .001). The regression coefficient (b1) between silent reading fluency and reading comprehension is also statistically significant (.176, p < .001).

The indirect effect of working memory on reading comprehension through silent reading fluency is (.359)(.176) = .063. The effect of working memory on reading comprehension controlling for silent reading fluency (c’) is .193 (p < .001). The significance of this indirect effect is calculated using bootstrapped standard errors. Unstandardized indirect effects were computed for each of 1,000 bootstrapped samples. The bootstrapped unstandardized indirect effect for silent reading fluency is .063 (statistically significant), and the 95% confidence interval ranged from .027 to .099 and is statistically significant. Post hoc power analysis using Monte Carlo bootstrapping finds power to detect a significant indirect effects in the mediating model equal to .977 for the sample size of 315 with an alpha of .05.

**Results for Question 3b: Working Memory through Language Comprehension on Reading Comprehension—Simple Mediation Model**

The simple mediation model was employed to show how language comprehension (n = 312) mediates the relationship between working memory and reading comprehension. As Figure 4 illustrates, the regression coefficient (C) between working memory and reading comprehension is statistically significant (.258, p < .001). The regression coefficient (a1) between working memory and language comprehension is statistically significant (.441, p < .001). The regression coefficient (b1) between language comprehension and reading comprehension is statistically significant (.222, p < .001).

---

2 The Monte Carlo bootstrapping is programmed as follows: First, a random bootstrapped sample of the data is taken, with replacement, equal to the sample size. (Here, for the model where working memory is mediated solely through reading fluency, the sample size is 315). Second, the mediating model is estimated and the p-value of the indirect effect of working memory (through Reading Fluency) is calculated. Third, this process is repeated 1,000 times. Fourth, the proportion of times—out of the 1,000 samples—that an effect is found significant at the .05 level is the reported power.
Results for Question 3c: Working Memory Multiple Mediating Model

Parallel multiple mediation was used to compare the mediating effects of silent reading fluency and language comprehension on the relationship between working memory and reading comprehension. The results show that the relationship between working memory and reading comprehension is partially mediated by silent reading fluency and language comprehension as observed in the simple mediation models. As Figure 5 illustrates, the regression coefficient (C) between working memory and reading comprehension (.256, $p < .001$) is statistically significant, as is the regression coefficient ($a_1$) between working memory and silent reading fluency (.363, $p < .001$). The regression coefficient ($a_2$) between working memory and language comprehension (.437, $p < .001$) is statistically significant. The regression coefficient ($b_1$) between silent reading fluency and reading comprehension is statistically significant (.142, $p < .003$). The regression coefficient ($b_2$) between language comprehension and reading comprehension (.174, $p = .001$) is statistically significant.

The indirect effect of working memory through language comprehension on reading comprehension is (.437)(.174) = .076. The indirect effect of working memory through silent reading fluency on reading comprehension is (.363)(.142) = .052. The total indirect effect of working memory through language comprehension and silent reading fluency is .076 + .052 ≈ .127. The effect of working memory on reading comprehension controlling for language comprehension and reading fluency (c’) is .128. Confidence intervals for indirect effects were calculated from 1,000 bootstrapped samples. The 95% confidence interval ranged from .073 to .182. Thus, the indirect effect is statistically significant. Post hoc power analysis using Monte
Carlo bootstrapping\(^3\) finds power to detect a significant combined indirect effect in the dual mediating model equal to .999 for the sample size of 310 with an alpha of .05.

The indirect effect of working memory through language comprehension on reading comprehension is \((.441)(.222) = .098\). The effect of working memory on reading comprehension controlling for language comprehension \((c')\) is .160 \((p < .001)\). The significance of this indirect effect is calculated using bootstrapped standard errors. Unstandardized indirect effects were computed for each of 1,000 bootstrapped samples. The bootstrapped unstandardized indirect effect of working memory through language comprehension is .098, (statistically significant) and the 95\% confidence interval ranged from .049 to .148. Post hoc power analysis using Monte Carlo bootstrapping\(^4\) finds power to detect a significant indirect effect in the mediating model equal to .991 for the sample size of 312 with an alpha of .05.

\[\text{Fluency} \rightarrow \begin{align*}
\text{Working Memory} & \rightarrow \text{Reading Comprehension} \\
& \quad .359^* \\
& \quad .257^* (.194^*) \\
& \quad .176^*
\end{align*}\]

\textbf{Figure 3}. Regression coefficients for the relationship between working memory and reading comprehension as partially mediated by silent reading fluency. The regression coefficient \((c')\) between working memory and reading comprehension controlling for silent reading fluency is shown in parenthesis.

\(* p < .001.\)

---

\(^3\) See footnote 1.
\(^4\) See footnote 1.
Figure 4. Regression coefficients for the relationship between working memory and reading comprehension as partially mediated by language comprehension. The regression coefficient \(c'\) between working memory and reading comprehension controlling for language comprehension and silent reading fluency is shown in parenthesis. *\(p < .001\).

Figure 5. Regression coefficients for the relationship between working memory and reading comprehension as partially mediated by language comprehension and silent reading fluency. The regression coefficient \(c'\) between working memory and reading comprehension controlling for language comprehension and silent reading fluency is shown in parenthesis. The indirect effect through fluency is .052 and the indirect effect through language comprehension is .076. *\(p < .001\).
**Question 4**

The results for question 4 are described in three parts, 1) the results of the simple mediation model with silent reading fluency as the mediating variable, 2) the results of the simple mediation model with language comprehension as the mediating variable, and 3) the results of the multiple mediating model with language comprehension and silent reading fluency as mediating variables.

**Results for Question 4a: Attention through Silent Reading Fluency on Reading comprehension—Simple Mediation**

The simple mediation model was employed to show how silent reading fluency (n = 333) mediates the relationship between attention and reading comprehension. As Figure 6 illustrates, the regression coefficient (C) between attention and reading comprehension (.115, p = .291) is not statistically significant at the .05 or .01 level, nor is the regression coefficient (a₁) between attention and silent reading fluency (.217, p = .103). The regression coefficient (b₁) between silent reading fluency and reading comprehension (.236, p < .001) is statistically significant.

The indirect effect of attention through silent reading fluency on reading comprehension is (.217)(.236) = .051. The effect of attention on reading comprehension controlling for silent reading fluency (c’) is .063 (p = .519). The significance of this indirect effect was completed using bootstrapping procedures. Unstandardized indirect effects were computed for each of 1,000 bootstrapped samples. The bootstrapped unstandardized indirect effect for silent reading fluency is .051, and the 95% confidence interval ranged from -.014 to .116, further demonstrating nonsignificant results. Post hoc power analysis using Monte Carlo bootstrapping
found that power to detect an indirect with a sample size of 333 is .328. A sample size of at least 500 is necessary to detect significance at .80 with an alpha of .05.

Figure 6. Regression coefficients for the relationship between attention and reading comprehension as partially mediated by silent reading fluency. The regression coefficient between attention and reading comprehension controlling silent reading fluency (c') is shown in parenthesis. *p < .001.

Results for Question 4b: Attention through Language Comprehension on Reading comprehension—Simple Mediation

The simple mediation model was employed to show how language comprehension (n = 327) mediates the relationship between attention and reading comprehension. The model shows the relationship between attention and reading comprehension is not partially mediated by language comprehension (n = 327). As Figure 7 illustrates, the regression coefficient (C) between attention and reading comprehension (.089, p = .405) is not statistically significant, nor is the regression coefficient (a1) between attention and language comprehension (-.035, p = .794). The regression coefficient (b1) between language comprehension and reading comprehension (.298, p < .001) is statistically significant.

The indirect effect of attention through language comprehension on reading comprehension is (-.035)(.298) = -.011. The effect of attention on reading comprehension

---

Simulation of this model (and the following models with attention as the independent variable) with increased sample sizes and relative power is provided in Appendix F: Power Analysis.
controlling for language comprehension \((c')\) is .099 \((p = .294)\). The significance of this indirect effect is determined using bootstrapping procedures. Indirect effects were computed for each of 1,000 bootstrapped samples. The bootstrapped unstandardized indirect effect for listening comprehension is .011, and the 95% confidence interval ranged from -.090 to .068 further demonstrating nonsignificant results. Post hoc power analysis using Monte Carlo bootstrapping finds power to detect a significant indirect effects in the mediating model equal to .074 for the sample size\(^7\) of 327 with an alpha of .05.

Figure 7. Regression coefficients for the relationship between attention and reading comprehension as partially mediated by language comprehension. The regression coefficient \((c')\) between attention and reading comprehension controlling language comprehension is shown in parenthesis.  

*\(p < .001\).

Results for Question 4c: Attention Multiple Mediating Model

Parallel multiple mediation was used to compare the mediating effects of silent reading fluency and language comprehension on the relationship between attention and reading comprehension. The results show that the relationship between attention and reading comprehension is not partially mediated by silent reading fluency and language comprehension (\(n=324\)). As Figure 8 illustrates, the regression coefficients \((C)\) between attention and reading comprehension (.116, \(p = .275\)) and \((a_1)\) attention and silent reading fluency (.237, \(p = .097\)) are not statistically significant. The regression coefficient \((b_1)\) for language comprehension and

---

\(^6\) See footnote 1  
\(^7\) See footnote 5 and Appendix F: Power Analysis
reading comprehension is statistically significant (.153, \( p < .001 \)). The regression coefficient \( (a_2) \) between attention and language comprehension is not statistically significant (.015, \( p = .913 \)). The regression coefficient between language comprehension \( (b_2) \) and reading comprehension is statistically significant (.226, \( p < .001 \)). The effect of attention on reading comprehension controlling for silent reading fluency and language comprehension \( (c') \) is .076 and is not statistically significant \( (p = .410) \).

**Figure 8.** Regression coefficients for the relationship between attention and reading comprehension as partially mediated by language comprehension and silent reading fluency. The regression coefficient between attention and reading comprehension controlling for language comprehension and silent reading fluency is shown in parenthesis. *\( p < .001 \)

The indirect effect of attention through language comprehension on reading comprehension is (.014)(.226) = .003. The indirect effect of attention through silent reading fluency on reading comprehension is (.237)(.153) = .036. The total indirect effect of attention through language comprehension and silent reading fluency is .036 + .003 \( \approx .040 \). Confidence intervals for indirect effects were calculated from 1,000 bootstrapped samples. The 95% confidence interval ranged from -.054 to .133 and is not statistically significant.
Post hoc power analysis using Monte Carlo bootstrapping\textsuperscript{8} finds power to detect a significant combined indirect effect in the dual mediating model equal to .254 for the sample size of 324 with an alpha of .05. See Appendix F for power analysis with increased sample sizes.

\textsuperscript{8} See footnote 1.
CHAPTER 5
DISCUSSION

This study compared college students with ADHD to a national sample of college students to determine differences between groups on variables associated with reading comprehension. Furthermore, the study addressed reading comprehension ability among college students with ADHD to determine if components of the simple view of reading mediate the relationship between ADHD symptoms and reading comprehension. The results of this study seek to provide information that guides the development of reading interventions and academic support for college students with ADHD.

Major Finding 1: Comparison of ADHD College Students to National Norms

The first finding is that college students with ADHD did not score lower than the normative sample of college students on measures of working memory, reading comprehension, language comprehension, and silent reading fluency. College students with ADHD actually scored significantly higher than the normed sample on measures of reading comprehension and working memory and equally well as the normed sample in areas of silent reading fluency and language comprehension. This opposes the prediction. This is a unique finding among this population because other ADHD populations generally underperform significantly in these areas using a variety of reading measures (Barkley et al., 2008; Brock & Knapp, 1996; Cain et al., 2004; Mahone, 2011; Purvis & Tannock, 2000; Samuelsson et al., 2004; Sesma et al., 2009). Measures used in childhood, adolescent, and adult ADHD studies that have demonstrated that those with ADHD generally underperform their non-ADHD peers include the following: letter-word identification and word attack from the Woodcock-Johnson Test of Achievement, measures of comprehension addressing macro and micro skills (i.e., identifying main ideas and completing cloze sentences), processing speed and rapid automatized naming tasks, Wide Range

The measures used in this study include were taken from the Woodcock-Johnson III Tests of Cognitive Abilities, Normative Update and Woodcock-Johnson III Tests of Achievement, Normative Update. These measures are well known and well researched. They were selected for the study because of their

a) strong reliability and validity as a research instrument.

b) strong reliability and validity as a clinical tool in diagnosis.

c) fit for use in the theoretical model employed (the simple view of reading).

The results demonstrated by these measures are statistically significant, but they also must be considered significant in context of the WJ III scores to be considered meaningful. Scores on the WJ III measures that range between 90 and 110 are considered in the Normal range. The mean for reading comprehension from the normed sample was 100, for the study sample it was 104.42. The mean for working memory from the normed sample was 100, for the study sample it was 105.25. These differences show that the college students with ADHD outperformed the normed sample, but they still performed within the normal range and not in the above average range.

These results suggest that those with ADHD perform within the same range of functioning as those without ADHD on the measures used in this study. This suggests that those with ADHD in a college setting do not have difficulties with reading comprehension compared to those without ADHD on the constructs evaluated with the selected measures. Consideration may be given to
the fact that college students may be a unique subgroup of the population with ADHD and are better readers, hence they are attending college. Further, the college students in this study are also attending a competitive top-tier state institution. This may further distinguish them from the adult population with ADHD. Additionally, it is possible that there were circumstances specific to the measures used, the testing situation, or the sample, that produced these results. The next section discusses those possibilities.

The assessment measures used included four measures from the WJ III batteries: working memory (a cluster score including two subtests: Numbers Reversed and Auditory Working Memory), reading comprehension (as measured by the subtest Passage Comprehension), language comprehension (as measured by the subtest Listening Comprehension), and fluency (as measured by the subtest Reading Fluency, a silent reading task). While these tests show strong reliability and validity, they may not be the best tools to measure the reading difficulties those with ADHD face in a college setting. For example, the reading comprehension measure (Passage Comprehension) asks the participant to read a short passage and fill in the missing word in the paragraph. It does not ask the participant to hold a large amount of information in working memory, commit that information to memory, and then relay that information to another party, such as a professor or peer in study group. However, a measure, such as the Nelson-Denny Reading Test (1993) that incorporates these additional components of reading comprehension may more accurately capture the differences between those with ADHD in a college setting and those without ADHD in a college setting. The results of this study provide evidence that college students with ADHD do not show impairment on a reading comprehension measure based on filling in cloze sentences. Those working with college students with ADHD may consider that
performance on a standardized measure, like the one used here, may not fully capture impairment.

Additionally, caution should be taken with assuming that college students with ADHD perform as well as their non-ADHD peers outside of this testing environment because in the testing environment distractions were limited and an evaluator consistently prompted reading behavior. These influential behaviors likely positively affected scores because they inhibited inattentive behaviors. One of the major symptoms of ADHD is the inability to control attention. A setting where a college student with ADHD is expected to focus, read, comprehend, and process new and challenging information where there are distractions common to a university experience (i.e., roommates, noises in the library, social events, etc.) will likely yield poorer comprehension results than in the setting created in this study. Here the evaluator worked with the participant in a small room with few distractions. The requirement to read and comprehend was time-bound, and if the participant became distracted, the participant was cued back to the task at hand. In this setting, the study shows that college students with ADHD can perform within the normal range on a simple measure of comprehension in a non-distractible, structured, time-bound and monitored environment.

This finding has strong implications for those designing interventions and supports for college students with ADHD and their reading comprehension difficulties. The presence of external cues to stay on task, minimal interruptions and distractions, and a time-bound structured process may be what allowed students with ADHD to perform similarly to their peers without ADHD in the present study. An ADHD coach may find it beneficial when working with clients who struggle with comprehension to re-create as much of the testing environment used here as
possible ways to help the client maximize reading comprehension. ADHD coaches may encourage their clients to

a) read in non-distracting environments.

b) divide large reading tasks into smaller more manageable tasks.

c) ask for a roommate or peer to check in and encourage the client to return to the task at hand if they become distracted.

d) design reminders (i.e., phone alarms, kitchen timers) help remind the client to stay focused for a set amount of time.

e) have the client report what they have taken from the reading to another person.

The silent reading fluency task may also be affected by the testing environment. This task asks the participant to quickly read short sentences (i.e., Insects have many wheels. YES/NO) and circle yes if the statement is correct or no if the statement is incorrect. This is a timed task that is monitored by the evaluator. It measures the speed and accuracy of basic silent reading fluency, but it does not address fluency with novel, complex college-level text. Similar to the results found with the reading comprehension task, the finding that college students with ADHD do not show deficits in fluency may not be accurate with college-level reading in a non-testing environment.

The language comprehension task asks a participant to listen to a set of instructions specific to a picture and then point to objects in a specific order. Given the difficulty those with ADHD have in areas of attention, it is likely that the timed nature of the task at hand and the prompts presented by the evaluator may have positively influenced the performance on this task.
Finally, working memory was found to be an area of normal functioning for those with ADHD in this study. This is surprising because working memory deficits are associated with ADHD (Martinussen et al., 2005; Samuelsson et al., 2004). Working memory in this study was evaluated using a cluster score. Two subtests were administered and combined to obtain the score. The first subtest, Numbers Reversed measures participant’s ability to hold a span of numbers in immediate awareness (memory) while performing a mental operation on it (reversing the sequence). The second subtest, Auditory Working Memory measures the participant’s ability to listen to a series containing digits and words, such as “cat, 1, shirt, 8, 2, orange.” The participant was then asked to attempt to reorder the information, repeating first the objects in a specified order and then the digits in a specified order.

The results of the study suggest that college students with ADHD perform equally well as their peers on these measures of working memory. Again, these findings should be viewed in context of the assessment setting. It is possible that deficits in working memory were not fully observed in this setting because of the design of the testing environment which minimized distraction and included an evaluator who prompted the participant to stay focused on the task at hand. For clinicians working with those with ADHD, the nature of the environment may have a strong impact on the ability for the college student with ADHD to perform on tasks that involve working memory.

**Major Finding 2: Working Memory Mediating Models**

The second major finding from this study is that the relationship between working memory performance and reading comprehension is partially mediated by silent reading fluency and language comprehension. The simple mediation model and the parallel multiple mediation models show that these relationships are significant. However, it is important to determine if they are meaningful. For example, the results of the parallel multiple mediation model (Figure 2)
show a positive correlation between working memory and both mediating variables (silent reading fluency and language comprehension). Both mediating variables are positively correlated with the reading comprehension variable, but the increase in reading comprehension is very small, suggesting large changes in working memory do not result in practical changes in reading comprehension.

Practically speaking, this means that a ten-point increase in working memory, looking at WJ III COG NU and WJ III ACH NU scores, only yields an improvement in reading comprehension of two and a half points. The mediating effects of silent reading fluency account for .63 points of that increase. This means that as significant gains (essentially a score increase from the Average range to the Above Average range) occur in working memory performance through intervention efforts, the resulting increase in reading comprehension is very small. This provides preliminary empirical evidence against the notion that working memory improvement substantially improves reading comprehension.

Furthermore, these results suggest that interventions focused on improving working memory as a means to improve reading comprehension may not be highly effective. Additionally, this supports the findings of Melby-Lervåg and Hulme’s (2013) meta-analysis, that argues interventions aimed at improving working memory do not result in working memory increases that are generalizable to other working memory tasks. Melby-Lervåg and Hulme (2013) show that non-pharmacological interventions aimed at improving working memory—including those with ADHD—are ineffective at improving “nonverbal and verbal ability, inhibitory processes in attention, word decoding, and arithmetic” (2013, p. 270). There is much evidence that ADHD symptom presentation is associated with deficits in working memory; there
is little evidence, however, that interventions designed to improve working memory can improve reading comprehension for those with ADHD.

Further, research addressing the benefits of stimulant medications among those with ADHD shows that the medications improve working memory and reading comprehension (Bental & Tirosh, 2008; Gray & Climie, 2016; Keulers et al., 2007). However, the results from the present study suggests that stimulant medications improve reading comprehension, but that this is not likely occurring directly through improved working memory. For example, “One of the most common findings in the literature is an improvement in inhibition or impulse control in those with ADHD” when stimulant medications are employed (Barkley, 1997, p. 299). Stimulant medications among those with ADHD have been shown to improve executive functioning skills associated with self-monitoring, working memory, and attentional control (Biederman, Seidman et al., 2008; Snyder, Maruff, Pietrzak, Cromer, & Snyder, 2008) The reading comprehension literature argues that reading comprehension is more successful when readers are able to draw upon executive skills such as self-monitoring, planning, organization, working memory and attentional control (NICHHD, 2000; S. A. Stahl, 2004). Thus, the improvements in working memory via stimulant medications are not negligible in the reading comprehension process, but it is likely that other gains in executive functions through stimulant medication play a larger role in improved reading comprehension

**Major Finding 3: Attention Mediating Models**

The third major finding from this study is that the self-report assessment tool used to measure inattentive symptoms did not perform well in the models. The single and multiple mediation models that used attention as the independent variable were not significant. Results show that attention did not share a statistically significant relationship with any of the variables in the study. This is surprising considering the correlations found among other attention
measures in studies of reading and working memory (McNamara, O’Riley, Best, & Ozuru, 2006; Riccio, Reynolds, & Love, 2001).

A potential reason for this unexpected outcome is failing to consider the lack of variability within the sample on this measure. It is possible that, by using a measure of attention (BAAR-IV) that addresses severity of inattention amid a population that is inattentive, a ceiling effect is created and linear relationships cannot be observed due to this lack of variability. In this study, inclusion criteria required a diagnosis of ADHD, thus all of the scores on this measure fall in the above average range in areas of inattentive ADHD symptoms. In a study where more variability exists among samples on this trait, this measure may perform more effectively. Further, it could be speculated that over-reporting of symptoms occurred because the subjects were all clinical referrals who were predominantly hoping to receive accommodations. A self-report measures like the BAAR-IV is more amenable to “faking bad” by exaggerating symptom severity than the more reliable and valid cognitive and academic measures used in this study (WJ COG III NU, WJ ACH III NU). The college students recruited and evaluated in this study were evaluated and diagnosed in and ADHD clinic, seeking support to manage ADHD symptoms, and could be subject to over-reporting of symptoms given their level of distress at the time of the evaluation. It is for this reason diagnosis of ADHD is not based on one measure, but includes multiple measures to protect against misdiagnosis. This study did not include multiple measures of inattention. The addition of neuropsychological measures (i.e., Test of Variables of Attention, Conners Continuous Performance Test, etc.) that are not biased to self-report would have allowed for a broader view of inattention among this population and allowed for further statistical analysis.
Major Finding 4: Support for the Simple View of Reading Among an Adult Population

The SVR was used to help guide the development of the mediation models in this study. The SVR as proposed by Gough and Tunmer (1986) has become a widely used and highly cited model employed in the United States, United Kingdom and other countries (García & Cain, 2014; Hoffman, 2009; Rose, 2005; Tighe & Schatschneider, 2014). This theory suggests that two major component skills of reading (language comprehension and reading fluency) interact and predict reading comprehension ability (i.e., that a deficit in one or the other or both result in comprehension difficulties). This exploratory study sought to expand SVR research by applying it to an adult population and expanding the model to include ADHD symptoms. The significant positive relationships identified among component reading skills (listening comprehension and silent reading fluency) and reading ability (reading comprehension) were consistent with findings in other SVR studies that show positive relationships between these variables (Cain et al., 2004; Cromley & Azevedo, 2007; Gremillion & Martel, 2012; Martinussen & Mackenzie, 2015; McVay, 2012). This supports the idea that the SVR can be extended to a unique adult population, be expanded to include areas of ADHD impairment, and yield significant results. However, the small net contribution of working memory shown in this study suggests that expanding the model to include working memory may not be necessary when considering using the model among adults with ADHD.

The adapted model of the simple view of reading that incorporates working memory is statistically significant. It shows that those with weaker performance on working memory tasks perform more poorly on silent reading fluency and language comprehension tasks; both of these limitations contribute to weaker reading comprehension performance. However, the results of the model do not yield enough evidence that working memory is a major contributor to the model from a practical standpoint. The model show that the component learnable skills, (language
comprehension and fluency) mediate the relationship between working memory ability and reading comprehension and that improvement in working memory alone will not yield practical gains in reading comprehension.

It should be noted that the mediation models used in this study were based upon expanding the SVR to include areas of cognitive ability affected by ADHD and the models do not address reciprocity among the variables. Some argue that the relationship between fluency and comprehension is not mono-directional as I display in these models (Cain & Oakhill, 2007). The reciprocity view suggests that fluency is more than a foundational skill for comprehension and that context improves recognition of anticipated words through expectancies that are gathered from context cues and prior knowledge—in essence that improved comprehension improves fluency (Priebe, Keenan, & Miller, 2012). Afflerbach (2015) addresses this concern and finds that this reciprocal relationship was only true among “poor decoders, but made no difference for average readers in terms of either fluency or comprehension” (p.111). This is an important view to consider when developing a model based upon the SVR. However, strong support for a reciprocal effects of a bidirectional relationship has been difficult to demonstrate, thus, it was not accounted for in this model (Afflerbach, 2015).

**Future Interventions**

This research helps direct intervention design aimed at improving reading comprehension for those with ADHD. The results from this study find that a significant increase in working memory is not correlated with a practical or meaningful increase in reading comprehension even when accounting for mediating variables. This study provides preliminary empirical evidence against the notion that working memory improvement substantially improves reading comprehension. Reading comprehension interventions designed for college students with ADHD
may be more effective if they are focused on the component skills of comprehension (i.e., language comprehension and reading fluency).

This study suggests that improvement in working memory does not meaningfully impact reading comprehension among adult college students with ADHD. This challenges research that stimulant medications improve reading comprehension solely through working memory. Research addressing stimulant medication and working memory would benefit from further research clarifying exactly how, or if, stimulants (i.e., through what additional neuropathways associated with reading comprehension) improve reading comprehension at a significant level. This study did not address the medication status of the participants in the study as the focus of the evaluation was on diagnosis of ADHD, not treatment.

**Implications for the Simple View of Reading**

Recognizing that silent reading fluency and language comprehension serve as mediators between ADHD symptoms (working memory) and reading comprehension is helpful because, according to the simple view of reading (SVR), both decoding (fluency) and language comprehension are necessary for successful reading comprehension. Interventions focused on improving fluency and language comprehension are efficacious towards improving reading comprehension. It is likely that even in a population with limited working memory ability interventions focused on component reading skills still show strong relationships with reading comprehension. Future research addressing reading comprehension interventions may have greater success focusing on component reading skills (i.e., language comprehension and fluency) among college students with ADHD, rather than working memory ability.

---

9 It is beyond the scope of this paper to address the reading literature addressing reading interventions relevant to this topic; for more information on reading and reading intervention see The Florida Center for Reading Research (FCRR) website: <http://fcrr.org>.
College students with ADHD presented significantly better than the normed sample on a measure of reading comprehension and performed equally as well on measures of fluency and listening comprehension in the testing environment created during testing. Thus, interventions seeking to improve reading comprehension for this group may wish to explore how environment contributes to ADHD symptom presentation and reading comprehension ability.

**Limitations and Future Research**

While the measures used in the study demonstrate high reliability and validity, the BAAR-IV (Barkley, 2011a), as a specific measure of inattention, has not been extensively used in studies such as this. Future research may take caution at using this very helpful clinical diagnostic tool in analysis such as this. It should not be assumed that attention ability does not correlate with working memory and reading abilities as there is ample literature arguing otherwise (see Chapter 1).

The sample utilized for this study offered many strengths including an equal number of males and females and a large sample sizes. However, there was not a large diversity of learning disorders, specifically reading disorders. The data was coded to include the broad category of ‘reading disorder’ but it was not coded to include specifics about the potential types of reading disorders. Future studies may include a larger sample of co-morbid reading difficulties. This would allow for multi-level analysis to determine if a specific population of those with a different reading disorder performed differently from comparison groups.

A direct comparison group was not included in this study. If resources had allowed for a direct comparison of a control group from a similar number of college students without ADHD, we could observe (1) if there are differences between college students with ADHD and their peers in cognitive and academic areas assessed, (2) and if the results from the mediation models were different by group. This study did not address the medication status of the participants in
the study as the focus of the evaluation was on diagnosis of ADHD, not treatment. Future studies addressing if and how medication is playing a role in performance would be helpful.

Future studies are needed to further clarify the specific reading difficulties experienced by college student with ADHD and how to properly measure, analyze, and quantify their unique difficulties (i.e., normed reading measures that accurately reflect difficulties experienced when reading college-level text for understanding while reading independently). Comparison groups of college students without ADHD would be useful to include in future studies in order to determine what features of reading performance and cognitive abilities are more or less impacted by ADHD symptoms. Future studies would benefit from including an attentional measure that can be analyzed successfully with other variables without the limitation of a ceiling effect or self-report bias. And finally, future studies of college students with ADHD would benefit from comparing those with ADHD on and off stimulant mediation to determine the intervention benefit of medication while comprehending text.

**Conclusion**

The limited research addressing college students with ADHD, reading ability and reading interventions fueled the idea for this exploratory study. This study sought to determine if college students with ADHD are a unique subgroup of the ADHD population. This paper suggests that they are because they perform in the same range as their peers without ADHD on component reading skills and on a measure of working memory. This is different from what was predicted because the literature generally shows that those with ADHD (child, adolescent and adult populations) underperform those without the disorder. I argue that these findings from this study do not suggest that college students with ADHD do not have difficulty with reading comprehension but that the measures used and testing environment may not accurately capture how ADHD affects reading ability in an academic setting (i.e., the ability to self-regulate and
focus on a complex task when not prompted to do so by an evaluator or the environment). Further, this population may be distinct from the sample and other adults with ADHD in that the college students in this study are a self-selected group into a competitive top-tier state institution and may not be representative of other college students with ADHD.

To gain insight into where potential reading interventions may be most effective, mediation models were used that expanded the SVR to account for ADHD symptoms. This study suggests that the SVR can be applied to this population and that component reading skills (i.e., language comprehension and silent reading fluency) mediate the relationship between areas of ADHD symptoms (working memory) and reading comprehension. The models suggest that large gains in working memory ability do not correlate with practical gains in reading comprehension and that component reading skills may be a more effective area of focus given their stronger contribution to reading comprehension. It was hoped that inattention could also be assessed in the mediation models. Unfortunately, the measure did not significantly correlate with any of the variables in the study. This prevented evaluation of how inattention interacts with component reading skills and reading comprehension. It is hoped that the findings here and the results of future studies can further assess the specific reading challenges faced by college students with ADHD and measure symptom/performance relationships more accurately. This will provide additional theoretical foundations for intervention development specific to this population and may improve their educational experience and outcomes.
APPENDIX A

INTERNAL REVIEW BOARD FOR HUMAN SUBJECTS APPROVAL

Office of the Vice President for Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 09/02/2015

To: Jennifer Coleman

Address:

Dept.: EDUCATIONAL PSYCHOLOGY AND LEARNING SYSTEMS

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research

READING COMPREHENSION ABILITY AMONG COLLEGE STUDENTS WITH ADHD

The application that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be Expedited per 45 CFR § 46.110(7) and has been approved by an expedited review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 08/31/2016 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to ensure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Frances Prevatt <fprevatt@fsu.edu>, Advisor

HSC No. 2015.10015
Office of the Vice President For Research
Human Subjects Committee
P. O. Box 3062742
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

RE-APPROVAL MEMORANDUM

Date: 05/13/2017

To: Jennifer Coleman

Address:

Dept.: EDUCATIONAL PSYCHOLOGY AND LEARNING SYSTEMS

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research:
   READING COMPREHENSION ABILITY AMONG COLLEGE STUDENTS WITH ADHD

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 06/12/2017, you are must request renewed approval by the Committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chairman of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc:
HSC No. 2016.18619
Consent Form

1. I consent to receiving a psycho-educational assessment from the Adult Learning Evaluation Center at Florida State University.

2. I understand that no information concerning my evaluation will be released from the Adult Learning Evaluation Center within the limits of confidentiality that have been specified (see Client Information).

3. I understand the information provided to me regarding supervision and observation of services.

4. I understand that the fee for a psycho-educational assessment is $500.00 and is payable on the first day of the evaluation unless other arrangements have been finalized through financial aid.

5. I understand that it is in my best interest to put forth my best effort during the psycho-educational evaluation.

6. The following section specifically applies to a research project that you are being asked to consider.

I freely and voluntarily and without element of force or coercion, consent to be a participant in the research project, *Exploration of the Factors Underlying Academic Difficulty in College Students*.

I understand that this research is being conducted by Dr. Frances Prevatt at Florida State University. I understand the purpose of the research project is to create an archival data base that can be used to evaluate correlates of learning disability (LD) and Attention Deficit Hyperactivity Disorder (ADHD) in a college population. I am being asked to allow the results of my current evaluation to be utilized in this archival data base. I understand that all clients in ALEC, (approximately 200 per year) are asked to participate in this research. I am not being asked to do anything other than my standard evaluation; I am just allowing my data to be used later for research purposes.
I understand that I must be at least 18 years of age in order to participate in this study.

I understand that I will receive no direct benefits in return for participating in this research project. I understand that my participation is totally voluntary and I may withdraw my consent at any time in the research. I understand that if I do not agree for my data to be used, that will have no impact on my evaluation.

I understand there is no risk involved if I agree to let my data be used.

I understand that my identity will never be associated with the data (that is, my name and any identifying information will be removed.) The records will be kept private and confidential to the extent permitted by law. Data will be stored securely and only the researchers will have access to the data base.

I understand that I may contact Dr. Frances Prevatt, Florida State University, Adult Learning Evaluation Center, 214 Stone Building, (850) 644-9445, for answers to questions about this research or my rights.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B. Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at jjcooper@fsu.edu.

I do [ ] do not [ ] consent to allow my data to be used in the manner described above.

I do [ ] do not [ ] give ALEC my permission to contact me by email or telephone to describe future research projects and ask me if I would be interested in participating. If yes, this permission is granted for _____ years from today's date.

I do [ ] do not [ ] consent to participate in an additional research study that involves the comparison of my responses to those of a group of college students without ADHD. Should I agree, I will be given an additional thirty-three questions, which will add approximately ten minutes to my psycho-educational evaluation.

I have read, understand, and agree to all Adult Learning Evaluation Center procedures outlined in this document.

Signature ___________________________   Date__________________________
APPENDIX C

HISTOGRAMS OF VARIABLE DISTRIBUTION

Reading Comprehension

Working Memory

Fluency

Language Comprehension

Attention

Year in School

Age

Female

Male

AGE

Sample (n=961)

Age<18 or Age>45 (9 cases removed)
APPENDIX D

STANDARDIZED RESIDUALS

Standardized Residuals

- Working Memory
- Fluency
- Language Comprehension
- Attention
APPENDIX F

POWER ANALYSIS

Power of Attention
Indirect Effects

Mediation Model:
- Reading Fluency
- Dual
- Language Comprehension

Sample Size

Estimated from 1,000 Monte Carlo bootstrapped samples each.
Data Review

Labeling, Cleaning Data, and Frequency Statistics

*------------------------
* First label, clean data
*------------------------

* Drop age>45 and <18 because non-comparable to normed sample
.hlist AGE, start(17) width(1) bcolor(gs16) freq addplot( hlist AGE if AGE>45 | AGE<18, start(17) ///
> width(1) bcolor(gs10) freq) legend(order(1 "Sample" "(n=361)" 2 "Age<18 or Age>45" "(9 cases removed)"") ///
> size(small) position(3) ring(0)) xscale(4) yscale(4) ytitle("Frequency", size(small)) xlab(18 25 35 45 55) ///
> (bin=40, start=17, width=1)

.graph export agedrop.png, replace
(file agedrop.png written in PNG format)

.sum AGE

Variable | Obs Mean Std. Dev. Min Max
-------------+------------------------------------------------------------------------
    AGE | 370 23.84865 6.397307 17 57

.drop if (AGE > 45 | AGE < 18) & AGE !-.

78
(9 observations deleted)

. sum AGE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>361</td>
<td>23.3518</td>
<td>5.137099</td>
<td>18</td>
<td>43</td>
</tr>
</tbody>
</table>

. * Other summary stats of the sample
. * 1- TABULATIONS FOR CATEGORICAL
. foreach x in ETHNICITY YEAR ADHDTYPE LDDX LDTYPE DEPRESDX ANXDX GENDER {
  2.   tab `x'
  3. }

ETHNICITY | Freq. | Percent | Cum.  
-----------|-------|---------|-------
caucasian | 219   | 64.99   | 64.99 |
african american | 34 | 10.09  | 75.07 |
asian | 8 | 2.37 | 77.45 |
hispanic | 59 | 17.51 | 94.96 |
other | 17 | 5.04 | 100.00 |
-----------|-------|---------|-------
Total | 337 | 100.00 |

YEAR | Freq. | Percent | Cum.  
-----|-------|---------|-------
freshman | 52 | 14.36 | 14.36 |
sophomore | 66 | 18.23 | 32.60 |
junior | 87 | 24.03 | 56.63 |
senior | 87 | 24.03 | 80.66 |
grd student | 70 | 19.34 | 100.00 |
-----|-------|---------|-------
Total | 362 | 100.00 |

ADHDTYPE | Freq. | Percent | Cum.  
----------|-------|---------|-------
0 | 1 | 0.28 | 0.28 |
1 | 186 | 51.81 | 52.09 |
2 | 1 | 0.28 | 52.37 |
3 | 170 | 47.35 | 99.72 |
4 | 1 | 0.28 | 100.00 |
----------|-------|---------|-------
Total | 359 | 100.00 |

LDDX | Freq. | Percent | Cum.  
-----|-------|---------|-------
no | 329 | 91.39 | 91.39 |
yes | 31 | 8.61 | 100.00 |
-----|-------|---------|-------
Total | 360 | 100.00 |
<table>
<thead>
<tr>
<th>LDTYPE</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>no diagnosis</td>
<td>323</td>
<td>91.76</td>
<td>91.76</td>
</tr>
<tr>
<td>reading</td>
<td>6</td>
<td>1.70</td>
<td>93.47</td>
</tr>
<tr>
<td>math</td>
<td>8</td>
<td>2.27</td>
<td>95.74</td>
</tr>
<tr>
<td>writing</td>
<td>2</td>
<td>0.57</td>
<td>96.31</td>
</tr>
<tr>
<td>multi</td>
<td>13</td>
<td>3.69</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>352</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DEPRESDX</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>286</td>
<td>79.01</td>
<td>79.01</td>
</tr>
<tr>
<td>yes</td>
<td>76</td>
<td>20.99</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>362</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANXDX</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>274</td>
<td>75.69</td>
<td>75.69</td>
</tr>
<tr>
<td>yes</td>
<td>88</td>
<td>24.31</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>362</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GENDER</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>female</td>
<td>167</td>
<td>46.13</td>
<td>46.13</td>
</tr>
<tr>
<td>male</td>
<td>195</td>
<td>53.87</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>362</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

* 2- SUMARY STATS FOR AGE

```
sum AGE
```

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>361</td>
<td>23.3518</td>
<td>5.137099</td>
<td>18</td>
<td>43</td>
</tr>
</tbody>
</table>

* 3- LABELS FOR MODEL VARIABLES

```
global DEPS PASSAGECOMPAGE WORKMEM READFLUEAGE UNDDIRECS

label var PASSAGE "Reading Comprehension"
label var WORKMEM "Working Memory"
label var READFLUEAGE "Fluency"
label var UNDDIRECS "Language Comprehension"```
. sum $DEPS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPE</td>
<td>342</td>
<td>104.42</td>
<td>9.28</td>
<td>68</td>
<td>133</td>
</tr>
<tr>
<td>WORKMEM</td>
<td>326</td>
<td>105.25</td>
<td>13.76</td>
<td>61</td>
<td>141</td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td>345</td>
<td>100.31</td>
<td>12.77</td>
<td>68</td>
<td>142</td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>340</td>
<td>99.26</td>
<td>12.09</td>
<td>61</td>
<td>127</td>
</tr>
</tbody>
</table>

T-Tests

. * 4- T-TESTS FOR EACH OF THE MODEL VARIABLES FOR SIGNIFICANT DIFFERENCE BETWEEN
. * STUDY SAMPLE AND THE NORMED SAMPLE. ONE AND TWO-TAILED TESTS.
. * NORMED SAMPLE HAS MEAN=100, SD=15, AND A SAMPLE SIZE OF 1165
. * This code loops over each of the model variables to perform the t-test
. * Welch's adjustment is used to correct for heteroscedasticity
. foreach x in $DEPS {
  2.  sdtest `x'=15
  3.  qui sum `x'
  4.  local n=r(N)
  5.  local mean=r(mean)
  6.  local sd=r(sd)
  7.  ttesti `n' `mean' `sd' 1165 100 15, unequal welch
  8. }

Reading comprehension

One-sample test of variance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>95% Conf.Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAG</td>
<td>342</td>
<td>104.41</td>
<td>0.50</td>
<td>9.28</td>
<td>103.43-105.40</td>
</tr>
</tbody>
</table>

sd = sd(PASSAGECOMPAG)  c = chi2 = 130.45
Ho: sd = 15   degrees of freedom = 341

Ha: sd < 15   Ha: sd != 15   Ha: sd > 15
Pr(C < c) = 0.0000  2*Pr(C < c) = 0.0000  Pr(C > c) = 1.0000

Two-sample t test with unequal variances

<table>
<thead>
<tr>
<th></th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>95% Conf.Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>342</td>
<td>104.41</td>
<td>0.50</td>
<td>9.28</td>
<td>103.43-105.40</td>
</tr>
<tr>
<td>y</td>
<td>1,165</td>
<td>100</td>
<td>0.44</td>
<td>15</td>
<td>99.14-100.86</td>
</tr>
</tbody>
</table>

combined | 1,507 | 101.00  |  0.36      |  14.03     |  100.29-101.71             |
### Working Memory

One-sample test of variance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORKMEM</td>
<td>326</td>
<td>105.2515</td>
<td>.7620504</td>
<td>13.75918</td>
<td>103.7524 106.7507</td>
</tr>
</tbody>
</table>

sd = sd(WORKMEM)  
Ho: sd = 15  
Ha: sd < 15  
Ha: sd > 15  
Pr(C < c) = 0.0173  
2*Pr(C < c) = 0.0346  
Pr(C > c) = 0.9827

Two-sample t test with unequal variances

<table>
<thead>
<tr>
<th>variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>326</td>
<td>105.2515</td>
<td>.7620504</td>
<td>13.75918</td>
<td>103.7524 106.7507</td>
</tr>
<tr>
<td>y</td>
<td>1,165</td>
<td>100</td>
<td>.4394691</td>
<td>15</td>
<td>99.13776 100.8622</td>
</tr>
<tr>
<td>combined</td>
<td>1,491</td>
<td>101.1482</td>
<td>.3856758</td>
<td>14.89228</td>
<td>100.3917 101.9047</td>
</tr>
</tbody>
</table>

combined sd = 14.89228  
Ho: sd = 15  
Ha: sd < 15  
Ha: sd > 15  
Pr(C < c) = 0.0173  
2*Pr(C < c) = 0.0346  
Pr(C > c) = 0.9827

### Reading Fluency

One-sample test of variance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
</table>

82
Language Comprehension (Understanding Directions)

One-sample test of variance

```
Variable     |   Obs  | Mean   | Std. Err. | Std. Dev. | 95% Conf. Interval
UNDDIRS      |   340  | 99.26  | 0.66      | 12.09     | 97.98 - 100.54

sd = sd(UNDDIRECS)  c = chi2 = 220.101
Ho: sd = 15        degrees of freedom = 339
Ha: sd < 15        Ha: sd != 15    Ha: sd > 15
Pr(C < c) = 0.0000  2*Pr(C < c) = 0.0000  Pr(C > c) = 1.000
```

Two-sample t test with unequal variances

```
|   Obs  | Mean   | Std. Err. | Std. Dev. | 95% Conf. Interval
x      |  340  | 99.26  | 0.66      | 12.09     | 97.98 - 100.54
y      | 1,165 | 100.0  | 0.44      | 15.1      | 99.14 - 100.86
combined| 1,505 | 100.05 | 0.37      | 14.51     | 99.34 - 100.80

diff = mean(x) - mean(y)   t = 0.38
Ho: diff = 0    Welch's degrees of freedom = 652.3
Ha: diff < 0    Ha: diff != 0    Ha: diff > 0
Pr(T < t) = 0.65  Pr(|T| > |t|) = 0.70  Pr(T > t) = 0.35
```

T-TEST
LESS THAN COMPARISON   TWO TAILED T-TEST   GREATER THAN COMPARISON

---

READFL-FL

```
READFL-FL |   345  | 100.31 | 0.69    | 12.77     | 98.96 - 101.66

sd = sd(READFLUEAGE)  c = chi2 = 249.13
Ho: sd = 15        degrees of freedom = 344
Ha: sd < 15        Ha: sd != 15    Ha: sd > 15
Pr(C < c) = 0.0000  2*Pr(C < c) = 0.0000  Pr(C > c) = 1.000
```

Two-sample t test with unequal variances

```
|   Obs  | Mean   | Std. Err. | Std. Dev. | 95% Conf. Interval
x      |  345  | 100.31 | 0.69      | 12.77     | 98.96 - 101.66
y      | 1,165 | 100.0  | 0.44      | 15.1      | 99.14 - 100.86
combined| 1,510 | 100.07 | 0.37      | 14.52     | 99.34 - 100.80

diff = mean(x) - mean(y)   t = 0.38
Ho: diff = 0    Welch's degrees of freedom = 652.3
Ha: diff < 0    Ha: diff != 0    Ha: diff > 0
Pr(T < t) = 0.65  Pr(|T| > |t|) = 0.70  Pr(T > t) = 0.35
```

T-TEST
LESS THAN COMPARISON   TWO TAILED T-TEST   GREATER THAN COMPARISON

---

Language Comprehension (Understanding Directions)

One-sample test of variance

```
Variable     |   Obs  | Mean   | Std. Err. | Std. Dev. | 95% Conf. Interval
UNDDIR-S     |   340  | 99.26  | 0.66      | 12.09     | 97.98 - 100.54

sd = sd(UNDDIRECS)  c = chi2 = 220.101
Ho: sd = 15        degrees of freedom = 339
Ha: sd < 15        Ha: sd != 15    Ha: sd > 15
Pr(C < c) = 0.0000  2*Pr(C < c) = 0.0000  Pr(C > c) = 1.000
```

Two-sample t test with unequal variances

```
|   Obs  | Mean   | Std. Err. | Std. Dev. | 95% Conf. Interval
x      |  340  | 99.26  | 0.66      | 12.09     | 97.98 - 100.54
y      | 1,165 | 100.0  | 0.44      | 15.1      | 99.14 - 100.86
```
### Attention Variable

* 5- CREATING A VARIABLE FOR ATTENTION, COMPOSED OF 9 BDEFS ITEMS
```stata
. gen attention = CURRSYM_1 + CURRSYM_3 + CURRSYM_5 + CURRSYM_7 + ///
> CURRSYM_9 + CURRSYM_11 + CURRSYM_13 + CURRSYM_15 + ///
> CURRSYM_17
```

(5 missing values generated)
```
. label var attention "Attention"
```

### Variable Distribution and Matrix Figures

* 6- DEFINING THESE VARIABLES TO LOOK TO FORM FIGURES WHICH SHOW THEIR DISTRIBUTION
```stata
. global INDS YEAR AGE GENDER
```
```
. label var YEAR "Year in School"
```
```
. label var AGE "Age"
```
```
. label var GENDER "Gender"
```
```
. label define year 1 "Fr" 2 "Sph" 3 "Jr" 4 "Sr" 5 "Grad"
```
```
. label values YEAR year
```
```
. label define gender 1 "Female" 2 "Male"
```
```
. label values GENDER gender
```
```
. *histograms
. foreach x in $DEPS attention AGE {
  2.   hist `x', freq normal normopts(lw(thick))
  3.   graph save `x'.gph, replace
```
```
Creating a scatterplot matrix showing the correlations between all variables.

* Defining and Running the Models

* Second, defining and running the models
Here is a picture of the dual mediator model:

* The Model:
  * Independent Var  Mediators      Dependent
  * ----------------  ---------      --------
  *      -> Reading Fluency
  * Working Memory   -> Reading Comprehension
  *      -> Language Comprehension

* Building up to that model, but starting with simpler models
* Bootstrapped standard errors (1000 bootstraps) for all models

Simple Regression Reading comprehension on Working Memory
* 1- Simple regression of passage comprehension on working memory

. sem (PASSAGECOMPAGE <- WORKMEM), nocapslatent vce(bootstrap, reps(1000))
(running sem on estimation sample)

Bootstrap replications (1000)

| Observed Bootstrap       Normal-based |
|-------------------------|--------------------------------------|
| Coef. Std. Err. z P>|z| [95% Conf. Interval] |

Structural equation model  Number of obs  =  318
Log likelihood  = -2417.5766  Replications  =  1,000

.
**Simple Regression Reading comprehension on Attention**

```
. estimates store wm

Simple Regression Reading comprehension on Attention
. * 2- Simple regression of passage comprehension on attention
. sem (PASSAGECOMPAGE <- attention), nocapslatent vce(bootstrap, reps(1000))
(running sem on estimation sample)

Bootstrap replications (1000)
-----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
.................................................. 50
.................................................. 100
.................................................. 150
.................................................. 200
.................................................. 250
.................................................. 300
.................................................. 350
.................................................. 400
.................................................. 450
.................................................. 500
.................................................. 550
.................................................. 600
.................................................. 650
.................................................. 700
.................................................. 750
.................................................. 800
.................................................. 850
.................................................. 900
.................................................. 950
.................................................. 1000

Structural equation model  Number of obs  =  337
Log likelihood = -2269.4008      Replications  =  1,000
```

Observed Bootstrap Normal-based
| Coef. Std. Err.  z  P>|z|  [95% Conf. Interval] |
|---------------------+----------------------------------------------------------------|
| Observed Bootstrap Normal-based
| Coef. Std. Err.  z  P>|z|  [95% Conf. Interval] |
```

<table>
<thead>
<tr>
<th>Structural</th>
<th>Observed Bootstrap Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>attention</td>
</tr>
<tr>
<td>_cons</td>
<td>102.1165 2.919203 34.98 0.000 96.39494 107.838</td>
</tr>
</tbody>
</table>
```

| var(e.PASSAGECOMPAGE) | 83.06718 7.947354 68.86392 100.1999 |
```

87
Mediator Models

* Single mediator models:
* separate mediating models for reading fluency and language comprehension

**Simple Mediation Question 3a: Working Memory through Silent Reading Fluency on Passage Comprehension**

```
. * 1- using reading fluency as a mediator for working memory
. sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ), noreaaslatent vce(bootstrap, reps(1000))
(running sem on estimation sample)
```

Bootstrap replications (1000)

```
<table>
<thead>
<tr>
<th></th>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef. Std. Err.</td>
<td>z P&gt;</td>
</tr>
</tbody>
</table>
```

```
Structural equation model          Number of obs  =  315
Log likelihood = -3610.591        Replications =  1,000
```

```
<table>
<thead>
<tr>
<th>READFLUEAGE &lt;-</th>
<th>WORKMEM</th>
<th>_cons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.3590571</td>
<td>62.65202</td>
</tr>
<tr>
<td></td>
<td>.0488947</td>
<td>5.174758</td>
</tr>
<tr>
<td></td>
<td>7.34</td>
<td>12.11</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>.2632252</td>
<td>52.50968</td>
</tr>
<tr>
<td></td>
<td>.454889</td>
<td>72.79436</td>
</tr>
</tbody>
</table>
```

88
estimates store medwm_fluen

* extract direct, indirect, and total effect
estat teffects

Direct effects

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
</tbody>
</table>

Structural |

READFLUEAGE <- |
WORKMEM  | \( a_1 = 0.3590571 \) 0.0488947 7.34 0.000 0.2632252 0.454889 |

PASSAGECOMPAGE <- |
READFLUEAGE  | \( b_1 = 0.1759594 \) 0.0445173 3.95 0.000 0.088707 0.2632118 |
WORKMEM  | \( C' = 0.1938698 \) 0.0373633 5.19 0.000 0.120639 0.2671006 |

Indirect effects

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
</tbody>
</table>

Structural |

READFLUEAGE <- |
WORKMEM  | 0 (no path) |

PASSAGECOMPAGE <- |
READFLUEAGE  | 0 (no path) |
WORKMEM  | \( 0.0631795 \) 0.0182789 3.46 0.001 CI \( 0.0273534 \) \( 0.0990055 \) |

Total effects

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural</th>
<th>READFLUEAGE &lt;-</th>
<th>WORKMEM</th>
<th>.3590571 .0488947  7.34 0.000  .2632252  .454889</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>READFLUEAGE</td>
<td>WORKMEM</td>
<td>.1759594 .0445173  3.95 0.000  .088707 .2632118</td>
</tr>
<tr>
<td>C</td>
<td>.2570493</td>
<td>.0378367</td>
<td>6.79 0.000  .1828908 .3312078</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural</th>
<th>READFLUEAGE &lt;-</th>
<th>WORKMEM</th>
<th>.3590571 .0488947  7.34 0.000  .2632252  .454889</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>READFLUEAGE</td>
<td>WORKMEM</td>
<td>.1759594 .0445173  3.95 0.000  .088707 .2632118</td>
</tr>
<tr>
<td>C</td>
<td>.2570493</td>
<td>.0378367</td>
<td>6.79 0.000  .1828908 .3312078</td>
</tr>
</tbody>
</table>
Simple Mediation Question 3b: Working Memory through Language Comprehension on Reading comprehension

* 2- using language comprehension as a mediator for working memory
* sem (WORKMEM -> UNDDIRECS, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
> (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent vce(bootstrap, reps(1000))
(running sem on estimation sample)

Bootstrap replications (1000)
---+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
.................................................. 50
.................................................. 100
.................................................. 150
.................................................. 200
.................................................. 250
.................................................. 300
.................................................. 350
.................................................. 400
.................................................. 450
.................................................. 500
.................................................. 550
.................................................. 600
.................................................. 650
.................................................. 700
.................................................. 750
.................................................. 800
.................................................. 850
.................................................. 900
.................................................. 950
.................................................. 1000

Structural equation model  Number of obs = 312
Log likelihood = -3528.8207      Replications = 1,000

<p>|Observed Bootstrap       Normal-based |
|-------------------------------|-------------------------------|
| Coef. Std. Err.  z P&gt;|z|  [95% Conf. Interval] |
|---------------------------------|---------------------------------|
| Structural | Workmem &lt;- | UNDDIRECS | .4414794 .0434105 10.17 0.000 .3563965 .5265624 |</p>
<table>
<thead>
<tr>
<th>Workmem _cons</th>
<th>53.06804 4.622877 11.48 0.000 44.00737 62.12872</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>UNDDIRECS &lt;-</td>
</tr>
<tr>
<td>UNDDIRECS _cons</td>
<td>.1601054 .035269 4.54 0.000 .0909794 .2292313</td>
</tr>
<tr>
<td>PASSAGECOMPAGE _cons</td>
<td>65.42529 5.135453 12.74 0.000 55.35999 75.4906</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>var(e.UNDDIRECS)</td>
<td>105.072 8.161049 122.3491</td>
</tr>
<tr>
<td>var(e.PASSAGECOMPAGE)</td>
<td>67.53782 7.041691 82.85063</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------------------</td>
</tr>
</tbody>
</table>
. estimates store medwm_comp
. * extract direct, indirect, and total effect
. estat teffects

**Direct effects**

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td>P&gt;</td>
<td>z</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural</th>
<th>UNDDIRECS &lt;- WORKMEM</th>
<th>a1</th>
<th>.4414794</th>
<th>.0434105</th>
<th>10.17</th>
<th>0.000</th>
<th>.3563965</th>
<th>.5265624</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;- UNDDIRECS</td>
<td>b1</td>
<td>.2223133</td>
<td>.0516234</td>
<td>4.31</td>
<td>0.000</td>
<td>.1211333</td>
<td>.3234932</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>C'</td>
<td>.1601054</td>
<td>.035269</td>
<td>4.54</td>
<td>0.000</td>
<td>.0909794</td>
<td>.2292313</td>
<td></td>
</tr>
</tbody>
</table>

**Indirect effects**

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td>P&gt;</td>
<td>z</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural</th>
<th>UNDDIRECS &lt;- WORKMEM</th>
<th>0 (no path)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;- UNDDIRECS</td>
<td>0 (no path)</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>.0981467</td>
<td>.0252789</td>
</tr>
</tbody>
</table>

**Total effects**

<table>
<thead>
<tr>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef.</td>
<td>Std. Err.</td>
<td>z</td>
</tr>
<tr>
<td>P&gt;</td>
<td>z</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural</th>
<th>UNDDIRECS &lt;- WORKMEM</th>
<th>.4414794</th>
<th>.0434105</th>
<th>10.17</th>
<th>0.000</th>
<th>.3563965</th>
<th>.5265624</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;- UNDDIRECS</td>
<td>.2223133</td>
<td>.0516234</td>
<td>4.31</td>
<td>0.000</td>
<td>.1211333</td>
<td>.3234932</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>C'</td>
<td>.2582521</td>
<td>.0362818</td>
<td>7.12</td>
<td>0.000</td>
<td>.187141</td>
<td>.3293632</td>
</tr>
</tbody>
</table>
Multiple Mediation Question 3c: Working Memory Multiple Mediating Model

* 3- Dual mediator model: working memory on reading comprehensions (via reading fluency and language comp)

```
sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) (WORKMEM -> UNDDIRECS, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent vce(bootstrap, reps(1000))
```

(running sem on estimation sample)

Bootstrap replications (1000)

---+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5

| Observed Bootstrap       Normal-based |
|--------------------------|--------------------------------------|
| Coef. Std. Err. z P>|z| [95% Conf. Interval] |

<table>
<thead>
<tr>
<th>Structural equation model</th>
<th>Number of obs = 310</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log likelihood = -4704.4806</td>
<td>Replications = 1,000</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>READFLUEAGE &lt;-</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>.3627893 .0474142 7.65 0.000  .269859 .4557195  _cons</td>
</tr>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td>.1424624 .0474432 3.00 0.003  .0494755 .2354492  UNDDIRECS</td>
</tr>
<tr>
<td>UNDDIRECS &lt;-</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>.4365319 .0434142 10.05 0.000  .3514375 .5216264  _cons</td>
</tr>
</tbody>
</table>
. estimates store med_wm
. * extract direct, indirect, and total effects
. estat teffects

### Direct effects

<table>
<thead>
<tr>
<th></th>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>a1</td>
<td>0.3627893</td>
<td>0.0474142 7.65 0.000 0.2698590 .4557195</td>
</tr>
<tr>
<td>PASSAGECOMPAGE</td>
<td></td>
<td>b1</td>
<td>0.1424624 0.0474432 3.00 0.003 0.0494755 .2354492</td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>b2</td>
<td>0.1735619</td>
<td>0.0500624 3.47 0.001 0.0754414 .2716823</td>
</tr>
<tr>
<td>WORKMEM</td>
<td>C</td>
<td>0.1282535</td>
<td>0.0356046 3.60 0.000 0.0584698 .1980373</td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>a2</td>
<td>0.4365319</td>
<td>0.0434163 10.05 0.000 0.3514375 .5216264</td>
</tr>
</tbody>
</table>

### Indirect effects

<table>
<thead>
<tr>
<th></th>
<th>Observed</th>
<th>Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td></td>
<td>0 (no path)</td>
<td></td>
</tr>
<tr>
<td>PASSAGECOMPAGE</td>
<td></td>
<td>0 (no path)</td>
<td></td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td></td>
<td>0 (no path)</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td></td>
<td>0.1274491</td>
<td>0.0279702 4.56 0.000 CI 0.0726285 .1822698</td>
</tr>
</tbody>
</table>

### Total effects
<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

### Structural

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

#### READFLUEAGE <-

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

#### PASSAGECOMPAGE <-

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

#### UNDDIRECS <-

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

### Workmem

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

| Coef. Std. Err. z P>|z| [95% Conf. Interval] |
Simple Mediation Question 4a: Attention through Silent Reading Fluency on Reading comprehension

* 3 - using reading fluency as a mediator for attention
\( \text{sem (attention} \rightarrow \text{READFLUEAGE, ) (attention} \rightarrow \text{PASSAGECOMPAGE, )} /// \)
\( \text{(READFLUEAGE} \rightarrow \text{PASSAGECOMPAGE, )}, \text{nocapslatent vce(bootstrap, reps(1000))} \)
(running sem on estimation sample)

Bootstrap replications (1000)

Observed Bootstrap Normal-based

| Coef. Std. Err.  z P>|z|  [95% Conf. Interval] |
|---------------------+----------------------------------------------------------------|
| Structural          | | |
| READFLUEAGE <-      | attention | .2170389 .1332119  1.63 0.103 -.0440516 .4781294  
|                     | _cons     | 94.41637 3.754582 25.15 0.000  87.05753 101.7752 |
| PASSAGECOMPAGE <-   | READFLUEAGE | .2359584 .0451513  5.23 0.000  .1474635 .3244532  
|                     | attention | .0632964 .098096  0.65 0.519 -.1289683  .255561  
|                     | _cons     | 79.09299 5.438547 14.54 0.000  68.43364 89.75235 |
| var(e.READFLUEAGE)  | 160.3313 11.74009 138.8961 185.0745 |
| var(e.PASSAGECOMPAGE)| 74.36101 6.795362 62.16695 88.94693 |

Number of obs = 333
Log likelihood = -3538.047  Replications = 1,000
estimates store medatt_fluen

* extract direct, indirect, and total effect
estat teffects

### Direct effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE &lt;-</td>
<td>attention</td>
</tr>
<tr>
<td>a1</td>
<td>0.2170389</td>
</tr>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>READFLUEAGE</td>
</tr>
<tr>
<td>b1</td>
<td>0.2359584</td>
</tr>
<tr>
<td>attention</td>
<td>C’</td>
</tr>
</tbody>
</table>

### Indirect effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE &lt;-</td>
<td>attention</td>
</tr>
<tr>
<td>0 (no path)</td>
<td></td>
</tr>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>READFLUEAGE</td>
</tr>
<tr>
<td>0 (no path)</td>
<td>attention</td>
</tr>
<tr>
<td>.0512122</td>
<td>0.0331485</td>
</tr>
</tbody>
</table>

### Total effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Structural</td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE &lt;-</td>
<td>attention</td>
</tr>
<tr>
<td>.2170389</td>
<td>0.1332119</td>
</tr>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td>READFLUEAGE</td>
</tr>
<tr>
<td>.2359584</td>
<td>0.0451513</td>
</tr>
<tr>
<td>attention</td>
<td>C</td>
</tr>
</tbody>
</table>
Simple Mediation Question 4b: Attention through Language Comprehension on Reading comprehension

. * 4 - using language comprehension (understanding directions) as a mediator for attention
. sem (attention -> UNDDIRECS, ) (attention -> PASSAGECOMPAGE, ) ///
> (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent vce(bootstrap, reps(1000))
(running sem on estimation sample)

Bootstrap replications (1000)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>300</td>
<td>350</td>
<td>400</td>
<td>450</td>
<td>500</td>
</tr>
<tr>
<td>550</td>
<td>600</td>
<td>650</td>
<td>700</td>
<td>750</td>
</tr>
<tr>
<td>800</td>
<td>850</td>
<td>900</td>
<td>950</td>
<td>1000</td>
</tr>
</tbody>
</table>

Structural equation model

Number of obs  =  327
Log likelihood = -3448.9756      Replications  =  1,000

<p>| Observed Bootstrap       Normal-based |
|---------------------------|-----------------------------------|
|  Coef. Std. Err.  z P&gt;|z|  [95% Conf. Interval] |
|------------------------|-----------------------------------|
| Structural             |                                   |
| UNDDIRECS &lt;-           |                                   |
| attention | -.0353754 .1352104 -0.26 0.794 -.3003828 .2296321 |</p>
<table>
<thead>
<tr>
<th>_cons</th>
<th>100.4051 3.803821 26.40 0.000  92.94978 107.8605</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOMPAGE &lt;-</td>
<td></td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>.2984201 .0460256 6.48 0.000 .2082135 .3886287</td>
</tr>
<tr>
<td>attention</td>
<td>.0997588 .0951351 1.05 0.294 -.0867026 .2862202</td>
</tr>
<tr>
<td>_cons</td>
<td>72.06307 5.638131 12.78 0.000  61.01254 83.11361</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>var(e.UNDDIRECS)</td>
<td>142.7976 11.27774 122.3194 166.7041</td>
</tr>
<tr>
<td>var(e.PASSAGECOMPAGE)</td>
<td>70.74576 6.613107 58.90234 84.97051</td>
</tr>
</tbody>
</table>

98
estimates store medatt_comp

* extract direct, indirect, and total effect
estat teffects

### Direct effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err.</td>
<td>z  P&gt;</td>
</tr>
</tbody>
</table>

#### Structural

| UNDDIRECS <- | attention | **a1** -.0353754 | 0.1352104 | -0.26 | 0.794 | -.3003828 | 0.2296321 |

**PASSAGECOMPAGE <- | UNDDIRECS**

| **b1** 0.2984201 | 0.0460256 | 6.48 | 0.000 | 0.2082115 | 0.3886287 |
| **C’** 0.0997588 | 0.0951351 | 1.05 | 0.294 | -0.0867026 | 0.2862202 |

### Indirect effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err.</td>
<td>z  P&gt;</td>
</tr>
</tbody>
</table>

#### Structural

| UNDDIRECS <- | attention | 0 (no path) |

**PASSAGECOMPAGE <- | UNDDIRECS**

| attention | **C’** -0.0105567 | 0.040321 | -0.26 | 0.793 | -0.0895843 | 0.0684709 |

### Total effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err.</td>
<td>z  P&gt;</td>
</tr>
</tbody>
</table>

#### Structural

| UNDDIRECS <- | attention | -.0353754 | 0.1352104 | -0.26 | 0.794 | -.3003828 | 0.2296321 |

**PASSAGECOMPAGE <- | UNDDIRECS**

| **C’** 0.0892021 | 0.107015 | 0.83 | 0.405 | -0.1205435 | 0.2989476 |
Multiple Mediation Question 4c: Attention Multiple Mediating Model

* 4- Dual mediator model: attention on reading comprehension (via reading fluency and language comp)

```stata
sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) (attention -> UNDDIRECS, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent vce(bootstrap, reps(1000))
```

(running sem on estimation sample)

Bootstrap replications (1000)

```
+--------------------------------+
<table>
<thead>
<tr>
<th>No. of replications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>17</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>19</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>21</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>23</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>26</td>
</tr>
<tr>
<td>27</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>29</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>31</td>
</tr>
<tr>
<td>32</td>
</tr>
<tr>
<td>33</td>
</tr>
<tr>
<td>34</td>
</tr>
<tr>
<td>35</td>
</tr>
<tr>
<td>36</td>
</tr>
<tr>
<td>37</td>
</tr>
<tr>
<td>38</td>
</tr>
<tr>
<td>39</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>41</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>43</td>
</tr>
<tr>
<td>44</td>
</tr>
<tr>
<td>45</td>
</tr>
<tr>
<td>46</td>
</tr>
<tr>
<td>47</td>
</tr>
<tr>
<td>48</td>
</tr>
<tr>
<td>49</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>51</td>
</tr>
<tr>
<td>52</td>
</tr>
<tr>
<td>53</td>
</tr>
<tr>
<td>54</td>
</tr>
<tr>
<td>55</td>
</tr>
<tr>
<td>56</td>
</tr>
<tr>
<td>57</td>
</tr>
<tr>
<td>58</td>
</tr>
<tr>
<td>59</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>61</td>
</tr>
<tr>
<td>62</td>
</tr>
<tr>
<td>63</td>
</tr>
<tr>
<td>64</td>
</tr>
<tr>
<td>65</td>
</tr>
<tr>
<td>66</td>
</tr>
<tr>
<td>67</td>
</tr>
<tr>
<td>68</td>
</tr>
<tr>
<td>69</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>71</td>
</tr>
<tr>
<td>72</td>
</tr>
<tr>
<td>73</td>
</tr>
<tr>
<td>74</td>
</tr>
<tr>
<td>75</td>
</tr>
<tr>
<td>76</td>
</tr>
<tr>
<td>77</td>
</tr>
<tr>
<td>78</td>
</tr>
<tr>
<td>79</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>81</td>
</tr>
<tr>
<td>82</td>
</tr>
<tr>
<td>83</td>
</tr>
<tr>
<td>84</td>
</tr>
<tr>
<td>85</td>
</tr>
<tr>
<td>86</td>
</tr>
<tr>
<td>87</td>
</tr>
<tr>
<td>88</td>
</tr>
<tr>
<td>89</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>91</td>
</tr>
<tr>
<td>92</td>
</tr>
<tr>
<td>93</td>
</tr>
<tr>
<td>94</td>
</tr>
<tr>
<td>95</td>
</tr>
<tr>
<td>96</td>
</tr>
<tr>
<td>97</td>
</tr>
<tr>
<td>98</td>
</tr>
<tr>
<td>99</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>
+--------------------------------+
```

Structural equation model

| Coef. Std. Err. | z | P>|z| | 95% Conf. Interval |
|-----------------|---|-----|-----------------|

Number of obs = 324
Log likelihood = -4687.8154

```stata
<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef. Std. Err.</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>

Structural

```
READFLUEAGE <- |
  attention | .2368612 .1426258  1.66 0.097 -.0426803 .5164026
   _cons | 93.77848 3.970952 23.62 0.000  85.99555 101.5614
```

```
PASSAGECOMPAGE <- |
  READFLUEAGE | .1532183 .0433381  3.54 0.000  .0682772 .2381593
  UNDDIRECS | .2258336 .0501609  4.50 0.000  .12752 .3241472
  attention | .0760578 .0923097  0.82 0.410  -.1048658 .2569814
   _cons | 64.54686 6.251405 10.33 0.000  52.29433 76.79939
```

UNDDIRECS <- |
  attention | .0147183 .1340281  0.11 0.913  -.247972 .2774087
   _cons | 98.90593 5.765836 26.26 0.000  91.52503 106.2868
```
. estimates store med_att
. * extract direct, indirect, and total effects
. estat teffects

Direct effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

| Structural |
| READFLUEAGE <- |
| attention | a1 .2368612 .1426258 1.66 0.097 -.0426803 .5164026 |

| PASSAGECOMPAGE <- |
| READFLUEAGE | b1 .1532183 .0433381 3.54 0.000 .0682772 .2381593 |
| UNDDIRECS | b2 .2258336 .0501609 4.50 0.000 .12752 .3241472 |
| attention | C' .0760578 .0923097 0.82 0.410 -.1048658 .2569814 |

| UNDDIRECS <- |
| attention | a2 .0147183 .1340281 0.11 0.913 -.247972 .2774087 |

Indirect effects

<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

| Structural |
| READFLUEAGE <- |
| attention | 0 (no path) |

| PASSAGECOMPAGE <- |
| READFLUEAGE | 0 (no path) |
| UNDDIRECS | 0 (no path) |
| attention | .0396153 .0476607 0.83 0.406 CI -.0537978 .1330285 |

| UNDDIRECS <- |
| attention | 0 (no path) |

Total effects
<table>
<thead>
<tr>
<th>Observed Bootstrap</th>
<th>Normal-based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coef. Std. Err. z P&gt;</td>
<td>z</td>
</tr>
</tbody>
</table>

-----

**Structural**

| READFLUEAGE <- | attention | .2368612 .1426258 1.66 0.097 -.0426803 .5164026 |

-----

| PASSAGECOMPAGE <- |
| READFLUEAGE | .1532183 .0433381 3.54 0.000 .0682772 .2381593 |
| UNDDIRECS    | .2258336 .0501609 4.50 0.000 .12752 .3241472 |
| attention    | .1156732 .105906 1.09 0.275 -.0918988 .3232452 |

-----

| UNDDIRECS <- |
| attention    | .0147183 .1340281 0.11 0.913 -.247972 .2774087 |

-----

* This creates a regression showing all the results from the previous models

```
estout wm med_wm med_att, ///
   cells(b(star fmt(%9.3f)) se(par fmt(%9.2f))) ///
   varwidth(25) modelwidth(10) order(WORKMEM attention READFLUEAGE UNDDIRECS) ///
   drop(var(e.PASSAGECOMPAGE): var(e.READFLUEAGE): var(e.UNDDIRECS):) ///
   stats(ll chi2 N, label("Log Likelihood" "N") fmt(%9.3f %9.0f)) ///
   mlabels("Model 1" "Model 2" "Model 3") ///
   varlabels(_cons Constant) label legend title(OIM standard Errors)
```

**OIM standard Errors**

```
-----------------------------------
Model 1  Model 2  Model 3
b/se   b/se   b/se
-----------------------------------
Reading Comprehension
Working Memory  0.259***  0.128***
   (0.04)  (0.04)
Attention  0.076
   (0.09)
Fluency    0.142**  0.153***
   (0.05)  (0.04)
Language Comprehension  0.174***  0.226***
   (0.05)  (0.05)
Constant  77.215***  59.314***  64.547***
   (3.98)  (5.49)  (6.25)
-----------------------------------
```

```
Fluency
Working Memory  0.363***
   (0.05)
Attention  0.237
   (0.14)
Constant  62.230***  93.778***
   (4.98)  (3.97)
```

102
Regression Table for Single Mediator Models

This creates a regression table showing all the results of the single mediator models.
.estout medwm_fluen medwm_comp medatt_fluen medatt_comp, extracols(3) mgroups("Working Memory" "Attention", pattern(1 0 1 0)) cells(b(star fmt(%9.3f)) se(par fmt(%9.2f))) varwidth(25) modelwidth(15) order(WORKMEM attention READFLUEAGE UNDDIRECS) drop(var(e.PASSAGECOMPAGE): var(e.READFLUEAGE): var(e.UNDDIRECS):) stats(ll N, label(\"Log Likelihood\" \"N\") fmt(%9.3f %9.0f)) mlabels("Fluency" "Comprehension" "Fluency" "Comprehension") eqlabels("Passage Comprehension Equation" "Mediation Equation") varlabels(_cons Constant) label legend title("Separated Models by Mediator and Independent Variable")

Separated Models by Mediator and Independent Variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Working Memory</th>
<th>Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b/se</td>
<td>b/se</td>
</tr>
<tr>
<td>Passage Comprehension E-n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working Memory</td>
<td>0.359***</td>
<td>0.441***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Attention</td>
<td>0.217</td>
<td>-0.035</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.14)</td>
</tr>
<tr>
<td>Constant</td>
<td>62.652***</td>
<td>53.068***</td>
</tr>
<tr>
<td></td>
<td>(5.17)</td>
<td>(4.62)</td>
</tr>
</tbody>
</table>

Mediation Equation

<table>
<thead>
<tr>
<th>Model (C')</th>
<th>Working Memory</th>
<th>Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b/se</td>
<td>b/se</td>
</tr>
<tr>
<td>Working Memory</td>
<td>0.194***</td>
<td>0.160***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Attention (C')</td>
<td>0.063</td>
<td>0.100</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>Fluency</td>
<td>0.176***</td>
<td>0.236***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Language Comprehension</td>
<td>0.222***</td>
<td>0.298***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
</tr>
</tbody>
</table>
**Correlation Table for All Variables**

```
.do "C:\Users\COLEMA-1\AppData\Local\Temp\STD0000000000.tmp"

.pwcorr $DEPS attention, sig

<table>
<thead>
<tr>
<th></th>
<th>PASSAGECOM-E</th>
<th>WORKMEM</th>
<th>READFLUEAGE</th>
<th>UNDDIRECS</th>
<th>attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSAGECOM-E</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>0.3839</td>
<td>1.0000</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td>0.3387</td>
<td>0.3778</td>
<td>1.0000</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>0.3930</td>
<td>0.5100</td>
<td>0.4489</td>
<td>1.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>attention</td>
<td>0.0526</td>
<td>-0.0186</td>
<td>0.0836</td>
<td>-0.0152</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
```

*p<0.05, ** p<0.01, *** p<0.001

```
Constant       66.372***   65.425***   79.093***   72.063***
(4.95)    (5.14)        (5.44)    (5.64)
Log Likelihood -3610.591   -3528.821       -3538.047   -3448.976
N          315    312        333    327

* p<0.05, ** p<0.01, *** p<0.001

```
**Diagnostics for Multiple Mediation Question 3C**

*------------------------
* Model diagnostics
*------------------------
* Now look at residuals and model diagnostics for Model 2, the working memory dual mediator model--this is the main model of interest
* sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) (WORKMEM -> UNDDIRECS, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
(52 observations with missing values excluded)

Endogenous variables
Observed: READFLUEAGE PASSAGECOMPAGE UNDDIRECS

Exogenous variables
Observed: WORKMEM

Fitting target model:

Iteration 0: log likelihood = -4704.4806
Iteration 1: log likelihood = -4704.4806

Structural equation model      Number of obs  =  310
Estimation method = ml
Log likelihood  = -4704.4806

|     OIM | Coef. Std. Err.  z  P>|z|  [95% Conf. Interval] |
|---------------------+----------------------------------------------------------------|
| Structural  | READFLUEAGE <-  | WORKMEM | .3627893 .0495251  7.33 0.000  .2657219 .4598566
 | _cons | 62.23034 5.246155 11.86 0.000  51.94806 72.51261 |
|---------------------+----------------------------------------------------------------|
| PASSAGECOMPAGE <-  | READFLUEAGE | .1424624 .0406052  3.51 0.000  .0628777 .2220471
 | WORKMEM | .1735619 .0470561  3.69 0.000  .0813336 .2657901
 | _cons | 59.31356 4.650653 12.75 0.000  50.19845 68.42868 |
|---------------------+----------------------------------------------------------------|
| UNDDIRECS <-  | WORKMEM | .4365319 .0427357 10.21 0.000  .3527714 .5202924
 | _cons | 53.55129 4.526963 11.83 0.000  44.67861 62.42398 |
|---------------------+----------------------------------------------------------------|
| var(e.READFLUEAGE) | 140.7898 11.30851 120.2821 164.794
| var(e.PASSAGECOMPAGE) | 65.30597 5.245502 55.79339 76.44042
| var(e.UNDDIRECS) | 104.8342 8.420484 89.56385 122.7081 |

LR test of model vs. saturated: chi2(1) =  30.08, Prob > chi2 = 0.0000
predict yhat redflhat lchat, xb // creates predicted y values (xb(READFLUEAGE PASSAGECOMPAGE UNDDIRECS) assumed)

gen resid=PASSAGE-yhat // creates residuals (20 missing values generated)

egen std_resid=std(resid) // standardized residuals (20 missing values generated)

** This creates histogram of standardized residuals
.hist std_resid, xtitle("") title(Standardized Residuals) ///
> note(Note: From {it:Working Memory} mediation model) freq normal xsize(4) ysize(4)
> (bin=18, start=-3.8112452, width=.40523554)

.graph export resids.png, replace
(file resids.png written in PNG format)

*- eyeball the heteroscedasticity across the model variables
. foreach x in WORKMEM READFLUEAGE UNDDIRECS attention {
  2. twoway scatter std_resid `x', yline(0, lc(gs10) lp(solid)) yline(1, lc(gs5) lp(dash)) yline(2, lc(gs2) lp(dash)) yline(-1, lc(gs3) lp(dash)) yline(-2, lc(gs3) lp(dash)) ytitle("") sa
  > ving( `x'_het.gph, replace)
  3. }
(file WORKMEM_het.gph saved)
(file READFLUEAGE_het.gph saved)
(file UNDDIRECS_het.gph saved)
(file attention_het.gph saved)

* combine these plots into a single figure and export
. graph combine WORKMEM_het.gph READFLUEAGE_het.gph UNDDIRECS_het.gph attention_het.gph, ///
> title("Standardized Residuals") rows(2) xsize(4) ysize(4) ycommon

.graph export hetgraphs.png, replace
(file hetgraphs.png written in PNG format)

* Bruesch-Pagan test of heteroscedasticity: regress squared residuals on independent variables
.gen resid2=resid*resid (20 missing values generated)
.reg resid2 WORKMEM READFLUEAGE UNDDIRECS attention

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 305</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>177669.213</td>
<td>4</td>
<td>44417.3034</td>
<td>Prob &gt; F = 0.1116</td>
</tr>
<tr>
<td>Residual</td>
<td>7039615.2</td>
<td>300</td>
<td>23465.384</td>
<td>R-squared = 0.0116</td>
</tr>
<tr>
<td>Total</td>
<td>7217284.41</td>
<td>304</td>
<td>23741.0671</td>
<td>Root MSE = 153.18</td>
</tr>
<tr>
<td>resid2</td>
<td>Coef. Std. Err.  t P&gt;</td>
<td>t</td>
<td>[95% Conf. Interval]</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>------------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>WORKMEM</td>
<td>-1.578624 .7598202 -2.08 0.039 -3.073876 -.0833714</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>READFLUEAGE</td>
<td>.5342923 .7796172 0.69 0.494 -.9999187 2.068503</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNDDIRECS</td>
<td>1.224302 .8955226 1.37 0.173 -.5379992 2.986604</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>attention</td>
<td>-2.706074 1.667482 -1.62 0.106 -5.987516 .5753687</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_cons</td>
<td>153.7257 98.14125 1.57 0.118 -39.40672 346.8582</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

. di "Bruesch-Pagan Test is: F("e(df_m) "," e(df_r) ")=" e(F) " with a p-value of " Ftail(e(df_m),e(df_r),e(F))
Bruesch-Pagan Test is: F(4,300)=1.8928863 with a p-value of .11160316
.
. *doesn't appear to be heteroscedasticity (at least at .1 level), but there are some large residuals
. * comparing those with large residuals, though, nothing stands out:
. list AGE YEAR GENDER if (abs(std_resid>2))

+---------------------+
<table>
<thead>
<tr>
<th>AGE    YEAR GENDER</th>
</tr>
</thead>
</table>
1. | 20 Jr Male |
2. | 27 Jr Male |
5. | 33 Grad Female |
9. | 36 Grad Female |
11. | 19 Fr Male |
|---------------------|
12. | 24 Grad Male |
13. | 27 Grad Female |
19. | 26 Sr Female |
20. | 21 Jr Male |
22. | 19 Fr Male |
|---------------------|
23. | 20 Sph Male |
24. | 18 Fr Male |
25. | 43 Jr Female |
37. | 27 Jr Male |
43. | 38 Grad Male |
|---------------------|
53. | 30 Sr Female |
80. | 21 Sr Male |
82. | 22 Sr Male |
111. | 22 Jr Female |
168. | 19 Fr Male |
|---------------------|
218. | 23 Sr Male |
262. | 24 Grad Female |
265. | 30 Grad Female |
281. | 20 Sr Female |
325. | 25 Grad Male |
|---------------------|
sum AGE YEAR GENDER if (abs(std_resid>2)) // summary stats of large residual cases

Variable | Obs  Mean  Std. Dev.  Min  Max
-------------+--------------------------------------------------------------------------
   AGE   |  32  25.25  6.559898   18   43
   YEAR  |  32  3.59375  1.340664   1    5
 GENDER |  32  1.65625  0.4825587   1   2

sum AGE YEAR GENDER if (abs(std_resid<2)) // summary stats of other cases

Variable | Obs  Mean  Std. Dev.  Min  Max
-------------+--------------------------------------------------------------------------
   AGE   |  329 23.16717  4.950919   18   43
   YEAR  |  330 3.115152  1.315819   1    5
 GENDER |  330 1.527273  0.5000138   1   2

log close
name: <unnamed>
log: C:\Users\ColemanEric\Dropbox\jen dissertation\data\jun2016\jendiss_jun2016.txt
log type: text

/*
> * Replicate results with robust standard errors to correct for arbitrary heteroscedasticity
> * standard errors are almost identical
> sem (PASSAGECOMPAGE <- WORKMEM), nocrapslatent vce(robust)
> estimates store wmrb
> > sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) (WORKMEM -> UNDDIRECS, ) ///
> > (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocrapslatent vce(robust)
> estimates store med_wmrb
> estat teffects
> > sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) (attention -> UNDDIRECS, ) ///
> > (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocrapslatent vce(robust)
> estimates store med_attrb

108
> estat techtacts
>
> estout wmb med_wmb med_attrb, ///
>   cells(b(star fmt(%9.3f)) se(par fmt(%9.2f))) ///
>   varwidth(25) modelwidth(10) order(WORKMEM attention READFLUEAGE UNDDIRECS) ///
>   drop(var(e.PASSAGECOMPAGE): var(e.READFLUEAGE): var(e.UNDDIRECS):) ///
>   stats(ll N, label("Log Likelihood" "N") fmt(%9.3f %9.0f)) ///
>   mlabels("Model 1" "Model 2" "Model 3") ///
>   varlabels(_cons Constant) label legend title(Huber-White Robust Standard Errors)
>
> log close
>
end of do-file

. save "C:\Users\ColemanEric\Dropbox\jen dissertation\data\july2016\Final Output Aug 7 2016.dta"
file C:\Users\ColemanEric\Dropbox\jen dissertation\data\july2016\Final Output Aug 7 2016.dta saved

. export excel using "C:\Users\ColemanEric\Dropbox\jen dissertation\data\july2016\trying excel.xls"
file C:\Users\ColemanEric\Dropbox\jen dissertation\data\july2016\trying excel.xls saved

.
Monte Carlo Power Analyses

. set seed 34092
. *--------------------------------------
. * WORKING MEMORY AS INDEPENDENT VARIABLE
. * -------------------------------------
. * Sample size is 317
. * Here is the multiple mediating model...extracting the effect size and standard
. * error of the effect size for random samples (with replacement) of the data
. * and calculating the z statistic for a single effect size
. capture program drop readfl_med_wm undi_med_wm two_med_wm
. *
. *------------------------
. * single mediator models
. *------------------------

Simple Mediation Question 3a: Working Memory through Silent Reading Fluency on Reading comprehension

. *** Reading Fluency ***
. * reading fluency sample size is 315
.
. use jendiss_mar2016, clear
(Written by R. )
.
. drop if (AGE > 45 | AGE < 18) & AGE !=.
(9 observations deleted)
.
. sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ), nocapslatent
(47 observations with missing values excluded)

Endogenous variables
Observed: READFLUEAGE PASSAGECOMPAGE

Exogenous variables
Observed: WORKMEM

Fitting target model:

Iteration 0: log likelihood = -3610.591
Iteration 1: log likelihood = -3610.591
Structural equation model      Number of obs  =  315
Estimation method = ml
Log likelihood  = -3610.591

|         | OIM | Coef. Std. Err.  z  P>|z|  [95% Conf. Interval] |
|---------------------+----------------------------------------------------------------|
| Structural    |   | READFLUEAGE <-   | WORKMEM | .3590571 .0492408  7.29 0.000  .262547 .4555673  _cons | 62.65202 5.220318 12.00 0.000  52.42039 72.88366 |
| PASSAGECOMPAGE <- | READFLUEAGE | .1759594 .0394573  4.46 0.000  .0986245 .2532943  WORKMEM | .1938698 .0372801  5.20 0.000  .1208021 .2669375  _cons | 66.37193 4.413148 15.04 0.000  57.72232 75.02154 |
| var(e.READFLUEAGE) | 141.3521 11.26321 120.9141 165.2448 |
| var(e.PASSAGECOMPAGE) | 69.32144 5.523664 59.2983 81.03879 |
| LR test of model vs. saturated: chi2(0) = 0.00, Prob > chi2 = . |

. keep if e(sample)
(47 observations deleted)

. save wm_med_readfl.dta, replace
(note: file wm_med_readfl.dta not found)
file wm_med_readfl.dta saved

. program readfl_med_wm, rclass
1.   syntax [, samp(integer 1) ]
2.   drop _all
3.   use wm_med_readfl.dta, clear
4.   bsample `samp'
5.   sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
> (READFLUEAGE -> PASSAGECOMPAGE, ), nocapslatent
6.   estat teffects
7.   matrix b=r(indirect)
8.   scalar b=b[1,3]
9.   matrix v=r(V_indirect)
10.  scalar v=v[3,3]
11. return scalar z=b/sqrt(v)
12. end

* Simulating the proportion of times the null hypothesis is rejected
.
. simulate z=r(z), reps(1000): readfl_med_wm, samp(315)

command: readfl_med_wm, samp(315)
z: r(z)

Simulations (1000)
----------- 1 ----------- 2 ----------- 3 ----------- 4 ----------- 5

.................................................. 50
.................................................. 100
.................................................. 150
.................................................. 200
.................................................. 250
.................................................. 300
.................................................. 350
.................................................. 400
.................................................. 450
.................................................. 500
.................................................. 550
.................................................. 600
.................................................. 650
.................................................. 700
.................................................. 750
.................................................. 800
.................................................. 850
.................................................. 900
.................................................. 950
.................................................. 1000

. qui gen p=2*(1-normal(abs(z)))<.05
. qui sum p

. di "Working Memory mediated through Reading Fluency: For a sample size of " `i' " the power is " r(mean)
Working Memory mediated through Reading Fluency: For a sample size of 315 the power is .977

Simple Mediation Question 3b: Working Memory through Language Comprehension on Reading comprehension

112
. *** Language Comprehension ***
. * language comprehension sample size is 312
.
. use jendiss_mar2016, clear
(Written by R. )
.
. drop if (AGE > 45 | AGE < 18) & AGE !=.
(9 observations deleted)
.
. sem (WORKMEM -> UNDDIRECS, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
>     (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
(50 observations with missing values excluded)

Endogenous variables

Observed: UNDDIRECS PASSAGECOMPAGE

Exogenous variables

Observed: WORKMEM

Fitting target model:

Iteration 0: log likelihood = -3528.8207
Iteration 1: log likelihood = -3528.8207

Structural equation model      Number of obs  =  312
Estimation method = ml
Log likelihood  = -3528.8207

| OIM         | Coef. Std. Err.  z  P>|z|  [95% Conf. Interval] |
|---------------------+---------------------------------------------------------------- |
| Structural          |                             |
| UNDDIRECS <- |                  |
| WORKMEM | .4414794 .0422556 10.45 0.000  .3586601 .5242988 |
| _cons | 53.06804 4.484025 11.83 0.000  44.27952 61.85657 |

| ---------------------+---------------------------------------------------------------- |
| PASSAGECOMPAGE <- |                  |
| UNDDIRECS | .2223133 .0453892 4.90 0.000  .133352 .3112745 |
| WORKMEM | .1601054 .0453892 4.07 0.000  .0829605 .2372502 |
| _cons | 65.42529 4.327343 15.12 0.000  56.94386 73.90673 |

| ---------------------+---------------------------------------------------------------- |
| var(e.UNDDIRECS) | 105.072 8.412491 122.9243 |
| var(e.PASSAGECOMPAGE) | 105.072 8.412491 122.9243 |

113
var(e.PASSAGECOMPAGE)  67.53782  5.407353  57.72931  79.01285
-------------------------------------------------------------------------------
LR test of model vs. saturated: chi2(0) = 0.00, Prob > chi2 = .

. keep if e(sample)
(50 observations deleted)

. save wm_med_undi.dta, replace
(note: file wm_med_undi.dta not found)
file wm_med_undi.dta saved

. program undi_med_wm, rclass
1.   syntax [, samp(integer 1) ]
2.   drop _all
3.   use wm_med_undi.dta, clear
4.   bsample `samp'
5.   sem (WORKMEM -> UNDDIRECS, ) (WORKMEM -> PASSAGECOMPAGE, ) ///
   >   (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
6.   estat teffects
7.   matrix b=r(indirect)
8.   scalar b=b[1,3]
9.   matrix v=r(V_indirect)
10.  scalar v=v[3,3]
11.  . return scalar z=b/sqrt(v)
12.  end

. * Simulating the proportion of times the null hypothesis is rejected
  . simulate z=r(z), reps(1000): undi_med_wm, samp(312)

command: undi_med_wm, samp(312)
z: r(z)

Simulations (1000)
-------- 1 -------- 2 -------- 3 -------- 4 -------- 5
.............................. .............................. 50
.............................. .............................. 100
.............................. .............................. 150
.............................. .............................. 200
.............................. .............................. 250
.............................. .............................. 300
. qui gen p=2*(1-normal(abs(z)))<.05
. qui sum p
. di "Working Memory mediated through Language Comprehension: For a sample size of " `i' " the power is " r(mean)

Working Memory mediated through Language Comprehension: For a sample size of 312 the power is .991

**Multiple Mediation Question 3c: Working Memory Multiple Mediating Model**

. *-------------------------------------
. * Dual Mediator Model Working Memory
. *-------------------------------------
. *** Reading fluency and language comprehension***
. * sample size is 310
. . use jendiss_mar2016, clear
   (Written by R.  )
. . drop if (AGE > 45 | AGE < 18) & AGE !=.
   (9 observations deleted)
. . sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) (WORKMEM -> UNDDIRECS, ) ///
   > (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
   (52 observations with missing values excluded)

Endogenous variables
Observed: READFLUEAGE PASSAGECOMPAGE UNDDIRECS

Exogenous variables
Observed: WORKMEM

Fitting target model:

Iteration 0: log likelihood = -4704.4806
Iteration 1: log likelihood = -4704.4806

Structural equation model Number of obs = 310
Estimation method = ml
Log likelihood = -4704.4806

| OIM | Coef. Std. Err.  z P>|z|  [95% Conf. Interval] |
|-----+----------------------------------|
| Structural |  
| READFLUEAGE <- | WORKMEM | 0.362793 0.0495251 7.33 0.000 0.2657219 0.4598566  
| _cons | 62.23034 5.246155 11.86 0.000 51.94806 72.51261 |
| PASSAGECOMPAGE <- | READFLUEAGE | 0.1424624 0.0406052 3.51 0.000 0.0628777 0.2220471  
| PASSAGECOMPAGE | UNDDIRECS | 0.1735619 0.0470561 3.69 0.000 0.0813336 0.2657901  
| WORKMEM | 0.1282535 0.0399077 3.21 0.001 0.0500358 0.2064713  
| _cons | 59.31356 4.650653 12.75 0.000 50.19845 68.42868 |
| UNDDIRECS <- | WORKMEM | 0.4365319 0.0427357 10.21 0.000 0.3527714 0.5202924  
| _cons | 53.55129 4.526963 11.83 0.000 44.67861 62.42398 |

| var(e.READFLUEAGE) | 140.7898 11.30851 120.2821 164.794 |
| var(e.PASSAGECOMPAGE) | 65.30597 5.245502 55.79339 76.44042 |
| var(e.UNDDIRECS) | 104.8342 8.420484 89.56385 122.7081 |

LR test of model vs. saturated: chi2(1) = 30.08, Prob > chi2 = 0.0000

. keep if e(sample)
(52 observations deleted)

. save wm_med_dual.dta, replace
(note: file wm_med_dual.dta not found)
file wm_med_dual.dta saved

. 116
program two_med_wm, rclass
1. syntax [, samp(integer 1) ]
2. drop _all
3. use "wm_med_dual.dta", clear
4. bsample `samp'
5. sem (WORKMEM -> READFLUEAGE, ) (WORKMEM -> PASSAGECOMPAGE, ) (WORKMEM -> UNDDIRECS, ) ///
  (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
6. estat teffects
7. matrix b=r(indirect)
8. scalar b=b[1,4]
9. matrix v=r(V_indirect)
10. scalar v=v[4,4]
11. return scalar z=b/sqrt(v)
12. end
.
.
* Simulating the proportion of times the null hypothesis is rejected
* qui simulate z=r(z), reps(1000): two_med_wm, samp(310)
qui gen p=2*(1-normal(abs(z)))<.05
qui sum p
.
di "Dual Mediator for Working Memory: For a sample size of `i' the power is `r(mean)

Simple Mediation Question 4a: Attention through Silent Reading Fluency on Reading comprehension

*--------------------------------------
* ATTENTION AS INDEPENDENT VARIABLE
*--------------------------------------
* Sample size is 333
* Here is the multiple mediating model...extracting the effect size and standard
* error of the effect size for random samples (with replacement) of the data
* and calculating the z statistic for a single effect size
* capture program drop readfl_med_att undi_med_att two_med_att

*------------------------
* single mediator models
*------------------------
*** Reading Fluency ***
* reading fluency sample size is 333

. use jendiss_mar2016, clear
(Written by R. )

. drop if (AGE > 45 | AGE < 18) & AGE !=.
(9 observations deleted)

. gen attention = CURRSYM_1 + CURRSYM_3 + CURRSYM_5 + CURRSYM_7 + ///
>   CURRSYM_9 + CURRSYM_11 + CURRSYM_13 + CURRSYM_15 + ///
>   CURRSYM_17
(5 missing values generated)

. label var attention "Attention"

. sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) ///
>     (READFLUEAGE -> PASSAGECOMPAGE, ), nocapslatent
(29 observations with missing values excluded)

Endogenous variables
Observed: READFLUEAGE PASSAGECOMPAGE
Exogenous variables
Observed: attention

Fitting target model:

Iteration 0: log likelihood = -3538.047
Iteration 1: log likelihood = -3538.047

Structural equation model          Number of obs  =  333
Estimation method = ml
Log likelihood  = -3538.047

|                      OIM                      |
|----------------------|----------------------------------------|
| Coef. Std. Err. z P>|z| [95% Conf. Interval] |
|----------------------|----------------------------------------|
| Structural           |                                        |
| READFLUEAGE <-       |                                        |
| attention            | 0.2170389 .129988 1.67 0.095 -.0377329 .4718107 |
| _cons                | 94.41637 3.630472 26.01 0.000 87.30078 101.532 |
---+-------------------------------------------------------------------+
   PASSAGECOMPAGE  <-  |
    READFLUEAGE  |  .2359584  .03732  6.32 0.000  .1628126 .3091042
    attention  |  .0632964 .088895  0.71 0.476 -.1109346 .2375273
    _cons  |  79.09299 4.304516 18.37 0.000  70.6563 87.52969
---+-------------------------------------------------------------------+
   var(e.READFLUEAGE)  |  160.3313 12.42542 137.7373 186.6316
   var(e.PASSAGECOMPAGE)  |  74.36101 5.762861  63.882 86.55896
---+-------------------------------------------------------------------+
LR test of model vs. saturated: chi2(0) = 0.00, Prob > chi2 = .

   . keep if e(sample)
   (29 observations deleted)

   . save att_med_readfl.dta, replace
   (note: file att_med_readfl.dta not found)
file att_med_readfl.dta saved

   . program readfl_med_att, rclass
   1.   syntax [, samp(integer 1) ]
   2.   drop _all
   3.   use att_med_readfl.dta, clear
   4.   expand(10)
   5.   bsample `samp'
   6.   sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) ///
       (READFLUEAGE -> PASSAGECOMPAGE, ), nocapslatent
   7.   estat teffects
   8.   matrix b=r(indirect)
   9.   scalar b=b[1,3]
  10.   matrix v=r(V_indirect)
  11.   scalar v=v[3,3]
  12.   return scalar z=b/sqrt(v)
  13. end

   . * Simulating the proportion of times the null hypothesis is rejected
   . simulate z=r(z), reps(1000): readfl_med_att, samp(333)

command:  readfl_med_att, samp(333)
z:  r(z)
Simulations (1000)
. qui gen p=2*(1-normal(abs(z)))<.05
.
. qui sum p
.
. di "Attention mediated through Reading Fluency: For a sample size of " `i' " the power is " r(mean)

Attention mediated through Reading Fluency: For a sample size of 333 the power is .328
.
.* Obtain these values to see how big a sample is needed
. forvalues i=500(500)3000 {
2. qui simulate z=r(z), reps(1000): readfl_med_att, samp(`i')
3. qui gen p=2*(1-normal(abs(z)))<.05
4. qui sum p
5. di "Attention mediated through Reading Fluency: For a sample size of " `i' " the power is " r(mean)
6. }

Attention mediated through Reading Fluency: For a sample size of 500 the power is .507
Attention mediated through Reading Fluency: For a sample size of 1000 the power is .816
Attention mediated through Reading Fluency: For a sample size of 1500 the power is .938
Attention mediated through Reading Fluency: For a sample size of 2000 the power is .977
Attention mediated through Reading Fluency: For a sample size of 2500 the power is .991
Attention mediated through Reading Fluency: For a sample size of 3000 the power is .997
Simple Mediation Question 4b: Attention through Language Comprehension on Reading comprehension

*** Language Comprehension ***
* language comprehension sample size is 327

use jendiss_mar2016, clear
(Written by R.)

. drop if (AGE > 45 | AGE < 18) & AGE !=.
(9 observations deleted)

gen attention = CURRSYM_1 + CURRSYM_3 + CURRSYM_5 + CURRSYM_7 + ///
CURRSYM_9 + CURRSYM_11 + CURRSYM_13 + CURRSYM_15 + ///
CURRSYM_17
(5 missing values generated)

. label var attention "Attention"

. sem (attention -> UNDDIRECS, ) (attention -> PASSAGECOMPAGE, ) ///
(UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
(35 observations with missing values excluded)

Endogenous variables
Observed: UNDDIRECS PASSAGECOMPAGE

Exogenous variables
Observed: attention

Fitting target model:

Iteration 0: log likelihood = -3448.9756
Iteration 1: log likelihood = -3448.9756

Structural equation model Number of obs = 327
Estimation method = ml
Log likelihood = -3448.9756

---------------------------------------------------------------------
| Coef. Std. Err. z P>|z| [95% Conf. Interval]
---------------------------------------------------------------------
Structural |
UNDDIRECS <- |
  attention | -.0353754 .1231298 -0.29 0.774 -.2767053 .2059546
  _cons | 100.4051 3.422421 29.34 0.000 93.69731 107.113
-------------------------------
PASSAGECOMPAGE <- |
  UNDDIRECS | .2984201 .0389239 7.67 0.000 .2221307 .3747095
  attention | .0997588 .0866778 1.15 0.250 -.0701265 .2696441
  _cons | 72.06307 4.590926 15.70 0.000 63.06502 81.06112
-------------------------------

var(e.UNDDIRECS)| 142.7976 11.16765 122.5044 166.4524
var(e.PASSAGECOMPAGE)| 70.74576 5.532756 60.69196 82.46499
-------------------------------
LR test of model vs. saturated: chi2(0) = 0.00, Prob > chi2 = .

. keep if e(sample)
(35 observations deleted)

. save att_med_undi.dta, replace
(note: file att_med_undi.dta not found)
file att_med_undi.dta saved

. program undi_med_att, rclass
1.   syntax [, samp(integer 1) ]
2.   drop _all
3.   use att_med_undi.dta, clear
4.   expand(10)
5.   bsample `samp'
6.   sem (attention -> UNDDIRECS, ) (attention -> PASSAGECOMPAGE, ) ///
> (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
7.   estat teffects
8.     matrix b=r(indirect)
9.     scalar b=b[1,3]
10.    matrix v=r(V_indirect)
11.    scalar v=v[3,3]
12.    return scalar z=b/sqrt(v)
13. end

. .
. * Simulating the proportion of times the null hypothesis is rejected

. simulate z=r(z), reps(1000): undi_med_att, samp(327)
command: undi_med_att, samp(327)
z: r(z)

Simulations (1000)

---+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5

.................................................. 50
.................................................. 100
.................................................. 150
.................................................. 200
.................................................. 250
.................................................. 300
.................................................. 350
.................................................. 400
.................................................. 450
.................................................. 500
.................................................. 550
.................................................. 600
.................................................. 650
.................................................. 700
.................................................. 750
.................................................. 800
.................................................. 850
.................................................. 900
.................................................. 950
.................................................. 1000

. qui gen p=2*(1-normal(abs(z)))<.05

. qui sum p

. di "Working Memory mediated through Language Comprehension: For a sample size of " `i' " the power is " r(mean)

Working Memory mediated through Language Comprehension: For a sample size of 327 the power is .074

.

. * Obtain these values to see how big a sample is needed
. forvalues i=500(500)3000 {
2.   qui simulate z=r(z), reps(1000): undi_med_att, samp(`i')
3.   qui gen p=2*(1-normal(abs(z)))<.05
4.   qui sum p
5.   di "Attention mediated through Language Comprehension: For a sample size of " `i' " the power is " r(mean)
6. }

Attention mediated through Language Comprehension: For a sample size of 500 the power is .086
Attention mediated through Language Comprehension: For a sample size of 1000 the power is .102
Attention mediated through Language Comprehension: For a sample size of 1500 the power is .123
Attention mediated through Language Comprehension: For a sample size of 2000 the power is .143
Attention mediated through Language Comprehension: For a sample size of 2500 the power is .141
Attention mediated through Language Comprehension: For a sample size of 3000 the power is .154

**Multiple Mediation Question 4c: Attention Multiple Mediating Model**

```
  . *---------------------------------------------------------------
  . * Dual Mediator Model Attention
  . *---------------------------------------------------------------
  . *** Reading fluency and language comprehension***
  . * sample size is 324
  .
  . use jendiss_mar2016, clear
  (Written by R.)
  .
  . drop if (AGE > 45 | AGE < 18) & AGE !=.
  (9 observations deleted)
  .
  . gen attention = CURRSYM_1 + CURRSYM_3 + CURRSYM_5 + CURRSYM_7 + ///
  > CURRSYM_9 + CURRSYM_11 + CURRSYM_13 + CURRSYM_15 + ///
  > CURRSYM_17
  (5 missing values generated)
  .
  . label var attention "Attention"
  .
  . sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) (attention -> UNDDIRECS, ) ///
  > (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
  (38 observations with missing values excluded)

Endogenous variables
Observed: READFLUEAGE PASSAGECOMPAGE UNDDIRECS

Exogenous variables
Observed: attention

Fitting target model:
Iteration 0: log likelihood = -4687.8154
Iteration 1: log likelihood = -4687.8154

Structural equation model    Number of obs = 324
Estimation method = ml
Log likelihood = -4687.8154
```
| OIM | Coef. Std. Err. z P>|z| [95% Conf. Interval] |
|-----|---------------------------------|
| Structural | READFLUEAGE <- attention | 0.2368612 .1330105 1.78 0.075 -.0238347  .497557 |
| | _cons | 93.77848 3.706931 25.30 0.000  86.51302 101.0439 |
| PASSAGECOMPAGE <- READFLUEAGE | .1532183 .0400918 3.82 0.000  .0746397 .2317968 |
| | UNDDIRECS | .2258336 .0427667 5.28 0.000  .1420125 .3096547 |
| | attention | 0.0760578 .0868795 0.88 0.381 -.0942228 .2463385 |
| | _cons | 64.54686 4.894738 13.19 0.000  54.95335 74.14037 |
| UNDDIRECS <- attention | 0.0147183 .1246914 0.12 0.906 -.2296723 .2591089 |
| | _cons | 98.90593 3.475081 28.46 0.000  92.0949 105.717 |
| var(e.READFLUEAGE)| 160.9379 12.64447 137.9690 187.7305 |
| var(e.PASSAGECOMPAGE)| 67.88613 5.333638 58.1975 79.1877 |
| var(e.UNDDIRECS)| 141.4357 11.11224 121.2502 164.9817 |
| LR test of model vs. saturated: chi2(1) = 68.29, Prob > chi2 = 0.0000 |

. keep if e(sample) (38 observations deleted)

. save att_med_dual.dta, replace (note: file att_med_dual.dta not found)
file att_med_dual.dta saved

. program two_med_att, rclass
1. syntax [, samp(integer 1) ]
2. drop _all
3. use "att_med_dual.dta", clear
4. expand(10)
5. bsample `samp'
6. sem (attention -> READFLUEAGE, ) (attention -> PASSAGECOMPAGE, ) (attention -> UNDDIRECS, ) ///
  > (READFLUEAGE -> PASSAGECOMPAGE, ) (UNDDIRECS -> PASSAGECOMPAGE, ), nocapslatent
7. estat teffects
8. matrix b=r(indirect)
9. scalar b=b[1,4]
10.     matrix v=r(V_indirect)
11.     scalar v=v[4,4]
12.     return scalar z=b/sqrt(v)
13. end

. * Simulating the proportion of times the null hypothesis is rejected
. qui simulate z=r(z), reps(1000): two_med_att, samp(324)
. qui gen p=2*(1-normal(abs(z)))<.05
. qui sum p
. di "Dual Mediator for Attention: For a sample size of " `i' " the power is " r(mean)
Dual Mediator for Attention: For a sample size of 324 the power is .254

. * Obtain these values to see how big a sample is needed
. forvalues i=500(500)3000 {
  2.   qui simulate z=r(z), reps(1000): two_med_att, samp(`i')
  3.   qui gen p=2*(1-normal(abs(z)))<.05
  4.   qui sum p
  5.   di "Dual Mediator for Attention: For a sample size of " `i' " the power is " r(mean)
  6. }
Dual Mediator for Attention: For a sample size of 500 the power is .304
Dual Mediator for Attention: For a sample size of 1000 the power is .459
Dual Mediator for Attention: For a sample size of 1500 the power is .609
Dual Mediator for Attention: For a sample size of 2000 the power is .706
Dual Mediator for Attention: For a sample size of 2500 the power is .792
Dual Mediator for Attention: For a sample size of 3000 the power is .85

. log close
. end of do-file
REFERENCES


Hoffman, J. V. (2009). In search of the “simple view” of reading comprehension. In S. E. Israel, & G. G. Duffy (Eds.), Handbook of research on reading comprehension (pp. 54-66) Routledge, Taylor & Francis New York.


StataCorp. (2015). STATA statistical software: Release 14. College Station, TX: StataCorp LP.


BIOGRAPHICAL SKETCH

VITA 2017

JENNIFER L.B. COLEMAN

Doctoral Candidate
Counseling and School Psychology
Florida State University
College of Education
1114 W. Call Street
P.O. Box 3064450
Tallahassee, FL 32306-4450

EDUCATION

Doctoral Candidate at Florida State University, Tallahassee, FL
Combined Counseling and School Psychology Ph.D.
Expected graduation: Fall 2017. Present Cumulative GPA 3.98
APA accredited
Bachelor of Science, Utah State University, Logan, UT
Associate of Science, Dixie State College, St. George, UT
Major: Communication. Academic Scholarship, Graduated Cum Laude May 2002

PSYCHOLOGY INTERNSHIP AND PRACTICA EXPERIENCE

<table>
<thead>
<tr>
<th>Fall 2016- Present</th>
<th>Atlanta VA Medical Center (APA-accredited APPIC internship site)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Doctoral Psychology Intern, Atlanta, GA</strong></td>
</tr>
<tr>
<td></td>
<td>• Trauma Recovery Rotation—PE and CPT</td>
</tr>
<tr>
<td></td>
<td>• Substance Abuse Treatment Program—Smart Choices</td>
</tr>
<tr>
<td></td>
<td>• Health Psychology—ACT Pain Treatment</td>
</tr>
<tr>
<td></td>
<td>• Primary Care Mental Health Integration Women’s Wellness</td>
</tr>
<tr>
<td></td>
<td>• Long-Term Therapy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summer/Fall 2015</th>
<th>North FL/ South GA Veteran’s Affairs Health Care System (APA-accredited APPIC internship site)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Doctoral Psychology Practicum Trainee, Lake City, FL</strong></td>
</tr>
<tr>
<td></td>
<td>• Serve residents in a community living center by providing psychological support for those experiencing dementia and other cognitive challenges, rehabilitation and restorative care, long-term care, and hospice/palliative care.</td>
</tr>
<tr>
<td></td>
<td>• Collaborate with interdisciplinary teams to provide comprehensive medical and psychological health services.</td>
</tr>
<tr>
<td></td>
<td>• Lead and support individual and group therapy sessions.</td>
</tr>
</tbody>
</table>

140
Summer/Fall 2015 **Health and Wellness Center at Florida State University**  
_Doctoral Psychology Practicum Trainee /Substance Abuse Health Educator_, Tallahassee, FL  
- Serve university students experiencing drug and alcohol problems.  
- Lead weekly individual and group substance abuse psychotherapy and psychoeducation sessions  
- Promote healthy choices and practices to reduce substance abuse among university students.

Summer/Fall 2015 **Florida State Hospital (APA-accredited APPIC internship site)**  
_Doctoral Psychology Practicum Trainee_, Chattahoochee, FL  
- Serve forensic and civil residents experiencing severe mental illnesses in the Specialty Care Unit as well as Civil Admissions.  
- Provide individual therapy sessions and assessments with residents with the goal of developing skills necessary to become competence to proceed in the adjudication process.  
- Co-lead therapy groups among women experiencing borderline personality disorders.

Spring 2015 **Tallahassee-Haiti Medical Team**  
_Doctoral Psychology Practicum Trainee /Clinical Assistant_, Dumay, Haiti  
- Serve the community members of Dumay experiencing limited access to health care in a rural and impoverished environment.  
- Work with translators to facilitate triage and routine intake procedures, accurate medical and mental health diagnosis, and culturally appropriate treatment plans.  
- Co-facilitate daily interdisciplinary team debriefing sessions to assess and support staff needs after traumatic events.  
- Network with community members in the U.S. and Haiti to obtain clinical supplies and donations to support the clinic and orphanage.

2014-2015 **Career Center at FSU**  
_Doctoral Psychology Practicum Trainee_, Tallahassee, FL  
- Serve community members and university students experiencing career and life-transitions.  
- Provide psychotherapeutic interventions and psycho-educational to address environment and internal barriers preventing gainful and fulling employment and life experience.  
- Utilize personality and career assessments to guide treatment plans and support intervention selection.
2014-2016  **Private Practice: Dr. Robert S. Kline, Psy.D.**
*Doctoral Psychology Practicum Trainee*, Tallahassee, FL and Dothan, AL
  - Serve a highly varied population experiencing the need for disability assessment due to mental health concerns including PTSD, anxiety, depression, cognitive damage as a result of substance abuse, etc.
  - Conduct interviews, evaluations, assessments and attend court sessions for forensic cases involving child custody, abuse, and sexual predation.
  - Recruited and support the training of incoming doctoral students.

2014  **Adult Learning and Evaluation Center ADHD Coaching**
*Doctoral Psychology Practicum Trainee*, Tallahassee, FL
  - Serve community and university students experiencing ADHD symptoms.
  - Provide psychotherapeutic therapy and coaching sessions to support ADHD symptom management.
  - Collect and code data to support an ongoing research project aimed at understanding the effectiveness of the therapy model being utilized.

2013-2014  **Adult Learning and Evaluation Center**
*Doctoral Psychology Practicum Trainee*, Tallahassee, FL
  - Serve community members and university students experiencing mental health symptoms related to learning disorders and ADHD.
  - Perform comprehensive psychodiagnostic evaluations and assessments, report writing, and feedback for sessions for clients.
  - Supervise and train incoming students for assessments, interviewing techniques, and writing reports.
  - Design and implement supporting materials to streamline report writing, scoring, and chart management.

2013-2014  **Capital City Youth Services**
*Doctoral Psychology Practicum Trainee/Family Advocate Intern*, Tallahassee, FL
  - Serve adolescents and their families experiencing abuse, substance abuse problems, family instability, and family transitions.
  - Provide individual and family therapy in clinical and school settings.
  - Design, recruit, and lead group therapy sessions focused on social skills and anger management.

2012  **Florida State University, Human Services Center**
*Doctoral Psychology Practicum Trainee*, Tallahassee, FL
  - Serve community members and university students experiencing mental health difficulties related to depression, anxiety, adjustment, and anger management.
  - Support peers in supervisory meetings by providing and receiving feedback aimed at improving therapy techniques and relationships to better serve our clients.
2012-2013  **Florida State University Multidisciplinary Evaluation and Consulting Center**  
(APA-accredited APPIC internship site)  
*Doctoral Psychology Practicum Trainee*, Tallahassee, FL  
- Serve children and adolescents experiencing learning disorders, neurodevelopmental disorders, and behavioral concerns in clinical and public school settings.  
- Provide comprehensive record reviews, diagnostic evaluations, and reports to support the educational team’s decision making process for interventions.  
- Develop and lead lectures supporting evidence-based practices in assessment.

**WORK EXPERIENCE**

2004-2006 **Asset Building Coalition**  
*Youth Network Coordinator*, Bloomington, IN  
- Serve public, charter, and private school students and teachers in efforts to prevent substance abuse in the community.  
- Design and host leadership training programs designed to promote healthy choices.  
- Organize annual Youth Summit leadership training.  
- Cooperate with city, county, and state government officials to support healthy choices.  
- Collaborate with local businesses and health care providers to create and distribute the Teen Connection Card to over 8,000 teens. This cost-effective tool provides education to teens about health services and other resources.

2000-2003  **Mount Logan & Pine View Middle Schools**  
*Special Education Assistant*, Logan, UT and St. George, UT  
- Serve students experiencing physical and mental disabilities, students with limited resources and easy access to alcohol, tobacco and other drugs, and transitioning students learning English as a second language.  
- Provide classes on life skills, academic mentoring, and reading instruction.

2002-2003  **Raindancer Youth Services**  
*Counselor Assistant*, St. George, UT  
- Support Native American youth removed from their homes and community due to crisis and unsafe conditions.  
- Assist counselors and therapists in psychoeducational and recreational activities designed to support the residents during their stay at the facility.
· Support counselors in research of culturally appropriate placements, and familial considerations related to diverse nations and political conflicts.

2002

**Confluence Expeditions**  
*River Guide*, Seeley Lake, MT.

· Serve corporate employees seeking leadership and team building trainings experience in an adventurous environment.
· Lead, plan, and guide river trips—maintain client and staff safety while on and off the river by providing relevant safety and recreational guidelines.
· Direct and support team building activities aimed at improving communication and trust.

**VOLUNTEER EXPERIENCE**

2013-2015  
**Archbold Medical Center /Hospice of Southwest Georgia**  
*Grief Counselor with Camp H.E.A.L.*, Thomasville, GA

· Support children and teens bereaving the loss of a family member.
· Lead and provide grief support activities in a camp setting.

2014  
**Children’s Medical Society**  
*Developmental Screener*, Tallahassee, FL

· Serve parents in providing preventative health care for their young children.
· Assess and screen children for social emotional delays.
· Provide support and information about community resources for parents.

2012-2013  
**Unitarian Universalist Church**  
*Instructor*, Tallahassee, FL

· Serve school aged children (K-12) in weekly instructional and spiritual meetings by teaching cooperation, compassion, and cultural awareness.

2004-2006  
**Youth Services Bureau of Monroe County**  
*Event and Staff Volunteer*, Bloomington, IN

· Support youth temporarily housed at a shelter due to crisis or unsafe home conditions by designing and leading activities and supporting staff needs.

2004-2009  
**Monroe County CARES Board**  
*Treasurer*, Bloomington, IN

· Serve in multiple roles including treasurer, co-chair and secretary.
· Support fundraising, grant review, and distribution of funds to evidence-based programs focused on drug abuse prevention, treatment and law enforcement.

2004-2009  
**Asset Building Coalition**  
*Board Member*, Bloomington, IN
· Assist with fundraising, budgeting, and marketing for family and youth programs aimed at improving healthy lifestyle choices and reducing substance use in the community.

2008-2009  **Celebration of Families**  
*Marketing Volunteer, Bloomington, IN*  
· Marketer and event planner for the month long celebration supporting families and providing resources for those experiencing limited financial resources.

2006  **International Women’s Club**  
*Fundraiser and Volunteer, Sofia, Bulgaria*  
· Serve children and teens living in orphanages in Sofia and Plovdiv, Bulgaria.  
· Collaborate with medical students and community members to raise funds and deliver hygiene supplies and toys to the orphanages.

**PRESENTATIONS**

Coleman, J (February 2017) *Differential Diagnosis Assessment Case: Bipolar, Obsessive Compulsive Disorder, and ADHD.* Atlanta VA Medical Center Assessment Seminar, Decatur, GA

Coleman, J. (December 2016) *ADHD Coaching and Assessment.* Atlanta VA Medical Center General Seminar, Decatur, GA

Coleman, J. (February, 2015) *Examining the Relationships Between Executive Functioning, Working Memory, Reading Comprehension in Adults with ADHD.* NASP conference poster presentation, Orlando, FL


**GUEST LECTURES**


**PUBLICATIONS AND WORKING PAPERS**


**DISSERTATION**

Coleman, J. (n.d.) *Reading Abilities Among College Students with ADHD*. [Defended May 2017]

**UNIVERSITY TEACHING EXPERIENCE**

Communication and Human Relations (SDS 4481) Florida State University. Instructor

**RESEARCH EXPERIENCE**

<table>
<thead>
<tr>
<th>2012- Present</th>
<th>Research Team Member working under Dr. Frances Prevatt, Florida State University</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Topics of research include: Adult ADHD, Executive Functioning, Academics, Coaching and Interventions, and Motivation.</td>
</tr>
</tbody>
</table>

| 2012-2015     | Doctoral Research Assistant at The Florida Center for Reading Research, Florida State University |
- Assess children’s reading, vision and memory.
- Data collection of pre and post test data aimed at improving evidence based instruction.

2004-2007  Data Collection and Management Assistant with the Asset Building Coalition’s, *Substance Abuse and Mental Health Services Administration (SAMHSA) Grant*, Bloomington, IN
  - Survey and document agency efforts to produce evidence-based drug-prevention practices.

2003-2004  Research Team Member working under Dr. Reed Geertsen, Medical Sociologist, Utah State University
  - Design and implementation of medical adherence surveys evaluating community health practices.

**LEADERSHIP EXPERIENCES AND PROFESSIONAL DEVELOPMENT**

**Student Organization of Health Service Psychology at Florida State University (SOHSP)**
*Vice-President*, 2012-Present
  - Co-founder of the organization
  - Work with students and faculty to foster professional and mentoring relationships through events, volunteer opportunities, and social gatherings
  - Fundraising for events and conferences
  - Participate in training, teaching, and faculty/student recruitment activities

**Professional Memberships**
American Psychological Association (APA) 2011-Present
Georgia Psychological Association (GPA) 2016-2017
FL Psychological Association (FPA) 2013-2015
National Association of School Psychologists (NASP) 2011-2015
FL Association of School Psychologists (FASP) 2011-2015
Student Organization of Health Service Psychology at Florida State University 2011-Present

**Grants and Awards**
Florida State University, Council on Research and Education Grant: 2015
Dixie State College, Academic Scholarship, 2000