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Examing the Associations Between Attention, Reading and Language Abilities in Young Adulthood

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EXAMINING THE ASSOCIATIONS BETWEEN ATTENTION, READING

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ABSTRACT

This study investigated the relationships between attention, reading and reading-related measures, and oral language abilities in young adulthood. The majority of studies have focused on younger participants and have used self-report measures of attention. In the present study, a more objective, behavioral measure of attention was used. Factor analyses and structural equation modeling were performed to examine whether the data supported the Simple Theory (Gough & Tunmer, 1986) in this age group and whether some of the variance in reading performance is accounted for by attention. The conventional Simple Theory proposes that reading comprehension performance is the product of decoding and listening comprehension skills and both skills are necessary for reading comprehension. Findings of the current study did not indicate that attentional skills helped explain individual differences in reading comprehension. That is, performance on the attention measures did not significantly correlate with reading, reading-related or oral language performance, nor did they account for additional variance in predicting reading comprehension abilities. Potential explanations for these results, as well as limitations of the present study, are discussed.

ACKNOWLEDGEMENTS

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Introduction

Researchers have investigated the effects of attention on reading performance in kindergarten (Blair & Razza, 2007, Commodari, 2012; Monette, Bigras, & Guay, 2011), in elementary age students (Walcott, Scheemaker, & Bielski, 2010), and in adolescents (Rogers, Hwang, Toplak, Weiss, & Tannock, 2011). Overall, these studies indicate that attention skills are important for reading achievement in these age groups. However, little is known about the relationships between attention, reading, and language skills in early adulthood. By examining these relationships in a wide range of readers in early adulthood, the central goal of this study was to determine whether attention plays a role in literacy performance in this age group.

This investigation used data collected from college students who had participated in a project at a university in the Northeastern region of the United States for which a broad array of literacy, language, and cognitive skills had been assessed. In the present study, a subset of measures was selected for analysis that allowed exploration of the associations between attention, language and reading abilities. Based on past research, it was hypothesized that attention skills in adulthood would be associated with variations in reading profiles as has been found for in earlier ages. Specifically, higher attention skills were predicted to be linked with better reading performance, especially on measures of reading comprehension. Moreover, individual differences in attention were anticipated to be related to other reading and oral language abilities that are significant predictors of reading comprehension. Thus, we speculated that the results might provide evidence for expanding the Simple Theory of Reading (Gough & Tunmer, 1986). This theory states that reading comprehension

(RC) is explained by decoding (D) multiplied by listening comprehension (LC) (i.e., RC = D x LC). If attention adds to the prediction of RC, the formula that best represents the contribution of attention would be determined.

Justification and Significance of the Study

Attention

Many scholars agree that attention is a multidimensional construct (Moray, 1970; Posner & Boies, 1971; Plude & Doussard-Roosevelt, 1990; Plude, Ennsm & Brodeur, 1994), but disagree regarding the particular components. As a consequence, over the years a variety of theories of attention have been proposed. Most include dimensions of sustained, selective, or divided attention that relate to inhibitory control. In the field of reading research, researchers primarily have focused on sustained attention, referring to the ability an individual has to maintain and hold a focus on relevant information when faced with distractions, a behavioral component of attention (Strayer & Drews, 2008). One's ability to remain on task may be pivotal to acquiring the skills to become a competent reader, and subsequently to being able to focus on the storyline or factual information presented in text.

Attention and Reading Development in Early Childhood and Childhood

Research consistently has found that attention abilities influence preliteracy development (Blair & Razza, 2007; Commodari, 2012; Friedman-Weieneth, Harvey, Youngwirth, & Goldstein, 2007; McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007; Ponitz, McClelland, Matthews, & Morrison, 2009; Sarver, Rapport, Kofler, Scanlan, Raiker, Altro, & Bolden, 2012; Velting & Whitehurst, 1997; Wanless et al., 2011). Recently, a number of longitudinal investigations have examined the

relationships between preschool attention measures and kindergarten reading outcomes. For instance, Walcott, Scheemaker, and Bielski (2010) assessed the relations between teacher-rated attention problems and literacy skills in preschool and kindergarten, and concluded that higher levels of inattention during the preschool years predicted lower levels of kindergarten phonemic awareness and letter naming scores. Dice and Schwanenflugel (2012) also examined the importance of attention skills in preschoolers. They reported that children who had weak attention abilities in preschool had delays in acquiring emergent literacy skills, and that this, in turn, postponed the development of early decoding skills in kindergarten. This relationship still remained after accounting for maternal education, a strong predictor of child literacy outcomes. These results support the view that attention skills are prerequisites for young children to engage in learning, although most studies have included teacher-ratings of attention instead of cognitive measures of attention.

Attention appears to continue to play a crucial role in academic success during the elementary school years in first grade and beyond. Overall, research findings suggest that attention problems in childhood have a negative association with school achievement (Monette, Bigras, & Guay, 2011; Pingault, Tremblay, Citaro, Carbonneau, Genolono, Falissard, & Côté, 2011). For instance, in a study that monitored teacher-ratings of students' attention skills and student's reading achievement from kindergarten to fifth grade, more attention problems were associated with lower reading achievement scores, even after controlling for prior reading achievement, other behavioral problems, and IQ (Rabiner & Coie, 2000). Similarly, even inattentive first graders who had normal reading outcomes in the first

grade were found to be at risk for developing later reading problems (Rabiner, Murray, Schmid, & Malone, 2004), indicating the persistent effects of attention on reading outcomes. In short, past research concurs that attention skills are relevant to academic success and reading acquisition in early childhood, with attention problems generally being associated with poorer reading outcomes. In addition, research studies find that attention limitations at an early age add to the risk of reading difficulties in later years.

Reading in Adolescence and Young Adulthood

The Simple Theory of Reading (STR; Gough & Tunmer, 1986) has served as a helpful framework to understand the components of reading comprehension. This theory proposes that reading comprehension performance is the product of decoding and oral language skills. The relationships between decoding and oral language skills are thought to be multiplicative in that reading comprehension would not occur if an individual did not have either basic decoding skills or essential oral language skills. Past research has suggested that the core components of the STR are important factors in individual differences in readers beyond the elementary years. For instance, basic reading skills such as decoding (Cunningham, Stanovich, & Wilson, 1990; Lundquist, 2004), word recognition (Sabatini, Sawaki, Shore, & Scarborough, 2010), isolated word fluency (Perfetti & Marron, & Foltz, 1996), contextual word fluency (Jenkins, van den Broek, Espin, & Deno, 2003; Klauda & Guthrie, 2008), and spelling (MacArthur, Konald, Glutting, & Alamprese, 2010) are relevant skills that have been found to be associated with reading comprehension. In addition, oral language skills such as vocabulary knowledge (Braze, Tabor, Shankweiler, & Mencl, 2007; Lundquist, 2004; Yovanoff, Duesbery, Alonzo, & Tindal, 2005), syntax (Nation &

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Snowling, 2000; Share & Leikin, 2004), semantics (Nation & Snowling, 1999), metaphorical language and inferential reasoning (Catts, Fey, Zhang, & Tomblin, 1999) all are known factors that impact reading comprehension.

Although many reading and word-related variables have been identified as important for reading comprehension, studies have uncovered that different predictors of reading comprehension may exist for young adults with higher and lower reading skills. For instance, in a sample of college students, Landi (2010) investigated the relationships between reading comprehension and reading skills in higher-level and lower-level adults. In her study, vocabulary knowledge and extent of print exposure were more strongly related to reading comprehension in the higher-level reading group, whereas basic skills such as decoding and spelling were determinants of reading comprehension in the lower reading group. Comparable effects of decoding weaknesses were obtained from another study of young adults with low literacy skills (Catts, Adlof, & Weismer, 2006; Sabatini et al., 2010), although these adults also had weak oral language skills. In addition, Mellard and colleagues (2010) found that adults with low literacy heavily depend on basic reading skills such as word recognition in order to comprehend the materials being read. Overall, investigations have confirmed that basic reading skills (such as word recognition) and listening comprehension each account for individual differences in reading comprehension for young adults, with varying patterns for those with reading difficulties.

Some researchers who have studied older poor readers have pointed out that individuals with decoding weaknesses have similar reading profiles as younger poor readers, suggesting persistence in deficits in basic reading skills. For instance,

Shankweiler, Lundquist, Dreyer, and Dickinson (1996) documented that differences in comprehension in high school students were associated with differences in spelling and decoding skills. In another study, Leach, Scarborough, and Rescorla (2003) examined the characteristics of late emerging poor readers and identified these readers as having heterogeneous reading abilities. Although the participants in their study were only in the late elementary years, results of that investigation, along with other research with participants in early adulthood, point out that a significant proportion of older poor readers may have reading profiles exhibiting deficits in basic word reading skills, in comprehension skills, or in many cases, difficulties in both (Bruck, 1990; Fowler & Scarborough, 1984; Wilson & Lesaux, 2001). Other researchers have investigated the relationship between vocabulary and reading comprehension and reported that poor readers also have deficits in vocabulary knowledge (Braze, Tabor, Shankweiler, & Mencl, 2007).

More recently, Sabatini and colleagues (2010) investigated the relationships among reading skills in adults with low literacy skills. The purpose of their study was to identify additional reading-related factors that contribute to the STR (Gough & Tunmer, 1986). Results of the confirmatory factor analyses (CFA) revealed that, in addition to the factors of the STR (i.e., decoding and listening comprehension), vocabulary skills and fluency also were unique underlying factors of reading comprehension. However, when standardized path coefficients were taken into account, only the core factors of STR were significantly related to reading comprehension outcomes. In conclusion, these findings suggested that performance on both basic reading skills and oral language factors have effects on reading

comprehension, and that these two factors still could be considered as the bases of reading comprehension in adolescence and young adulthood. Furthermore, investigations indicate that weaknesses in basic word level skills could be a prominent characteristic of young adults with poor reading skills.

Shifts in the Role of Decoding and Oral Language in Reading Development

The STR points to the importance of basic reading abilities and factors of oral language. However, the importance of these two factors is not static across age. Research has shown that the core factors influencing reading comprehension shift, with basic word level skills having relatively greater importance during the early childhood years and oral language skills such as vocabulary knowledge influencing reading proficiency in later childhood years (Woodcock, Mather, & Schrank, 2004). For example, longitudinal data showed that word recognition and listening comprehension accounted for substantial amounts of variance in predicting reading comprehension in the second, fourth, and eighth grades (Catts, Hogan, & Adlof, 2005). However, the relative importance for predicting reading comprehension shifted over time; word recognition was more important in predicting reading comprehension in the earlier years, whereas listening comprehension was more relevant in the later grades. Compatible to this, Buly and Valencia (2003) found that fifth-grade students who scored poorly on a statewide reading assessment had deficiencies in reading fluency and reading comprehension, but fewer problems with basic word-level skills such as word recognition and single word fluency. Recently, adolescent readers in the ninth grade with poor reading skills were studied using latent class analyses. The results indicated that there were multiple distinct reading profiles, with one of the

subgroups exhibiting weaknesses solely in oral language skills (Brasseur-Hock, Hock, Kieffer, Biancarosa, & Deshler, 2011). The findings of these studies support the theory that there are varying patterns of reading weaknesses as students get older (c.f., Leach et al., 2003) and most studies have found that a large proportion of the older poor readers have deficits in oral language with or without concomitant deficits in basic reading skills.

Links between Attention Abilities and Reading Performance in Adolescence and Young Adulthood

Some scholars have proposed that attentional skills in early adulthood are at their maximum (Hale, 1990; Williams, Ponesse, Schachar, Logan, & Tannock, 1999). For instance, researchers have documented that selective focused attention (assessed by visual choice reaction time tasks) increased throughout childhood, peaked during early adulthood, and significantly declined in late adulthood in a cross-sectional study (Bedard, Nichols, Barbosa, Schachar, Logan, & Tannock, 2010). Correspondingly, another cross-sectional study in which other aspects of attention were examined also indicated that young adulthood may be when attention skills are at their optimal level (Waszak, Li, & Hommel, 2010).

Although one's attentional capacities may peak during young adulthood, research suggests that even at this stage of life, relatively lower attention abilities are associated with poor reading achievement. For instance, one study examined reading abilities in young adults who had medical diagnoses of Attention Deficit Hyperactivity Disorder (ADHD) and/or Reading Disability (RD). In this study, teacher-ratings of attention were used in the analyses and results indicated that the ADHD group had

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subtle weaknesses in silent reading comprehension, as well as in rate and accuracy of text reading (Ghelani, Sidhu, Jain, & Tonnock, 2004). Further, Samuelsson, Lundberg, and Herkner (2011) analyzed the relationships between self-diagnosis of attention problems and reading outcomes in prison inmates and found that adults who identified themselves as having attention problems performed significantly less well on reading comprehension, in spite of similar levels of accuracy on measures of phoneme awareness, decoding and spelling. Altogether, these studies show that individuals with attention difficulties, or those who believe they have attention problems, may have weaknesses in comprehending what they read, even with unimpaired basic reading skills.

Nonetheless, a question remains as to whether similar results would be found when a behavioral measure of attention is used instead of a teacher-report measure. In the past, a number of studies that have examined the relationship between reading and attention beyond the early grades have used teacher-ratings of attention (i.e., Pingault et al., 2011) rather than a behavioral measure of attention. Considering that significant correlations have been reported between behavioral measures of attention (i.e., CPT) and self/teacher-ratings of attention (Halperin et al., 1988; Klee & Garfinkel, 1983; Shapiro & Garfinkel, 1986), it is reasonable to presume that a significant association also would be present between reading and behavioral measures of attention. Indeed, a small number of studies have explored the relationship between behavioral measures of attention and reading ability. In one study, Lam and Beale (1991) investigated the relationships between attention and reading comprehension by using two indices from the Continuous Performance Test (CPT) (i.e., sensitivity and bias), and the reading

comprehension subtest from the Progressive Achievement Test with children ages

seven to ten. Results indicated that the bias index from the CPT measures, as well as

teacher-ratings of inattention, were significant predictors of the children's reading

ability. More recently, Stern and Shalev (2013) researched the associations between

sustained attention and reading comprehension in adolescents with and without

ADHD. In this study, the percentages of commission errors and the standard deviation

of reaction time of correct responses from Conjunctive Continuous Performance Task

(CCPT) were used to assess attentional skills. The researchers reported that

adolescents with poor sustained attention had fewer correct answers on the reading

comprehension questions and slower silent reading times. In conclusion, although

prior studies indicate that attentional skills are closely associated with, and predictive

of, reading outcomes, this research primarily has utilized self-report or teacher-report

measures of attention (e.g., Blair & Razza, 2007; Pingault et al., 2011; Samuelsson et

al., 2011). Nonetheless, the findings to date suggest that the young adults with

attention problems may experience problems in reading comprehension.

Purpose of the Study

The primary purpose of the study was to examine the relationships between

attention, reading, and language abilities in young adulthood, with more focus on these

domains and the interactions than generally has been examined in previous research.

In the study, a behavioral measure of attention was used to assess attentional skills,

strengthening the objectivity and potential sensitivity of the measurement of this

cognitive ability. Likewise, the reading measures encompassed the full spectrum of

reading skills (i.e., phonological awareness, decoding, word identification, fluency and

reading comprehension), allowing a more thorough analysis of the potential effects of individual differences in attention on reading abilities in early adulthood than has been carried out in prior studies (e.g., Samuelsson et al., 2011). In addition, by evaluating oral language skills such as vocabulary knowledge and listening comprehension, further domains possibly affected by attention weaknesses were examined.

In this study, attention was expected to be associated with reading performance in young adults because attentional skills are conceptualized as enhancing reading comprehension outcomes. It also is anticipated that, even in young adulthood, basic reading skills as well as oral language skills would be crucial in predicting reading comprehension outcomes, as proposed by the STR (Gough & Tunmer, 1986). Better attention skills were predicted to facilitate individuals' abilities to maintain attention on the content being read with the expectation that this could result in better comprehension outcomes for these individuals. However, individuals with poor attention skills may have spent less time in reading-related activities over the years, perhaps due to their attention difficulties, and the reduced exposure to reading may have potential consequences, as well, of reduced fluency and vocabulary knowledge (Anderson, 1996). The theory on which this study was based derives from the STR (Gough & Tunmer, 1986) that emphasizes the importance of decoding and oral language skills, and suggests that reading comprehension is the product of the two skills. Here, attention was proposed as an additive variable that may facilitate reading comprehension outcomes.

This was a secondary data analysis utilizing the data for measures of attention, language and reading from a pool of 150 students from a university in the

Northeastern region of the United States. The participants were comprised of a broad range of readers that included a sizeable proportion of below-average readers. In summary, the purposes of this study were to:

- Examine the relationships among attentional skills, reading and reading-related measures, and oral language skills. Past research studies have found that attentional skills, as measured by self-reports and teacher-reports, have significant associations with reading, reading-related and oral language measures. A goal of the study was to investigate whether this relationship still would remain when behavioral measures of attention were used.

- Explore the underlying latent constructs of the tasks that were administered to examine reading/reading-related and oral language skill. This study used various measures that were purported to assess one's reading/reading-related, oral language, and attentional abilities. What are the underlying factor structures of these measures in predicting reading comprehension? Gough and Tunmer (1986) suggest a two-factor structure (decoding skills and oral language ability) in predicting reading comprehension. Is this two-factor structure valid when participants of the study are young adults as reported by Sabatini and colleagues (2010)? In early adulthood, would basic reading/reading-related and oral language abilities load as one factor or would they load as separate, independent factors?

- Examine if basic reading/reading-related and oral language skills are significant predictors of reading comprehension in young adulthood. Gough and Tunmer's (1986) theory suggests that basic reading skills and oral

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language skills still will be crucial elements in predicting reading

comprehension. In addition to that, examine if attention performance might be

the third factor predicting reading comprehension outcomes.

Method

Participants

This study was a part of a larger project that examined the cognitive processes related to individual differences in reading abilities in college students from 2009 to 2012. Individuals who participated in this larger project were assessed on numerous cognitive measures. The project was conducted at a large public university in the Northeast region of the United States. In the original dataset, there were 230 participants (female = 131; male = 93) who spoke English as their native language. When examining the ethnicity of the participants, the individuals who took part in this study were predominantly Caucasian (63.7%), followed by Black or African American (6.2%), and Asian (5.3%). A further 24.8% did not specify their ethnicity. Among the 230 participants, 80 were dropped from the analysis. The majority ($n = 72$) were excluded because they were missing data for several measures pertinent to this study; an additional eight individuals were dropped because they were considered to be outliers. For the remaining 150 participants, 89 were female and 59 were male; 43 individuals (28.7%) reported that they had been diagnosed with a learning disability in the past, although the type of assessment or the specific kind of disability is unknown.

To obtain a broad range of readers, multiple methods were used to recruit participants. Advertisements for the study were presented in highly populated places throughout the campus and on Internet bulletin boards. Some participants were contacted via email through the office for disabled students that served students who qualified for accommodations for learning disabilities or specific reading disabilities (e.g., extra time during examinations). As a result of this recruiting process, students

with a wide range of reading scores took participation, with a sizeable proportion of students displaying below average scores on some of the reading measures. Because this was a cohort of college students, there was less likelihood that poor reading performance was influenced by low intelligence, lack of exposure to instruction, or low motivation.

Procedures

The original study was approved by the Institutional Review Board (IRB) at the northeastern university where the study took place. The IRB documents from that institution were sent to the Office of Research Compliance at the University of Rhode Island, and the decision was made that the present study did not require further approval for human subject research because it would be utilizing secondary data that already had been collected.

For the original assessment process, students were tested during two sessions with all subjects given the measures in the same order. During the first four-hour session, subtests of the Woodcock-Johnson Diagnostic Reading Battery III (WJ-III; Woodcock et al., 2004) and the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) were administered. In addition, the Gray Oral Reading Test, Fourth Edition (GORT-4; Wiederholt & Bryant, 2001) and the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007) were used to assess oral reading comprehension and receptive vocabulary, respectively. For the second session, the participants were given the Continuous Performance Test-II (CPT-II; Conners, 2000) to examine attentional skills that lasted for approximately 20 minutes.

Informed Consent

Informed consent was obtained from all participants who took part in the study. All students were shown the consent form and were given unlimited time to thoroughly read the form and ask relevant questions. In addition, the research assistant verbally told the participants about the number of hours he or she would have to invest in testing and the associated financial compensations (i.e., $56 per session plus an additional $25 when the entire battery was completed). Before the assessments were administered, the individuals involved in the study were reminded that their participation was voluntary, and that they had the right to withdraw their consent to participate at any time.

Measures

Attention.

Inattention. The CPT-II (Conners, 2000) is a computerized assessment that measures sustained attention. The test lasts approximately 14 minutes and requires the participant to press the space bar on the keyboard when any letter except the target letter "X" is visible on the screen. The sum of the omission errors on the CPT-II (Conners, 2000) constitute the total number of missed targets and were used as a measure of inattention. A high omission rate demonstrates that the individual either is not responding to the stimuli or that the person has sluggish responses (Conners, 2000). CPT Omission errors have been interpreted to be evidence of sustained attention deficits in children with ADHD (Epstein, Erkanli, Conners, Klaric, Costello, & Angold, 2003; Hale, Fiorello, & Brown, 2005; Willcutt, Doyle, Nigg, Faraone, &

Pennington, 2005). Split-half and test-retest reliability for this measure are reported to be .94 and .84, respectively.

Inhibitory control. Total commission errors on the CPT-II (Conners, 2000) consists of the number of times the individual responded to nontarget stimuli and is interpreted as a measure of impulsivity. Split-half and test-retest reliability values for this measure are stated to be .83 and .65, respectively. For all of the attention measures, t-scores that compare the participant's performance to a normative group with the same gender and age were used in the analyses. It is common for the CPT-II measures to have skewed distributions; therefore, results of the CPT-II outcomes are automatically transformed prior to calculating t-scores (Conners, 2000).

Both omission and commission errors formed a latent construct (i.e., attention) in structural equation modeling.

Reading and Reading-related Measures.

For all the reading and reading-related measures, standardized scores were used in the analyses. In addition, all measures, except for reading comprehension outcomes (i.e., WJ-III Reading Comprehension cluster and Comprehension score from GORT-4), served as observed variables creating the reading/reading-related latent construct. The two reading comprehension results were used as the dependent variable in the structural equation modeling.

Phonological awareness (PA). The Phonemic Awareness cluster from the WJ-III (Woodcock et al., 2004) assesses the ability to analyze and manipulate speech sounds. This cluster consists of two subcategories: Sound Awareness and Sound Blending. The Sound Awareness Test evaluates phonological awareness and is

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composed of three subtests: Rhyming, Deletion, and Substitution. In the rhyming subtest, there are three different types of questions. The first set of question requires an individual to choose two pictures that rhyme from an array of three. The second part asks participants to finish a sentence with a word that rhymes with the target word. The last set of questions asks the person to provide a word that rhymes with the stimulus word that is presented orally. In the Deletion subtest, individuals are asked to remove parts of a compound word or individual phonemes from a word to make a new word. For instance, sample questions would ask the participant to say *'firefighter'* without the *'fighter'* or *'jogging'* without the *'ing'*. Finally, the college students were asked to create new words in the Substitution subtest by substituting a phoneme, a word ending, or a word (e.g., *if I say running and then change the run to walk, the new word would be… what?*).

The Sound Blending Test measures the ability to combine speech sounds to form a word. In this test, after listening to a series of phonemes or syllables on an audio recording, individuals are asked to blend the sounds together. On both the Sound Awareness and the Sound Blending Test, the number of items correctly answered was tallied, and the composite score was used in the analyses. The reported median reliability for this composite is .94 in the adult range.

Decoding. The Word Attack subtest from WJ-III (Woodcock et al., 2004) measures one's ability to read printed nonsense words out loud. The first portion of this subtest has the individual produce the sounds of single alphabet letters. The rest of this subtest consists of nonwords or low frequency real words that conform with patterns of the English orthography. As the subtest progresses, the decoding demands

become more advanced and complex. The number of items correctly answered was recorded to use in the analyses. The reported median reliability for Word Attack is .87 in the adult range.

Word recognition. The Letter-Word Identification subtest from the WJ-III (Woodcock et al., 2004) measures word recognition ability. The first few items ask the participant to point out or name letters of the alphabet. On the following items, an array of words or letters is listed on a page and the student is asked to point to a certain word or letter that is said by the test administrator. Finally, the last section of this subtest requires the student to pronounce written words. As the subtest progresses, the items encountered by the student become increasingly difficult because the selected words are more complex and have lower frequencies in written English. The reported median reliability for this subtest is .94 in the adult range.

Fluency. The Test of Word Reading Efficiency (TOWRE; Torgesen et al., 1999) is an assessment that measures the participant's ability to sound out printed words fluently and accurately. For this study, the Sight Word Efficiency (SWE) subtest from the TOWRE (Torgesen et al., 1999) was utilized to measure the number of printed real words that could be accurately identified in 45 seconds on a list of 104 words. The test-retest reliability for this measure is reported to be .91.

Reading comprehension. Two measures were employed to assess reading comprehension abilities. First, the Comprehension Score from the Gray Oral Reading Test, Fourth Edition (GORT-4; Wiederholt & Bryant, 2001) was used. This assessment is a norm-referenced, reliable, and valid test of oral reading rate, accuracy, fluency, and comprehension. The test is composed of thirteen passages that are

organized in the order of difficulty. After a participant reads the short passages out

loud, the test administrator reads five multiple-choice questions relevant to the

passage. From this assessment, five scores are produced: Rate, Accuracy, Fluency,

Comprehension, and Overall Reading Ability. For the present study, the

Comprehension score (i.e., the number of correctly answered questions about the text)

was used. The test-retest reliability for the Comprehension score is stated to be .97.

The second reading comprehension measure, the Reading Comprehension

cluster from the WJ-III (Woodcock et al., 2004), is comprised of the Passage

Comprehension and Reading Vocabulary (WJPC) measures. The Passage

Comprehension Test uses a modified cloze procedure[1] to examine silent reading

comprehension. The initial questions utilize pictorial stimuli, the later ones have

written passages. As the assessment progresses, the items become more difficult by

increasing the length of the passages, the level of vocabulary, and the complexity of

syntactic and semantic cues. The Reading Vocabulary Test evaluates one's ability to

read words and provide appropriate definitions, and includes three subtests:

Synonyms, Antonyms, and Analogies. In the Synonyms subtest, individuals are asked

to read each word out loud and provide another word that has the same meaning. On

the Antonyms subtest, participants are requested to read the word and give another

word that has the opposite meaning. Finally, on the Analogies subtest, individuals are

exposed to three words and are asked to say what the fourth word should be.

Typically, the first two words that are presented (first set) have a relationship. By

examining the association between the words in the first set, the participant is to state

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[1] A cloze test is a type of assessment that requires an individual to provide a word in a
place in a passage where the original word has been removed (e.g., *A cat has four…*).

an appropriate answer for the second set that only has one word provided. The number of correctly answered items on all three subtests were recorded in the original study, and the composite score was used in the analyses for this study. The reported median reliability for adults is .94 (Woodcock et al., 2004).

Oral Language Abilities.

For the two oral language abilities in this study, standardized scores were used in the analyses. In addition, both measures were used as observed variables to form the oral language latent construct.

Receptive vocabulary. The Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007) measures receptive vocabulary and requires the participant to select a picture from a set of four that best corresponds with the spoken target word. The average reliability in the adult population is .95 for this measure.

Language skills. The Oral Language Comprehension cluster from the WJ-III (Woodcock et al., 2004) evaluates word and passage level verbal comprehension, and two measures from the WJ-III, Oral Vocabulary and Oral Comprehension, comprise this cluster. The Oral Vocabulary Test is similar to the Reading Vocabulary Test described above, but differs in that the words also are presented orally. In other words, in the Oral Vocabulary Test, the target word is verbally and visually provided to the participant by the test administrator, so the participant does not have to decode the written target word. The Oral Comprehension Test is a cloze test that requires an individual to provide missing words by drawing on syntactic and semantic information, after listening to a short passage on an audio recording. The median

reliability for the Oral Language Comprehension cluster is reported to be .95 for adults.

Results

Statistical Analyses

Before conducting any analyses, the results of the descriptive analyses (i.e., means, standard deviations, skewness and kurtosis, as well as normality) were examined. Results of the descriptive analyses were used to determine the distributions of reading and attention abilities in this sample. Then, a correlation matrix was created to begin to explore the relationships between attention, reading/reading-related, and oral language measures, the first purpose of the study.

Principal component analyses (PCA) and confirmatory factor analyses (CFA) were used to address further questions regarding the underlying factor structures predicting reading comprehension. For the PCA, an oblique factor rotation (Direct Oblimin) was chosen to be appropriate because the correlation matrix indicated moderate correlations among the variables (Tabachnick & Fidell, 2007). The proper number of components was determined by using Parallel Analysis (PA; Rinenchelegger, 1989). After the number of components was identified through PCAs, CFAs were conducted to assure that the model fit was acceptable. To determine the best model relative to parsimony, models were compared using χ^2, along with other model fit indices including the Root Mean Square Error of Approximation (RMSEA) and Comparative Fit Index (CFI). After these processes, the most optimal model was selected, and that model was used to predict reading comprehension outcomes.

Finally, to investigate the last question regarding attention as an additional predictor of reading comprehension, structural equation modeling was conducted

using the EQS 6.2 (Bentler, 2006). In the structural models, the two reading

comprehension measures, GORT-4 and WJPC, separately served as the observed,

dependent variables and the underlying factor structure that had the most appropriate

CFA result indicating the most adequate factor model served as the predicting,

independent variables. In other words the main purpose of this structural model was

to examine whether the underlying factors of reading and attentional outcomes would

predict the reading comprehension measures. Considering that the GORT-4 and the

WJPC have different characteristics (Keenan, Betjemann, & Olson, 2008), the results

of the structural model may vary depending on the reading comprehension measures

that were used.

Descriptive Statistics and Preliminary Analyses

The current study involved 150 young adults ($M = 23.18$ years). There were

59 male college students (39%) and 89 female college students (59.3%) who

participated in the study. The following table presents the results of the descriptive

information regarding the measures used in the study.

Results of the CPT-II (Conners, 2000) are presented in *T*-scores ($M = 50$; $SD =$

10) (See Table 1). Results for all three measures from the CPT were in the average

range. When examining the types of errors involved, results revealed that young

adults in this study committed more commission errors than omission errors.

In addition, the descriptive statistics were obtained for the reading and reading-

related measures (see Table 1). Results of preliminary analyses showed that

performance on these measures is comparable to the population norms, with measures

of vocabulary knowledge, listening comprehension, and phonological awareness being

slightly above or at average.

Table 1

Descriptive Statistics for Attention and Reading-related Measures

Measure	*M*	*SD*	Skewness	Kurtosis
Omission	48.28	6.25	1.13	.94
Commission	54.04	10.95	.38	-.78
PA	99.08	11.07	-.39	1.17
Decoding	93.63	14.07	.18	-.56
Word recog.	95.91	12.34	-.54	.16
Fluency	88.30	13.64	.58	-.64
RC: GORT-4	92.30	10.50	-.20	-.66
RC: WJPC	94.05	11.47	.31	-.31
Voca.	104.34	12.28	.19	.19
LC	99.90	11.54	-.11	-.06

Note. $N = 150$. CPT: Omission = CPT omission errors; CPT: Commission = CPT Commission errors; Phonological awareness (PA) = WJ-III Phonic Awareness cluster; Decoding = WJ-III Word Attack; Word recog. = WJ-III Letter-Word Identification; Fluency = TOWRE Sight Word Efficiency; RC: GORT-4 = Reading Comprehension score from GORT-4; RC: WJPC = WJ-III Reading Comprehension cluster; Voca = Vocabulary knowledge from PPVT; LC = WJ-III Oral Language cluster.

Moreover, multiple indices were investigated to ensure the normality of the measures. First, skewness and kurtosis were acceptable for all measures (Harlow, 2005), as indicated in Table 1. In addition, a non-significant result was obtained for all measures on the test of normality (the Kolmogorov-Smirnov statistic), confirming that the distributions of these scores were normal. Visual representation of the measures also was investigated (i.e., Histograms, Normal Q-Q Plot, Detrended Normal Q-Q, and Boxplot) to verify the normality of the data and to identify outliers.

Correlational Analyses

Pearson product-moment correlation coefficients were calculated among measures of attention, reading, reading-related, and oral language measures, as shown in Table 2 using SPSS 20.0 (IBM Corp, 2011). As expected, variables assessing basic reading skills and oral language skills were found to have strong, significant correlations. For instance, word recognition and decoding had the strongest correlation, .76. Other reading-related skills and oral language abilities had moderate to high correlations, ranging from $r = .28$ to $r = .60$.

Basic reading, reading-related, and oral language abilities had significant, positive correlations with reading comprehension outcomes. Moderate to strong associations were found between basic reading-related and reading skills (i.e., phonological awareness, decoding, and word recognition) and reading comprehension (i.e., WJPC and GORT-4) outcomes. Specifically, the correlations between WJPC and phonological awareness, decoding, and word recognition were $r = .52$, $r = .59$, and $r = .70$, respectively, whereas the correlations between GORT-4 and the three basic reading-related skills were $r = .30$, $r = .39$, and $r = .46$, respectively. These results are

consistent with the findings of Keenan, Betjamann, and Olson (2008) who identified basic reading-related skills such as decoding to be more related to the WJPC measure than with the GORT-4 assessment of reading comprehension.

In addition, strong correlations were found between the WJPC measure and the two oral language abilities. Notably, the correlations between WJPC and vocabulary was $r = .77$ and the correlation between WJPC and listening comprehension was $r = .82$. For the GORT-4, moderate correlations were reported between GORT-4 and oral language abilities (i.e., vocabulary and listening comprehension), with a slightly higher correlation between GORT-4 and listening comprehension ($r = .54$) than with vocabulary knowledge ($r = .52$). In sum, these results point out that the WJPC is more reflective of basic word level reading abilities, while the correlations with oral language skills were strong for both reading comprehension outcomes.

When examining the correspondence between two reading comprehension outcomes, the correlation between WJPC and GORT-4 was modest, $r = .58$, considering that these two assessments are measuring the same construct. The correlation that was obtained between WJPC and GORT-4 from young adults in this study was very similar to what Keenan and colleagues (2008) have found with young children, $r = .54$. Thus, the results show that there are shared source of variance for these two commonly used reading comprehension measures, but also differences in the skills assessed by each.

Table 2

Correlational Matrix of All the Reading, Reading-related, and Oral Language Measures

Measure	1	2	3	4	5	6	7	8	9	10
1. PA	-	$.40^+$	$.47^+$	$.32^+$	$.30^+$	$.52^+$	$.47^+$	$.43^+$	-.07	-.03
2. Decoding		-	$.76^+$	$.54^+$	$.39^+$	$.59^+$	$.50^+$	$.52^+$	-.08	-.09
3. Word recog.			-	$.51^+$	$.46^+$	$.70^+$	$.58^+$	$.59^+$	.06	.00
4. Fluency				-	$.40^+$	$.39^+$	$.32^+$	$.28^+$	$-.17^*$	-.09
5. RC: GORT-4					-	$.58^+$	$.52^+$	$.54^+$	-.05	.01
6. RC: WJPC						-	$.77^+$	$.82^+$	-.13	-.05
7. Voca.							-	$.73^+$	-.18	-.08
8. LC								-	-.10	-.04
9. Omission									-	$.37^+$
10. Commision										-

Note. $*p < .01$; $+p < .001$.

The associations between attentional abilities and oral language skills that is, listening comprehension as well as reading and reading-related measures were also of interest. One of the purposes in this study was to examine the relationship between attentional skills and listening comprehension. It was hypothesized that listening comprehension would be less affected by attention weaknesses than would reading and reading-related variables. However, the results of the correlational analysis indicated that measures of attention assessed by CPT-II did not have significant relations either with listening comprehension or with reading, reading-related variables. The only significant correlation that emerged was between Fluency and CPT omission errors. In this case, a significant negative correlation occurred for these two variables. This result suggested that individuals who were less attentive (as measured by committing more omission errors) were likely to read a lower number of independent words in a given time period.

Principal Component Analyses (PCA)

To address the second question regarding underlying dimensions/components of the reading and reading-related, oral language, and attentional tasks employed in the study, a PCA was conducted using SPSS 20.0 (IBM Corp, 2011). The correlation matrix was examined and the majority of correlations were above .30. In order to verify that a dataset is appropriate for a PCA, the value for the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO; Kaiser, 1974) is recommended to be larger than .60 with a significant value for the Bartlett's Test of Sphericity (Barrlett, 1954). For this dataset, the KMO value was .79 and the Bartlett's test was significant ($p <$ .001), indicating that conducting a PCA would be suitable.

The results of the PCA identified two components using the Kaiser criterion that points out the components that have an eigenvalue larger than 1. The first component explained 44.22% of the variance and the second component added an additional 17.36%. That is, the two components identified were able to explain approximately 62% of the variance. The screeplot also had a clear break after the second component (Cattell, 1966), validating the possibility of two components. In addition to the Kaiser criterion, a Parallel Analysis was conducted, and results confirmed that two components should be retained.

Table 3 shows the results of the pattern coefficients, structure coefficients and the communalities. The pattern coefficient displays the factor loading for the two components, and the structure coefficient shows the correlations between the factors and the variables. Finally, variance explained by each item is presented under communalities. When communalities are under .30, this may be evidence that the item does not fit well with the component. The results of the PCA with Direct Oblimin rotation show that each of the variables strongly loaded on one of the two components, as shown in the pattern coefficient. The first component identified included variables that measured reading and reading-related variables, and the second component consisted of variables assessing attentional skills.

According to Gough and Tunmer's Simple Theory (1986), reading comprehension is the product of decoding (or basic word reading skills) and oral language. The previous results of the PCA show that for this age group both decoding and oral language measures loaded on one component. Because these measures were identified as a single component, a PCA was conducted once again to examine which

components would be identified when three components were forced. In this case, hypothetically, the three components identified would be 1) basic reading and reading-related skills, 2) oral language abilities, and 3) attention performance.

The results of the PCA with three components are shown in Table 4. When three components were forced, the third component was able to explain an additional 11.11% of the variance. In short, the three components identified were able to account for approximately 73% of the variance. The first component consisted of oral language (i.e., listening comprehension and vocabulary knowledge) and phoneme awareness measures. The second component was comprised of attention measures, and the third component included measures of decoding, word recognition, and fluency. When examining the correlations among components, attentional skills (the second component identified) had low negative correlations with the first component (oral language measures) and the third component (reading and reading-related performances), $r = -.04$ and $r = -.07$, respectively. On the other hand, the second and third components had a moderate correlation of $r = .47$.

Table 3

Pattern and Structure Coefficients for PCA with Oblimin Rotation (Two-Factor Solution)

Item	Pattern coefficient		Structure coefficient		Communalities
	Comp 1	Comp 2	Comp 1	Comp 2	
PA	**.66**		**.66**		.43
Decoding	**.82**		**.82**		.68
Word recognition	**.89**		**.87**		.78
Fluency	**.61**		**.63**		.41
Vocabulary	**.79**		**.80**		.64
LC	**.79**		**.79**		.62
Omission		**.84**		**.84**	.71
Commission		**.81**		**.81**	.65

Note. The most appropriate component for the basic reading/reading-related and oral language skills are indicated in bold.

When three components were forced, the results of the PCA were more complex than the two-factor model (see Table 4). In other words, most of the reading and reading-related measures had relatively high correlations with the first and third components, as demonstrated in the structure coefficient. Vocabulary knowledge, listening comprehension, and fluency had relatively high correlations with only one of the two components; vocabulary knowledge ($r = .89$) and listening comprehension skills ($r = .89$) were more associated with the first component, and fluency ($r = .88$) was highly correlated with the third component. However, moderate to strong associations between phonological awareness, decoding, word recognition were evident for both of the two components. For instance, the correlations between word recognition and the first and third components were .72 and .78, respectively, indicating an ambiguous factor structure. Also, phonological awareness loaded with oral language outcomes instead of the basic reading skills. In sum, the result of the second PCA that forced three factors did not fully illustrate the three components (i.e., basic reading and reading-related, oral language, and attention measures) that were hypothesized. Listening comprehension outcomes and attentional skills clearly emerged as distinct components, whereas the basic-reading measures of decoding and word recognition had relatively strong associations with both the basic reading component and the listening comprehension component.

Table 4

Pattern and Structure Coefficients for PCA with Oblimin Rotation (Three-Factor Solution)

Item	Pattern coefficient			Structure coefficient			Communalities
	Com 1	Com 2	Com 3	Com1	Com 2	Com 3	
PA	**.61**			**.67**		.42	.46
Vocabulary	**.91**			**.89**		.39	.81
LC	**.92**			**.89**		.37	.80
Decoding			**.70**	.62		**.84**	.77
Word recog.	.46		**.58**	.72		**.78**	.81
Fluency			**.94**	.30		**.88**	.80
Omission		**.84**			**.84**		.71
Commission		**.80**			**.81**		.66

Note. The most appropriate component for the basic reading/reading-related and oral language skills are indicated in bold.

Confirmatory Factor Analyses (CFA)

In addition to the PCAs, confirmatory factor analyses (CFA) were conducted to investigate the overall model-fit of the two-factor and three-factor model discussed previously. Three CFAs were conducted. The initial two CFAs were performed on the two models presented above, and the third CFA was conducted on a theoretical, three factors model, based on Gough and Tunmer (1986). This third model was very similar to the three-factor PCA with the only difference being that phonological awareness was now included in reading and reading-related factor instead of the oral language factor.

The results of the CFAs are presented in Table 5. In this table, χ^2 statistics, along with the *df* and its significance, are presented with several goodness-of-fit indices. These values examine the model as a whole, investigating the models from a macro view. χ^2 statistics are computed by the differences that exist between the unrestricted sample covariance matrix and the restricted covariance matrix. The probability value associated with the χ^2 statistics indicates the possibility of obtaining a χ^2 value larger than that when the null hypothesis is true. Therefore, higher values of significance indicate better fit with the hypothesized model (Bollen, 1989a). However, because χ^2 statistics are affected by sample size (Jöreskog & Sörbom 1993), goodness-of-fit indices also were investigated to examine model fit.

Table 5

Values of Selected Fit Indices for the Three CFA Models

Index	Model		
	2-factor model	3-factor model (Gough & Tunmer)	3-factor model (based on PCA)
χ^2_M	80.37	30.93	28.41
df_M	19	17	17
p	< .001	.02	.04
CFI	.86	.97	.97
GFI	.88	.95	.95
RMSEA (90%CI)	.15 (.11-.18)	.07 (.03-.12)	.07 (.01-.11)
SRMR	.07	.05	.05
AIC	42.37	-3.07	-5.59
CAIC	-33.84	-71.25	-73.77

Note. CI, confidence interval.

When investigating model fit, one commonly used incremental fit index (Hu & Bentler, 1999) is the Comparative Fit Index (CFI) that compares the hypothesized model to a more restricted (also expressed as independent or null) model. The CFI generates a value that ranges from zero to 1.00, and values that are greater than .95 are considered to be representative of a good-fitting model. In addition, the Goodness-of-Fit Index (GFI; Jöreskog & Sörbom 1984) is an absolute fit index that examines how well the model fits the sample data. This value also could range from zero to 1.00, and values that exceed .90 are considered to be a well-fit model (Hu & Bentler, 1999). Another way to examine the fit of a model is to investigate the residuals. Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Residual (SRMR) analyze the absolute misfit indices and when these values are close to zero, the model is thought to have a good fit (Browne et al., 2002). Hu and Bentler (1995) have suggested that RMSEA and SRMR values less than .05 are indicative of a well-fitting model, although values of .10 or less are acceptable. Finally, Akaike's (1987) Information Criterion and Bozdogan's (1987) Consistent Akaike Information Criterion allow the researcher to compare models that are non-nested, by addressing the issue of parsimony and by taking into account the number of estimated parameters. In general, the model has better fit when the obtained AIC or CAIC is smaller.

After examining the model as a whole, more investigation was needed at the micro-level by checking the individual parameter estimates. By examining the unstandardized solution, information regarding the viability of the estimated values (e.g., correlations under 1.00, positive variance), the size of the standard errors, and the statistical significance of the parameter estimates can be obtained. In addition, the

investigation of the standardized solution can provide information about the magnitude of the relationships, as well as the proportion of variance accounted for by the factor by the measured variables (Bryne, 2008).

As shown in Table 5, identification of the two-factor model was established with 19 degrees of freedom *(df)*. Originally, from 36 data points, the parameters that estimated eight factor loadings, the eight measurement error variances associated with the factor loadings, and one covariance between the two factors were subtracted from the totally number of data points to obtain a *df* of 19. In other words, the total data point was calculated by 8(8+1)/2 and the *df* was computed, $df = 8(8+1)/2 - (8+8+1) = 19$. The standardized residuals also were investigated to make sure that these values were relatively small, for these values indicate the discrepancy between the sample covariance matrix and the model covariance matrix: the average off- diagonal value and the largest off- diagonal value were .046 and .059, respectively. Standardized residual values that are over 2.58 are considered to be large (Jöreskog & Sörbom, 1988), so the two small values indicated a very good fit for this model. Generally, large residuals associated with certain variables are evidence that the variable being explained by the structural model is insufficient. Nonetheless, when examining the fit of the two-factor model, the result of the χ^2 statistics was significant, χ^2 (80.37, *df* = 19, $p < .001$), suggesting that the model was somewhat inadequate. Other goodness-of-fit indices also pointed out that the two-factor model did not fit well with the data (i.e., CFI = .86; GFI = .88; RMSEA = .15; SRMR = .07).

Secondly, the model fit for the three-factor model based on the previous PCA also was investigated. First the standardized residual matrix was examined. The

average off- diagonal value and the largest off- diagonal value were .03 and .04,

respectively, indicating that the residuals are small. For this three-factor model, there

was 17 degrees of freedom. Compared to the previous two-factor model, this model

had a better fit, as indicated by the smaller AIC index value. The χ^2 statistics for this

three-factor model was nonsignificant, χ^2 (28.41, $df = 17, p = .04$), and goodness-of-

fit indices revealed that this model had a good fit. Further, the incremental fit indices

(i.e., CFI = .95; GFI = .97) also demonstrated that the model had good fit. Yet, other

absolute misfit indices of macro-fit (i.e., RMSEA = .07; SRMR = .05) showed that the

model had reasonable fit with the data. The micro-fit of this three-factor model also

was relevant: the parameter estimates were viable and the standard errors were

appropriate. In addition, the investigation of the unstandardized parameter estimates

revealed that phonological awareness (B = 6.15; $\beta = .56, p < .05$), decoding (B =

11.60; $\beta = .82, p < .05$), word recognition (B = 11.38; $\beta = .92, p < .05$), fluency (B =

7.72; $\beta = .57, p < .05$) were significant predictors of the reading/reading-related factor,

and vocabulary knowledge (B = 10.57; $\beta = .86, p < .05$), and listening comprehension

(B = 9.65; $\beta = .84, p < .05$) were significant predictors of the oral language factor.

Specifically, word recognition ($R^2 = .85$) had a large effect size and the largest

proportion of variance accounted for by the reading/reading-related factor after

controlling for other variables in the model, followed by fluency ($R^2 = .32$) that had

typical effect size (Kline, 2011). In addition, for the oral language factor, both

vocabulary knowledge ($R^2 = .74$) and listening comprehension ($R^2 = .70$) also

accounted for significant amounts of variance, indicating a large effect size (Kline,

2011).

Finally, the hypothesis driven three-factor model was explored (Figure 1). In this model, the first factor consisted of measures assessing oral language (vocabulary and listening comprehension). Attentional outcomes created the second factor (omission and commission errors), and phoneme awareness, decoding, word recognition, and fluency generated the third factor that could be conceptualized as basic reading and reading-related measures. The standardized residual matrix indicated that the average off-diagonal and the largest off-diagonal values were .03 and .04, respectively, showing a good fit to the data. For this model, there were also 17 degrees of freedom. The total number of data points were calculated by 8(8+1)/2 and the df was computed, $df = 8(8+1)/2 - (8+8+3) = 17$. The χ^2 statistic for this theory-based three-factor model was significant, χ^2 (30.93, $df = 17, p = .02$), and goodness-of- fit indices revealed that this model had a fairly good fit. The CFI was .97 and GFI was .95, both of which indicated a good fit. In addition, the results of the two absolute misfit indices (i.e., RMSEA = .07; SRMR = .05) revealed that the model reasonably fits with the data.

The micro-fit of this theory-based model also was reasonable: the parameter estimates were viable and the standard errors were appropriate. In addition, the unstandardized parameter estimates indicated that phonological awareness (B = 5.89; $\beta = .53, p < .05$), decoding (B = 11.61; $\beta = .83, p < .05$), word recognition (B = 11.27; $\beta = .91, p < .05$), and fluency (B = 7.78; $\beta = .57, p < .05$) were significant predictors of the reading and reading-related factor, and vocabulary knowledge (B = 10.60; $\beta = .86, p < .05$) and listening comprehension (B = 9.77; $\beta = .85, p < .05$) were significant indicators of the oral language factor. The standardized parameter estimates showed

that word recognition had the largest proportion of variance accounted for by the reading factor ($R^2 = .83$), followed by decoding ($R^2 = .68$), and fluency ($R^2 = .33$). In addition, listening comprehension accounted for 71.6% of the variance for the oral language factor.

In sum, when comparing the models, the PCA favored the two-factor model, with 1) reading/reading-related and oral language skills as the first factor and 2) attentional abilities as the second factor. On the other hand, the results of the CFA preferred the three-factor solution relative to the two-factor model with 1) reading/reading-related as the first factor, 2) oral language as the second factor, and 3) attention as the third factor. Overall, the three-factor models had better fit than the two-factor model. When examining the two three-factor models, the three-factor models were comparable. However, because the three-factor model based on an extension of Gough and Tunmer's STR had an underlying theory, this hypothesis driven three-factor model was selected to be used to examine the last research question regarding reading comprehension.
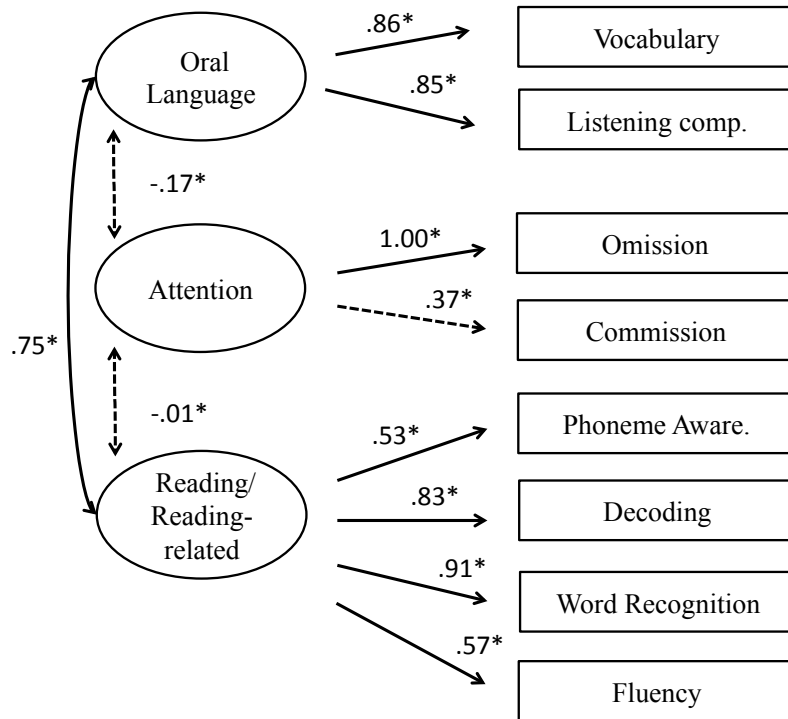
Figure 1. The Three-factor CFA Model Based on the Extension of Gough and Tunmer's (1986) Theory.
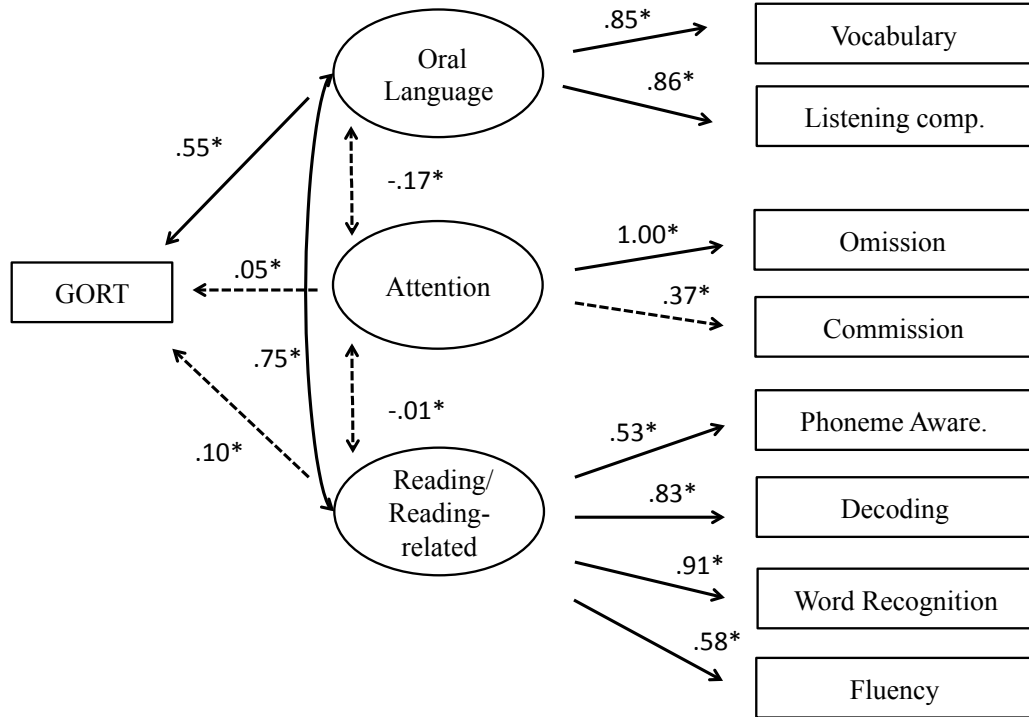
Asterisks indicate observed variables that were free to vary in the model. The dotted lines demonstrate nonsignificant relations and the straight lines point out significant associations.

Structural Equation Modeling (SEM)

To address the last question concerning if attention would add to the variance accounted for in reading comprehension beyond basic reading and oral language skills, structural equation models (SEM) with latent variables were created using EQS 6.2 (Bentler, 2006). Accordingly, two hybrid models were built. The first model entailed the combination of GORT-4 as the observed, dependent variable and the theory-based, three-factor CFA model. In the second model, the results of the WJPC were included as the observed, dependent variable, and this was integrated with the hypothesis driven three-factor CFA results.

When the predicted reading comprehension measure was GORT-4, the factor variances were set at 1.0, and multiple model fit indices indicated that the model had moderate fit. For instance, the χ^2 statistic for this model was significant, χ^2 (40.33, *df* = 20, *p* = .01). In addition, the incremental fit indices (i.e., CFI = .96; GFI = .94) as well as the absolute misfit indices (i.e., RMSEA = .08; SRMR = .05) both demonstrated that the model had acceptable fit with the data. Moreover, the factor loadings for most of the measured variables on their latent variables were fairly large and significant, suggesting that the hypothesized model is justifiable. When investigating the residuals more carefully, results of the standardized residual matrix showed that the average off-diagonal and the largest off-diagonal values were .03 and .04, respectively. The frequency distribution of the standardized residuals demonstrated that 93.33% of the residuals fall between -1.0 and 1.0. In sum, when GORT-4 outcome was the measure of interest, the data had reasonable fit with the hypothesis driven, three factor model.

The micro-level fit of the model also was analyzed. When examining the unstandardized parameter estimates, results indicated that phonological awareness (B = 5.88; β = .53, p < .05), decoding (B = 11.61; β = .83, p < .05), word recognition (B = 11.25; β = .91, p < .05), fluency (B = 7.87; β = .58, p < .05), vocabulary knowledge (B = 10.48; β = .85, p < .05), and listening comprehension (B = 9.88; β = .86, p < .05) were significant estimates. However, in the construct equation, only the oral language factor was found to be significant at a .05 level (R^2 = .30). Overall, in predicting GORT-4 outcomes, reading and reading-related, oral-language, and attentional skills accounted for 39.2% of the variance.

Figure 2. Structural Equation Modeling with GORT-4 Reading Comprehension Results.

Asterisks indicate observed variables that were free to vary in the model. The dotted lines demonstrate nonsignificant relations and the straight lines point out significant associations.

In the next analysis, WJPC outcomes served as the dependent variable. First, the standardized residual matrix was investigated and the average off-diagonal and the largest off-diagonal values were .03 and .04, respectively, showing a good fit to the data. Exactly as found for the previous model, the frequency distribution of the standardized residuals indicated that 93.34% of the residuals fell between -1.0 and 1.0. To explore the overall model fit, several goodness-of-fit indices were examined. The χ^2 statistic for this model was acceptable, χ^2 (35.88, df = 21, p = .023), and the absolute misfit indices (i.e., RMSEA = .07; SRMR = .05), also indicate that the model had reasonable fit with the data. The results of the incremental fit indices (CFI = .98 and GFI = .95) demonstrated relatively better fit.

When examining the micro-level fit of this model, similar to the previous model with GORT-4 as the dependent variable, results of the unstandardized parameter estimates indicated that phonological awareness (B = 5.94; β = .54, p < .05), decoding (B = 11.47; β = .82, p < .05), word recognition (B = 11.37; β = .92, p < .05), fluency (B = 7.70; β = .56, p < .05), vocabulary knowledge (B = 10.19; β = .83, p < .05), and listening comprehension (B = 10.16; β = .88, p < .05) were significant estimates. However, with the WJPC, the construct equation identified that both oral language (R^2 = .77) and reading and reading-related factors were significant predictors, with the latter showing trends toward significance (R^2 = .03).

In sum, the two models under investigation had acceptable model fit as indicated by the χ^2 statistic and the other model-fit indices. The only factor that emerged as a significant predictor of both the GORT-4 and WJPC was the oral language factor, consisting of vocabulary knowledge and listening comprehension. In

addition, reading and reading-related factor revealed trends towards significance in predicting performance on the WJPC. However, contrary to our hypothesis, attentional skills did not account for additional variance for either the GORT-4 or the WJPC reading comprehension outcomes.
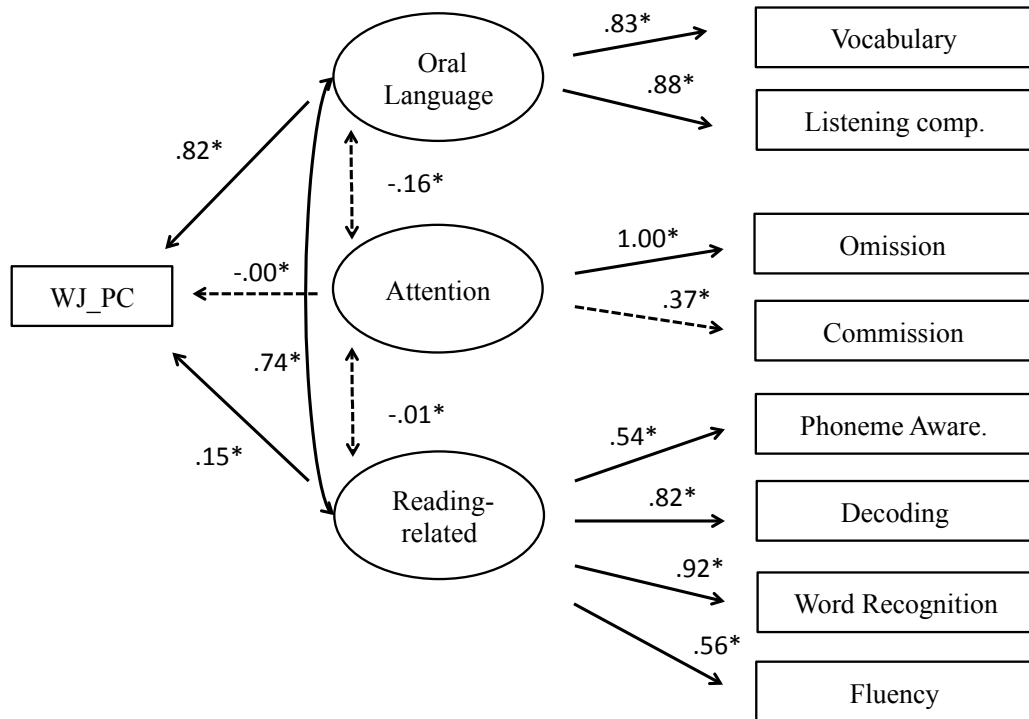
Figure 3. Structural Equation Modeling with WJPC Reading Comprehension Results. Asterisks indicate observed variables that were free to vary in the model. The dotted lines demonstrate nonsignificant relations and the straight lines indicate significant associations.

Discussion

The major goal of this study was to investigate the contribution of attention to reading comprehension in the young adult population. It is meaningful to examine this topic because better attentional abilities in earlier years are known to be predictors of enhanced academic outcomes (Monette et al., 2011; Pingault et al., 2011; Rabiner & Coie, 2000). The purpose of this research was to verify whether that association still is evident in young adulthood. Moreover, it was worthwhile to explore the contribution of attention to reading comprehension given the indications that noteworthy numbers of young adults have attentional difficulties (Akinbami, Liu, Pastor, & Reuben, 2011). Nevertheless, the results of this study failed to find evidence of links between attentional abilities and reading comprehension in this age range with the sample of 150 college students examined here.

Examining the Role of Attention in Reading and Oral Language Performance

The first research question involved examining the correlational relationships among attentional, reading/reading-related, and oral language skills for the participants. The CPT-II measures are purported to assess accuracy measures of attention (omission and commission). However, in contrast to the central hypothesis, the CPT-II measures of attention were not significantly associated with phoneme awareness, decoding, word recognition, fluency, vocabulary knowledge or listening comprehension. Instead, in this study significant patterns of association only were evident between the oral language skills (i.e., listening comprehension and vocabulary knowledge), reading comprehension outcomes, and among the various reading measures, as found by other researchers studying this age group (e.g., Braze et al.,

2007; Landi, 2009; Sabatini et al, 2010). The reading and language findings lend credence to the validity of the data set. Yet, the correlational results indicate that individual differences in attentional abilities may not be related to reading performance in early adulthood, at least as measured by the CPT-II.

To further investigate how attention might be related to reading comprehension, multiple PCAs and CFAs were performed to examine the underlying structure of the measures that were utilized in this study. That is, by examining the underlying structure (or the latent constructs) that emerged, the measures that predict reading comprehension could be investigated in more detail. The results of the first PCA clearly suggested that there were two components: reading/oral language and attentional measures. Compared to the other measures, for phoneme awareness and fluency relatively low pattern and structure coefficients were obtained, and the variance explained by the two measures indicated that these skills might be less relevant in early adulthood. While this is not surprising for phoneme awareness, a skill necessary for learning to read, fluency tends to remain an important factor in reading success beyond the early grades (Jenkins et al., 2003).

In the second PCA, three factors were forced to extend the Simple Theory of Gough and Tumner (1986) by examining if the reading and oral language component would load as two separate components instead of one, and investigating if attention also loads as a distinct component. As anticipated, the three-factors that emerged were 1) oral language and reading-related (i.e., phoneme awareness), 2) attention, and 3) basic reading abilities. Similar to the previous PCA, attention did form a component of its own. Phoneme awareness had moderate correlations with both the oral language

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component ($r = .67$) and the basic reading component ($r = .42$), reflecting its associations both with vocabulary knowledge and decoding skill.

Another interesting observation yielded in this PCA regarded word recognition skills. The pattern and structure coefficients for word recognition were comparable on the oral language and the basic reading components. Although the slightly higher coefficient that was obtained on the pattern and structure coefficient denotes that word recognition could possibly be more related to basic reading skills (McClelland et al., 2007), these results also demonstrate the link between word recognition and oral language skills. For instance, in oral conversation, it is fair to say that individuals tend to use the lexical items that they fully know (Jenkins, Stein, & Wysocki, 1984). Because vocabulary gains are heavily influenced by reading experience, one would anticipate associations between word recognition and vocabulary knowledge, in turn influencing comprehension of both oral and written language (Perfetti, 1985; 2010).

In addition to the PCAs, a detailed investigation of the models was conducted by performing CFAs to examine the model fit of each model. Overall, the CFA results showed that the three-factor model had a superior fit when compared to the two-factor model. These results indicate that the hypothesis-based three factor model with 1) oral language as the first factor, 2) attention as the second, and 3) basic reading and reading-related skills as the third had the better fit when compared to the previously mentioned three factor forced model. However, one drawback of this model was that there were only two indicators for two of the three latent variables. Usually, three to four indicators are recommended per latent construct in CFAs (Harlow, 2010). Another weakness was that in this model attentional skills had

nonsignificant parameter estimates. This nonsignificant result might point out that: 1) attentional skills are unimportant to the model, or 2) the sample size was too small to report this skill as a significant parameter (Bryne, 2008). However, because there are multiple reasons why the nonsignificant parameter was obtained, at this point it is difficult to conclude what is the exact cause. In sum, the structural modeling results indicated that the underlying structure of the variables was best described by a hypothesis-based three factor model with: 1) phoneme awareness, decoding, word recognition, and fluency as the first factor; 2) oral language abilities such as listening comprehension and vocabulary knowledge as the second; and 3) attentional skills as the third factor. Noticeably, the solution of the three-factor model conforms with Gough and Tunmer's (1986) theory and also addressed attention as an additional factor. However, due to the nonsignificant parameter estimate, at this point it is questionable to say that this attention measure would be a significant factor in predicting reading comprehension outcomes for young adults.

As a final way to investigate if reading comprehension skills can be predicted by the three factors mentioned above, structural equation modeling was performed. For both GORT-4 and WJPC measures, the oral language factor was a significant predictor. These results concur with past research suggesting the importance of oral language in predicting reading comprehension outcomes in later childhood (Buly & Valencia, 2003; Catts et al., 2005; Woodcock et al., 2004). In addition, the reading/reading-related factor also showed trends toward significance, however only for the WJPC. This result suggests that basic reading skill such as decoding may still be a crucial factor of WJPC, a finding that has been documented by Keenan and

colleagues (2008). However, attentional skills again failed to be a significant

predictor of reading comprehension outcomes. In short, structural equation modeling

strongly implicated oral language as an essential factor in predicting reading

comprehension outcomes in young adulthood. Thus, in contrast to the hypothesis

regarding the role of attention, performance on the CPT-II did not predict reading

comprehension outcomes in this sample of 150 college students.

In sum, the contribution of attention to the reading and oral language outcomes

was explored with a series of analyses. Across the different types of analyses, the

results converge to indicate that attention, reading, and language outcomes present

distinct factors. However, when these factors were predicting reading comprehension

outcomes, only the oral language factor (i.e., vocabulary knowledge and listening

comprehension) was a significant predictor of the WJPC and GORT-4 for this age

group. Attention, on the other hand, failed to be a significant predictor of reading

comprehension outcomes, despite the fact that it did display as a unique factor.

Why Attention May Not Have Been Found To Be Associated With Reading
Performance

The findings of this study did not align with past research that has found

various CPT measures to correlate with reading comprehension (e.g., Stern & Shalev,

2013). The current results may indicate either attentional skills have less impact on

reading comprehension in young adulthood or that the attentional skills measured by

the CPT-II merely are measures with high face validity (Epstein et al., 2003) that have

less association with the attentional components necessary for reading comprehension.

In other words, if an individual's ability to sustain attention was not associated with

reading comprehension outcomes at the college level, this might be indicating that students with lower attentional capacity are employing alternative strategies that they have found effective for their learning. Indeed, one study identified that individuals with ADHD had relative, ipsative strengths in the following areas measured by the Learning and Study Strategies Inventory (LASSI; Weinstein & Palmer, 2002): attitudes toward work, information processing, and use of study aids (Reaser, Prevatt, Petscher, & Proctor, 2007). Moreover, young adults who are attending college may have an explicit purpose for reading. Although there are young adults who read for pleasure, most college students might be aware that the primary role of reading is to obtain factual information necessary for their classes. Because the main purpose of reading is evident to college students, perhaps attentional weaknesses or attentional capacities do not determine the outcomes of reading any longer. Another explanation could be that students at the college level have developed adequate basic reading skills throughout their prior years with the result that individual differences in attentional capacity no longer account for variance in reading comprehension. That is, young adults with lower attentional abilities who attend higher education might have attained strong enough skills in decoding, word recognition, and word reading fluency that they are able to process the information that is read, despite weaknesses in attention.

While the current study did not find attention to be contributing to reading comprehension, there is still some potential that attentional skills are crucial for young adults. In other words, there is a chance that the CPT-II is either not a satisfactory measure or that the sample may not be large and broad enough to reveal this relationship. Despite the fact that CPT-II is a widely used assessment to examine

attentional skills, many researchers have noted that this measure should be used with caution. In a recent meta-analysis of CPT performance, researchers found that commission and omission errors, sensitivity measure (d'), and response bias (β) were the most widely used CPT indices in research studies, instead of measures of sustained attention that address performance over time (Huang-Pollock, Karalunas, Tam, & Moore, 2012). In addition, a majority of studies that have utilized the CPT have included less demanding, distinctive targets/nontargets that allow increased hit rates and low false alarm rates (See, Howe, Warm, & Dember, 1995).

Another possible reason why CPT-II outcomes did not reveal any relations with reading/reading-related and oral language measures may be because a different kind of attention is required in reading. In other words, other attentional skills (i.e., focused attention, selected attention, divided attention, or more prolonged sustained attention) that were not measured in this study may be more pertinent. However, the cognitive actions that underlie these different kinds of attention are mental processes that can be challenging to measure directly, limiting the efforts of researchers. Perhaps these kinds of mental processes are better reflected in teacher- or self-reports of attention, and that may be why studies that have used those forms of reporting have found attention to be linked with reading and other academic outcomes.

Limitations

While associations between phoneme awareness, decoding, word recognition, fluency, listening comprehension, vocabulary knowledge, and reading comprehension clearly emerged, as expected, the results were less clear with regard to the relationships between these abilities and attentional skills. An overall limitation of

the current research involves the use of a relatively small convenience sample of college students, a fact that limits the generalizability of this study. Although students were recruited from multiple campuses, and the ethnic composition of the sample approximated that of the greater university population, the majority of the participants were Caucasian. In addition, a sizeable proportion of the sample reported that they had been diagnosed with a learning disability; however, the specific diagnosis, as well as when these individuals were diagnosed with the disability, were unknown to the researcher. Because this information was missing, a more thorough investigation of the various subgroups of learning disabilities was not possible. Moreover, the dataset did not specify the individuals who were taking stimulant medication for their attentional difficulties. If students were taking medication when they were being assessed, this may have obscured examination of the relationships between attention and reading outcomes.

Finally, the use of secondary data limited our ability to focus more on attentional skills of young adults. Specifically, the original dataset employed a single measure of attention. Although the CPT-II is an assessment widely used in the field to measure attentional abilities, there is a possibility that the use of a different attentional measure would yield different findings.

Future Directions

In this study, the relationships among attention, reading-related, and oral language abilities were examined. Although attention skills, as measured by the CPT-II, did not show any significant associations with reading or oral language abilities, it remains possible that attentional abilities nonetheless may have positive relations with

these domains. Future research could examine these relationships in more detail by utilizing a variety of assessments to evaluate the multidimensional attributes of attention. Furthermore, because attention is a construct that lacks an agreed-upon definition, it would be interesting to examine which definitions (or which attentional constructs) are more closely related to reading comprehension outcomes at different ages. A thorough investigation of behavioral measures of attention and self/teacher/parent-ratings of attention is strongly recommended as part of the further research in this area. This line of research could have practical use, because more students are being identified as having attentional problems (Akinbami et al., 2011), and more accurate tools are needed in the field.

Secondly, if attention as assessed by the CPT-II were an accurate measure of attentional capacity, there may be a mediator that exists but that was not taken into consideration in this study. Indeed, Sarver and colleagues (2012) recently examined the relationships between attention difficulties, as measured by teacher reports, and near- and long-term academic achievement in children. The results indicated that phonological short-term memory served as a mediator between attention difficulties and near-term academic achievement, whereas visuospatial short-term memory served as a mediator between attention difficulties and long-term academic achievement. More investigation is necessary to identify the mediator(s) between attentional skills and reading comprehension.

Finally, more tasks related to oral language should be incorporated in future studies. For instance, the inclusion of expressive vocabulary knowledge, background knowledge, metaphorical language, inferential reasoning, and syntactic awareness

skills could provide a more in-depth understanding of the contribution of oral language skills to reading comprehension. By using multiple indicators, this could provide an improved representation of the latent construct (Pedhazur, 1997). In addition, various measures assessing listening comprehension also need to be incorporated in future research to examine if both reading comprehension and listening comprehension outcomes could be explained by the Simple Theory.

In summary, the results revealed support for relationships between reading skills and oral language prowess, however, attentional ability did not have significant associations with these domains in this sample. The findings suggest that Gough and Tumner's theory provides a reasonable model in predicting reading comprehension outcomes in college students. The results of the present study contribute to the literature given that little research thus far has examined the potential contribution of attention to reading and language performance in early adulthood.

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