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Assessment of Phonological and Orthographic Differences in Adults With Reading Disabilities

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ASSESSMENT OF PHONOLOGICAL AND ORTHOGRAPHIC DIFFERENCES IN ADULTS WITH READING DISABILTIES

by

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(Under the Direction of Jeff Klibert)

ABSTRACT

There is debate surrounding how to effectively identify and distinguish reading disabilities from other deficits in college populations. Although several theories have proposed a positive relationship between nonword decoding weaknesses and higher intelligence levels, currently there is no conclusive evidence supporting these claims. The primary purpose of the current study was to determine if individuals of diverging levels of verbal intellectual functioning display profile differences with regard to accuracy for spelling and single word reading of regular words and nonwords. Identifying the specific deficits displayed in populations with reading disabilities assists in formulating interventions targeted at areas of weakness and in determining appropriate academic accommodations. Participants consisted of college students who have received a formal diagnosis of a reading disability. Participants' Verbal Comprehension Index (VCI) scores on the Wechsler Adult Intelligence Scale scores were used to determine grouping (High, Average, Low). Participants' performance on intellectual and achievement tests for nonword reading, nonword spelling, real word reading and real world spelling served as the dependent variables. A multivariate analysis of variance (MANOVA) was conducted to analyze mean differences among the three groups' spelling and word reading scores for real words and nonwords. Results indicated that the three groups significantly differed on all reading subscales variables. Notably, the High Reading group scored significantly higher than the Low and Average Reading groups on all subtests of reading. These findings were partially consistent with the study's hypotheses. Theoretical and practical implications are explored further.

Keywords: Nonword Reading and Spelling, Verbal Intelligence, College Students with Reading Disabilities

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by

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CHAPTER 1: INTRODUCTION

Definition of Reading

Most modern societies agree that reading is crucial for the pursuit of learning and knowledge. Poor reading skills have been linked with failure to graduate from high school, unemployment, welfare dependency, criminal behavior, and mental disorders (Schonhaut, 1983; Caspi, Wright, Moffitt, & Silva, 1998). There is strong evidence for the existence of disabilities in reading both at the level of words (basic reading) and in texts (reading comprehension) (Fletcher et al., 2002). It is generally agreed that reading is a language-based skill, and written language represents spoken language (Lundberg, 2009); however, there is no widespread consensus regarding the definition of "reading."

Reading acquisition requires visual recognition of letters and letter combinations to convert the visual forms into their appropriate sounds using primary grapheme-phoneme mapping (Menghini et al., 2010). Reading can be assessed through evaluating performance on outcome measures, contextual information, and the cognitive processes needed to become a competent reader. In the current proposal, reading will be defined using 'single word reading' measures requiring words to be read in isolation and out of context. The capacity to identify single written words accurately and fluently is considered the fundamental process in reading (Seymour, 2008, as cited in Grigorenko & Naples). The current study focused on context-free single word reading skills in light of past research suggesting that individuals with reading disabilities have greater problems in naming and recognizing single words, yet their reading comprehension skills are less impaired (Conners & Olson, 1990; Perfetti, 1985). Furthermore, these articles primarily attribute the deficits observed in reading comprehension skills to problems in word recognition.

Definition of Reading Disability

There is no consensus among professional opinion regarding the conceptual framework and approaches to assessment and diagnosis of a reading disability. The variance in definitional criteria has led to differences in how individuals are designated as reading disabled. There are no specific guidelines when diagnosing a learning disability in private practices, which often leads practitioners to rely on the guidelines set forth in the DSM-IV-TR and professional judgment when diagnosing. According to the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition-Text Revision (DSM-IV-TR), a reading disorder is characterized by

> "reading achievement (reading accuracy, speed, or comprehension as measured by individually administered standardized tests) that falls substantially below that expected given the individual's chronological age, measured intelligence, and age-appropriate education. The disturbance in reading significantly interferes with academic achievement or with activities of daily living that require reading skills" (American Psychiatric Association, 2000, p. 51).

A reading disability is most commonly diagnosed when a discrepancy exists between an individual's potential ability and the actual achievement of reading skills (Fletcher, Espy, Francis, Davidson, Rourke, & Shaywitz, 1989; Muter, 2003). These discrepancy-based definitions of reading disabilities are based upon a comparison between intelligence and achievement. Higher scores on intelligence measures, as opposed to lower scores on achievement tests, are critical in determining reading disabilities. Intelligence scores assist in distinguishing low-achieving individuals from IQ-discrepant individuals. According to the University System of Georgia's specific documentation guidelines for learning disabilities (University System of Georgia, 2012), standardized measures of academic achievement and cognitive processing abilities are essential in diagnosing learning disabilities. Functional academic limitations in reading, mathematics, or written expression should be present. Relative strengths in academic achievement can help determine if a significant discrepancy exists between academic domains. In the University of Georgia System, a significant discrepancy is a difference of one standard deviation between scores. Most states and educational institutions use some form of the discrepancy-based approach; however, the amount of discrepancy and procedures vary.

Prevalence of Reading Disability

Many people experience reading difficulties throughout their lifespan. Reading disability (RD) is the most common type of specific learning disability, and it is estimated that approximately 4% of students in the United States are diagnosed with a reading disability (American Psychiatric Association, 1994; Booth & Burman, 2001; Feifer & Defina, 2000). There are estimates that 17% to 20% of children in the United States have severe reading deficits that meet the criteria for the diagnosis of a reading disability (Lyon, 1999). Grossman (1997) reports that 40% of the population has reading difficulties that are severe enough to limit their enjoyment of reading. Due to the prevalent nature of reading difficulties, this study aims to provide insight on diagnosing and treating reading disabilities.

Purpose

The purpose of the current study was to determine if individuals of diverging levels of verbal intellectual functioning display profile differences with regard to accuracy for spelling and single word reading of regular words and nonwords. This research will provide much needed insight on the defining criteria, clinical practice, profile differences, and possible subtypes of reading disabilities in college-aged populations. Much of the research conducted on reading disabilities and nonword reading skills has involved younger children or adults without postsecondary education. This literature on reading disabilities often fails to account for developmental lags (delay hypothesis) and the complexity of nonword tasks on children and on adults lacking postsecondary education.

College populations are expected to have exposure to the heavy demands on phonological and reading processes given their likelihood of exposure to novel words within subject specific material. It is believed that these participants will have developed additional skills and strategies to aid in spelling and reading. This population has intensive exposure to the semantics, phonology, orthography, vocabulary, and word-specific knowledge needed to perform complex reading tasks. Nonword and real word spelling and reading assessments within this population will allow for a better understanding of whether phonological problems are more prominent in populations with average to high verbal intelligence, as suggested by the literature.

Significance

The current study will advance the current literature on adult reading disabilities, specifically with typical intellectually functioning adults. A main goal was to establish a better system of identifying and classifying adults with reading disabilities in order to provide appropriate academic accommodations and suggestions for intervention. Providing remediation in specific reading areas of weakness is widely believed to improve reading skills. There is evidence that interventions aimed at enhancing sound segmentation and phonological skills can improve later reading and spelling attainment (Bradley & Bryant, 1985; Lundberg, Frost, & Petersen, 1988; Rack, Snowling, Olson, 1992). Olson, Wise, Ring, and Johnson (1997) concluded that children supplied with remediation in phonological processes made greater gains in phonological awareness, phonological decoding, and untimed word recognition at the end of training. In addition, the researchers found that children who spent a greater amount of time reading stories with speech feedback for difficult words gained better limited-time word recognition. Furthermore, there has been some indication that phonological awareness is especially important in high-IQ poor readers while listening comprehension is more important in low-IQ poor readers (Tiu, Thompson, & Lewis, 2003).

Determining the specific deficits displayed in different populations with reading disabilities helps to guide treatment toward targeted areas of weakness. For example, students who exhibit weak decoding skills may benefit from interventions aimed at strengthening their phonological skills. In addition, comprehension strategies may provide greater assistance to students with poor comprehension skills. Determining specific deficits will also assist in designing individualized remediation plans for each student based upon that particular student's weaknesses. Targeting each student's individual needs results in a more concentrated approach in teaching and allows for greater strides in reading capabilities, leading to a more successful outcome.

Furthermore, the current study explored the possibility that even with increasing age and print exposure, some readers continue to experience a nonword reading deficit and impairments in representing, storing, and retrieving phonological information. A secondary goal of the current study was to expand upon the limited literature available on the cognitive profile patterns of reading disabled adults with postsecondary education. Additionally, it provided insight as to whether these phonological deficits may be exhibited more overtly on measures of auditory processing or phonological pronunciation and sequencing.

CHAPTER 2: LITERATURE REVIEW

Progression of Reading Development

There are several models of reading development. The majority of reading theorists agree that reading develops in overlapping "phases," rather than "stages," which suggest that the mastery of a specific set of skills is not a prerequisite for advancing to higher phases of reading. Many models propose that in the earliest stage of reading acquisition, children are exposed to reading when storybooks are read aloud and through social interactions. Children rely on book images to understand the written text. This early form of word recognition occurs in the absence of alphabetic knowledge (Rieben & Perfetti, 1991).

In this early process of developing oral language skills, children lack the explicit awareness of the alphabet and phonemes. The object and the word represented are not differentiated in the child's language. Eye-tracking research has shown that children initially attend to more visual cues than print; however, this dynamic gradually shifts toward reliance on the text as age increases (Evans & Saint-Aubin, 2005; Justice, Pullen & Pence, 2008). Reading aloud to children enables them to build foundational knowledge for recognition of print, letters, and sounds. Furthermore, the spoken form of words learned early in life may be retrieved more efficiently and more quickly than late-acquired words (Gilhooly & Logie, 1981).

Hoover and Googh (2000) proposed a hierarchical approach to reading development in their cognitive-based theory known as the "reading acquisition framework." This model postulates that reading encompasses four main areas of knowledge with the first area being print. Print represents knowledge of the mechanics of the printed word and the knowledge that printed text has meaning. Letter knowledge refers to the ability to recognize letters by sight in a reliable and consistent manner. Phoneme awareness, which is stated to be a necessity, involves the understanding that words are constructed from a discrete set of abstract units in combination with the conscious ability to manipulate these units. Alphabetic principle, the final area, is the knowledge that a systematic relationship exists between the internal structure of written and spoken words, and the process of learning to identify individual words requires this relationship. Stated another way, this principle refers to the knowledge that individual sounds (phonemes) can be represented in groups of individual letters (graphemes), and all oral language can be translated into a written form. These four areas of knowledge are also believed to have corresponding language-based functions, background knowledge, phonology, syntax and semantics all resulting in the comprehension of printed text (Curry, 2006). The second level in this hierarchical theory identifies areas of knowledge that contribute to decoding or the ability to recognize written representations of words. These areas are cipher and lexical knowledge, knowledge of the relationship between spoken and written word, and knowledge of exceptions to the rules when decoding certain words.

Ehri's (1998; as cited in Hulme & Joshi) developmental theory of word acquisition suggests that children progress through four stages of word knowledge (prealphabetic, partial alphabetic, full alphabetic and consolidated alphabetic). During the prealphabetic stage, written words are decoded by visual attribute, which cue pronunciations, associations, and meanings stored in memory. These visual-spatial features can consist of letters, letter and word patterns, or length. The process of letter and word identification is comparable to recognizing an object or picture. For example, readers in this stage would recognize the word "McDonald's" based on adjunct golden arches. Learning how to make distinctions between the visual presentations of each letter is crucial in this stage. The contexts of letters and words allow the reader to acquire knowledge about sound-symbol relationships. Early word reading is dependent not only on basic reading skills but also on oral language skills, such as vocabulary (Stanovich, 1986). When a child possesses the ability to name letters fluently, this indicates that the child has learned the appearance of letters and can discriminate among them.

Seymour and Elder (1986) found that pre-school children aged four to five years old, instructed to read based on “sight vocabulary” and not phonetics, could read previously taught words; however, they could not decode unfamiliar words. This indicated a lack of knowledge surrounding letter-sound correspondences. This study demonstrated that the children possessed a “reading set” and were restricted according to the content of the word set involved. Using this whole-word approach often leads to word identification errors because visual cues are arbitrary and idiosyncratic. These errors often occur when trying to discriminate between visually similar words and in those words that share closely overlapping semantic features, such as color names. As reading progresses, spoken words are matched one at a time to the text written on the page while reading left to right. This process promotes knowledge of associations between written language (letters) and spoken language (sounds). The distinct sounds that are used to differentiate words are known as the phonemes of the language. Understanding of letter arrangement and knowledge that a word is made-up of smaller sound units helps children “sound out” written language. These letter-sound associations will typically form faster with letters that have a high frequency of exposure rate. Reading is enhanced by acquisition of orthographic and phonological processing skills. Through this process, conceptual word knowledge becomes important as children develop the awareness to match spoken words to written language. The self-teaching hypothesis indicates that knowledge surrounding letter-to-sound rules enables the acquisition of orthographic representations of novel words which contributes to writing and spelling skills (Mol & Bus, 2011).

Ehnri (1998; as cited in Hulme & Joshi) suggests that beginning readers will develop partial alphabetic connections by selecting the initial and final letter sounds in words because these are most salient. During this stage, errors occur less frequently because word decoding is based partly on letter-sound relationships rather than solely on visual attributes. Errors appear when complex rules of letter-sound correspondences are needed to decode a word. Goswami (1986) found that if six to seven year olds were taught to read an unfamiliar word, they were more likely to correctly read another unfamiliar word with a similar phonology. A critical factor in becoming literate is a shift from implicit to explicit control of phonemic segments of language (Lundberg, 2009).

As reading development progresses, the skill of word recognition is acquired by making connections between visual attributes, sound-letter correspondences, and phonemes. Ehnri (1998; as cited in Hulme & Joshi) considers this the full alphabetic stage, and it is distinguished by the attainment of full phoneme segmentation ability. This is accomplished by processing all letter sounds, which enables the complete and accurate representation of words in memory. Morris's (1993) four stage model supports this predicted pattern of reading acquisition and labels the stages as beginning consonant knowledge, concept of word in text, phoneme segmentation ability, and word recognition.

Sight vocabulary increases with exposure and allows words to be decoded as a whole rather than a sequence of letters. Children are able to read phrases of print and store their meanings in memory. Contextual information and phonemes are often used to decipher unfamiliar words. Increasing the amount of relevant context from one to several words has shown to facilitate speed and efficiency with target word identification (Tulving & Gold, 1963). Oral language, by pronunciation, is also used to determine if words are approximate to known language. Multiple syllable words, past tenses, contractions, and possessives are taught at this stage.

Children aged seven to eight years old shift toward reading for meaning. They have a large vocabulary of stored words and are able to use meaning, grammar, and letter cues more fully, thereby, allowing more reading independence than in earlier stages. As development progresses, reading is measured by comprehension and acquisition of general knowledge from the text.

In the English language, only some of these sounds are used to distinguish between words because two variants of the same phoneme can be represented by the same letter (Ellis, 1993). The English language has over 40 phonemes that are represented by 26 letters meaning that a combination of letters is required for certain phonemes (e.g., TH, SH, ING). The intermediate position argues that words with common letter sequences are more predictable and easier to decode than those with uncommon sequences.

Reading Processes

In an attempt to locate specific processes involved in reading, several theories have been formulated surrounding reading development. Reading fluency and automaticity are considered major predictors of comprehension (Hook & Jones, 2004). Fluency encompasses automatic word identification along with prosodic features. Automaticity refers to the speed and accuracy of single word identifications. These features occur at the phrase, sentence, and text levels. Fluency and automaticity are interdependent with phonological skills. Some researchers support the hypothesis that reading speed and accuracy measure our ability to access phonological representations stored in long-term memory (Muter, 2003). In addition, many studies have documented differences in processing speed and memory capacities between high IQ poor readers and low IQ poor readers (Tiu, Thompson, & Lewis, 2003). Reaction times could place constraints on low-IQ poor readers when their deficits are memory based and not phonologically based, and this could attribute to the mixed results in current research.

Hoover and Gough (2000) proposed that decoding and listening comprehension are the two basic psychological processes involved in reading, and while each of these processes are necessary, neither alone is sufficient for reading. Listening comprehension involves the ability to understand spoken language and is measured by reading passages aloud. Decoding is the ability to recognize written words and can be divided into orthographic and phonological processes (Tiu et al., 2003).

Although orthographic processes are concerned with visual recognition of words, phonological processes refer to an identification of words based on letter-sound conversion. Many researchers believe these two processes to be central in understanding the components of reading. Wolf and Bowers (1999) proposed the Double-Deficit Hypothesis, which indicates that reading difficulties are due to deficits in both phonological awareness and naming speed. Furthermore, Kirby, Desrochers, Roth, and Lai (2008) suggested assessing reading disabilities through six cognitive constructs: phonological awareness, phonological decoding, naming speed, orthographic processing, morphological awareness, and vocabulary. Several researchers have assessed different populations on these key constructs involved in reading, but the findings surrounding phonological awareness and decoding were inconclusive.

There has been an enormous amount of research into the role of phonological awareness and its influence on reading skills. Phonological awareness refers to the ability to detect and manipulate sounds and is the major predictor of a child's potential reading and writing achievement (Goswami, 2008, as cited in Grigorenko & Naples; Schneider, Roth & Ennemoser, 2000). It has been demonstrated that phonological awareness is the most robust predictor of reading difficulties. Numerous studies have demonstrated a significantly high correlation between phonological skills and later reading achievement (Bradley & Bryant, 1983; Calfee, Lindamood, & Lindamood, 1973; Lundberg, Olofsson, & Wall, 1980; Tunmer, Herriman, & Nesdale, 1988; see Goswami & Bryant, 1990 for a review). Research has shown that, during infancy, language acquisition begins with the child's ability to discriminate between phonetic characteristics critical for understanding and communicating within his environment (Gleason, 2005; Kuhl, 1992).

It is important to note that all models of adult reading development acknowledge the importance of phonological processes and skills (Rack, Snowling, & Olson, 1992). The development of phonological awareness has shown similar stages across languages. Prior to learning to read, children tend to focus on "large" phonological units containing syllables, onsets, and rimes. As children learn to read the alphabet, there is a shift in awareness toward smaller units of sound and mapping phonemes and graphemes. A phone is an individual speech sound, and a phoneme is the smallest unit of contrasting speech sound that signals meaning in a particular language (Gleason, 2005). Phonemic awareness is defined as the understanding that words are comprised of different sounds (National Reading Panel, 2000). Grapheme is the smallest unit of written language, such as letters of the alphabet (Gleason, 2005). Grapheme-phoneme correspondence rules define the relationship between a letter or group of letters and the sound they represent. In the English language, most letters correspond to at least two phonemes, and some letters correspond to several phonemes. This increases the difficulty involved in developing phonemic awareness. Awareness of phonemes is believed to be dependent upon a child gaining metalinguistic or conscious control through direct instruction (Gombert, 1992).

Learning to read and to spell are the most common methods of gaining phonemic awareness (Goswami, 2008 in Grigorenko & Naples).

Morris et al. (1998) identified seven subtypes of reading disabilities based upon eight constructs highly correlated with reading disabilities. It was determined that six of the seven subtypes had impairments in phonological awareness skills, but performance varied on other cognitive skills (Fletcher et al., 2002). The general finding indicated that phonological awareness was the only construct correlated with different types of reading disabilities. This included those identified using the IQ-discrepancy model and those who met the low achievement definition of reading disability (Beaton, 2004). There is research supporting the phonological deficit hypothesis that states individuals with reading disabilities have specific deficits in phonological skills. These deficits are associated with problems in short-term memory, in sound segmentation and categorization, in sound blending, and in reading and spelling (Rack, Snowling, & Olson, 1992; Snowling, 1987; Stanovich, 1988).

Single Word Reading

By implementing the single word approach, words are deciphered through whole word recognition, decoding or sounding out of syllables, or by ‘analogizing’ to similarly constructed words coded in the semantic system (Muter, 2003). Single word reading requires letters to be pronounced by decoding a given letter string into smaller units. The phonology of each unit is assigned according to a set of context-dependent rules to provide the appropriate pronunciation (Beaton, 2004).

This process can be used in reading familiar regular words as well as nonwords or pseudowords. There is a vast amount of research suggesting that identification of word units, ‘sounding’ out skills, and blending and syllabification skills are significant predictors of later reading and spelling development in normal and reading disabled populations (Beaton, 2004; Thompson, 2001). It is commonly believed that impairments in recognition and decoding of real words and pseudowords are critical in reading disabilities (Fletcher et al., 2002). Single word reading recognizes the roles of the phonological, orthographic, and graphemic processing in reading.

Single word reading has been shown to be a necessary, but insufficient, predictor of good reading comprehension skills (Stanovich, 2000). The process of reading at higher levels requires reading in context. Contextual reading involves decoding sentences, passages, and longer more involved texts. In these instances, contexts affect recognition and the meaning of words. Reading comprehension is defined as an active process that is based on the ability to understand, retain, and recall whole texts (Muter, 2003). Many individuals with phonological deficits compensate by over-relying on comprehension processes in order to identify and decode words in single word reading (Aaron, 1989; Bruck, 1988).

Nonwords or Pseudowords

The most commonly used method for assessing phonological processes is nonword reading, and nonwords are commonly referred to as pseudowords or pseudohomophones (Rack et al., 1992). Nonwords are invented words that have no meaning. A nonword can result from simply changing one sound or phoneme of a meaningful word. With deep dyslexia or pre-alphabetic reading, individuals lack alphabetic knowledge and do not possess the ability to decode simple nonwords. Illiterate adults are believed to lack the awareness of phonemes. Nonwords are believed to be unfamiliar to the reader, thereby, increasing reliance on phonological processes to decode the nonword. Nonword measures help to assess an individual's single-word reading skills while minimizing the roles of previous reading experiences and knowledge on reading scores (Stothers & Klein, 2010). The skills required to read nonwords are assumed to be similar to those which are needed in novel-word learning. Some researchers differentiate the term “pseudoword” from “nonword.” In linguistic studies, pseudowords are units of speech or text that have no meaning; however, they obey all the phonotactic rules of a specific language and are pronounceable for speakers of that language (Khanna, Cortese, & Birchwood, 2010).

Phonological and Orthographic Neighborhoods

Phonological neighborhoods are words that sound similar to each other or have phonemic similarity. The target word’s number of phonological neighbors is often defined by the addition, deletion, or substitution of one phoneme to the target (Landauer & Streeter, 1973; Luce & Pisoni, 1998). Phonotactic probability is the “frequency with which phonological segments and sequences of phonological segments occur in the English language” (Jusczyk, Luce, & Charles-Luce, 1994). Familiar or common words tend to be comprised of phonological segments that frequently occur in the English language. Children have been shown to be better at remembering words and nonwords containing rimes from larger phonological neighborhoods when compared to sparse phonological neighborhoods (Thomson, Richardson, & Goswami, 2005). Additionally, research has shown that nonwords formed from high-frequency phoneme sequences are easier to repeat than nonwords constructed of low-frequency phoneme sequences (Jones & Witherstone, 2011; Munson, 2001).

Originally, Coltheart, Davelaar, Jonasson, and Besner (1977) defined the concept of orthographic neighborhood as all the existing words that can be formed from one target word by replacing one of its letters with a different one. In this definition, words must possess the same number of letters and are identical to the target word with the exception of one letter. For example, the words *send, band, said,* and *land* are all orthographic neighbors of the word *sand*. The number of orthographic neighbors is represented as *N*; therefore, *sand* would be classified as having an *N* of 4. Recent empirical data has suggested that other types of neighborhoods, such as addition, substitution, transposition, or deletion neighbors, are activated during reading (Dunabeitia & Vidal-Abarca, 2008). These findings have expanded Colheart et al.'s (1977) original definition through the inclusion of these additional subtypes. Literature has suggested a facilitatory effect of neighborhood size in which response time will be faster and accuracy will be greater for words with higher densities of *N* (Dunabeitia & Vidal-Abarca, 2008; Holcomb, Grainger, & O'Rourke, 2002).

Compensation

There is some empirical evidence that phonological and orthographic word decoding can be selectively impaired in children with reading disabilities (Gustafson, 2001). Individuals with orthographic impairment tend to rely more heavily on the phonological route, whereas the opposite is true for the phonologically impaired type of reading disability. This approach supports a multi-factorial view of the development of reading disorders (Bosse, Tainturier, & Valdois, 2007).

Compensatory strategies are often employed if a deficit in one or more skills necessary for reading is present. Readers with phonological impairments can rely on contextual cues as a strategy to compensate for poor decoding skills. This appears to contribute to the higher rates of visual and semantic errors in comparison with the phonetic errors that are often observed in poor readers (Pugh, Sandak, Frost, Moore, & Mencl, 2005). Producing concrete mental imagery can also improve reading comprehension by allowing an individual to construct mental representations of words while reading (Stothers & Klein, 2010). Research supports this notion in findings that visualization during reading and teaching can improve reading comprehension scores in individuals with and without learning disabilities (Mastropieri, Scruggs, & Graetz, 2003).

Another compensation strategy employed during nonword or novel word reading involves the application of previous knowledge and experience. Vocabulary and word knowledge have been shown to have a positive correlation with phonological awareness (Stothers & Klein, 2010). Readers may apply previous knowledge of orthographic and phonological neighborhoods of real words to decode a nonword or novel word. Additionally, an analogy strategy based on lexical knowledge about rime units may assist in pronunciation. For example, word knowledge may be used to help the reader recognize similarities between non-words (e.g., grawl) and real words (crawl) while assisting in the pronunciation and spelling of the target word.

Individuals with reading impairments, specifically phonological deficits, may also compensate by reading words slower. By allotting more time during reading, individuals with reading difficulties are better able to use re-reading and context to improve decoding accuracy (Friedman & Miyake, 2004; Lesaux, Pearson, & Siegel, 2006). Research has demonstrated that impaired word decoding and slow reading speed are associated with phonological deficits (Pennington, 2009; Stothers & Klein, 2010; Vellutino, Fletcher, Snowling & Scanlon, 2004). Empirical evidence has shown that individuals without learning disabilities perform better than those with learning disabilities on timed reading comprehension tasks. However, there were no significant differences between the two groups when reading comprehension scores were based on the number of items correct out of the total attempted items rather than scoring all of the items presented (Corkett & Parrila, 2007; Deacon, Parrila, & Kirby, 2006).

Cognitive Processing Model

In the current study, participants were identified as reading disabled based on whether they met the criteria outlined by the University System of Georgia. According to the University System of Georgia's specific documentation guidelines for learning disabilities (University System of Georgia, 2012), standardized measures of academic achievement and cognitive processing abilities are essential in diagnosing learning disabilities. Functional academic limitations in reading, mathematics, or written expression should be present. Relative strengths in academic achievement can help determine if a significant discrepancy exists between academic domains. In the University of Georgia System, a significant discrepancy is a difference of one standard deviation between scores.

Patterns of cognitive processing strengths and weaknesses help establish the presence of a significant discrepancy between cognitive domains. These cognitive domains include: attention, executive functions, fluency/automaticity, memory/learning, oral language, phonological/orthographic processing, visual-motor, and visual-perceptual/visual-spatial skills. In order to diagnose a learning disorder in the public university setting, alternative explanations for academic achievement and cognitive processing limitations must be considered and ruled out. Furthermore, evidence of strengths and weaknesses needs to be apparent on multiple measures and not based on an individual test or subtest.

IQ and Reading Disability

Stanovich (1988) proposed the phonological core-variable model to explain the relationship between IQ and reading disabilities. The phonological-core variable-differences model that states a reading disability is characterized by a deficit in phonological language (Stanovich & Siegel, 1994). Other deficits in the areas of language and cognitive processes are not adequate predictors of a “specific” reading disability. Stanovich proposed two subtypes of reading difficulties based on deficiencies. In order to diagnose a “specific” reading disability, Stanovich stated that cognitive deficits are limited to phonological processes. The “garden-variety,” or poor reader subtype, has phonological deficits combined with weaknesses in other language and cognitive domains. The cognitive profile of these readers may demonstrate an overall lag in development in all areas of reading. The low reading achievement found in the “garden-variety” subtype is believed to be consistent with IQ (i.e., low achievement). Although several theories have proposed relationships between specific reading deficits and intelligence, currently there is no conclusive research supporting these claims.

However, Torgesen (1989) found a correlation between IQ and single word reading scores and argued that IQ plays an important role in defining reading disabilities. Additionally, there have been limited cases of reading disabled individuals that have low IQ but average or better reading skills (Beaton, 2004). Metz, Marx, Weber, and Scheider (2003) compared poor readers with high IQs to poor readers with low IQs and noted that the high IQ group performed unexpectedly well in reading and spelling tasks. In addition, the high IQ group performed better than the low IQ group on tests of phonological information processing. Other studies demonstrated that children with reading disabilities outperformed those who are poor readers on assessments dealing with working memory and phonological processing measures (Swanson, Howard, & Saez, 2006).

In contrast, Hoskyn and Swanson (2000) compared the cognitive functioning of children with reading disabilities to that of children with low reading abilities and low intelligence. Hoskyn found that children with reading disabilities performed better than low achievers on measures of lexical disabilities, syntactical knowledge, and visual-spatial processing but not on measures of phonological processing. Furthermore, experimenters have found that high-IQ poor readers experienced difficulty in taking a phonological approach to reading; whereas, the low-IQ readers had fewer phonological problems (Johnston & Morrison, 2007). In general, an assessment using nonsense words appears to be the best predictor of reading level (Ackerman & Dykman, 1993).

Presently, there is much debate surrounding the effectiveness of the IQ-discrepancy method in identifying and distinguishing reading disabilities from other deficits. Many researchers in this field agree that a discrepancy between IQ and reading is not an adequate predictor of cognitive differences that exist between those who are underachieving and those with reading disabilities (Hoskyn & Swanson, 2000). Stanovich and Siegal (1994) argue against the discrepancy model by claiming that reading problems are best understood in terms of phonological difficulties. Phonological tests have been shown to be better predictors of reading ability than the IQ-discrepancy model (Muter, 2003).

The intra-achievement model, similar to the IQ discrepancy model, is another method used to classify reading disabilities. This model allows for a comparison of one area of academic achievement to other achievement areas. An intra-achievement discrepancy is present when an individual demonstrates specific strengths or weaknesses relative to the average of all other areas of achievement (McGrew, Schrank, & Woodcock, 2007). The discrepancy can occur in one or more areas of achievement. The presence of an intra-achievement discrepancy suggests that an individual could have a specific difficulty in learning.

The heuristic model, based on a biobehavioral systems approach, divides assessment into four components when determining individuals with learning disability (Fletcher et al., 1995; as cited in Kaplan & Sadock). Fletcher et al. (1995) define a learning disability in reading as being a word-level reading disorder associated with phonological processing problems. It is also believed to be characterized by difficulties in the development of accurate and fluent single-word decoding skills that are unexpected in relation to age and other cognitive and academic abilities. The first level of analysis, or manifest disability, involves defining and characterizing the presenting problem in relation to performance. Impairment in word recognition skills is the most common manifest disability (Fletcher, Taylor, Levin, & Satz, 1995, as cited in Kaplan & Sadock). The other components consist of evaluations of cognitive and psychosocial traits, environmental variables, and biological variables. This hierarchical model aims to identify achievement patterns and predict cognitive deficits within the context of environmental and internal psychological variables (Fletcher, Espy, Francis, Davidson, Rourke, & Shaywitz, 1989; Muter, 2003).

The Individuals with Disabilities Education Act (IDEA) stated that if a significant discrepancy exists between intellectual functioning and academic achievement, not related to sensory, visual, hearing, or motor handicap, Mental Retardation, emotional disturbance, or environmental, cultural or economic disadvantage (Fletcher, Francis, Rourke, Shaywitz, & Shaywitz, 1992; IDEA, 2006), then the individual is said to have a disability. The criteria for a reading disability indicated by the federal definition and IDEA suggest that there are three essential components: discrepancy, heterogeneity, and exclusion (Fletcher, Floorman, Boudousquie, Barnes, Schatschneider, & Francis, 2002).

The IDEA has led to a recent trend in schools implementing research-based interventions rather than the traditional IQ discrepancy model for disability identification. To define a disability, a student's achievement levels and rate of growth are considered. In this model, a disability is characterized by a discrepancy between performance and the learning opportunities encountered (Piasta & Wagner, 2007). Response to intervention (RTI) is considered an alternative and new method for identifying students who are struggling with reading. The key components in RTI are the use of empirically validated interventions, continual assessments, and universal screenings to identify students that qualify for special education services. This is a multi-tiered service delivery model where a student's progress on multiple assessments initiates interventions that increase in intensity the greater the tier.

The first tier consists of universal screenings and other brief measures conducted within the general classroom to determine if a student is performing poorly and/or is not showing typical progress in the area of concern. At the secondary intervention, or tier, students not responding to general education classrooms receive moderate interventions, tutoring, different reading programs, and small-group instructions. If a student continues to demonstrate a lack of progress, the student moves to the tertiary tier where highly intensive individualized interventions are implemented. If a student shows no improvement in the area of concern, the student may repeat intensive interventions or be referred for special education services. A major assumption of RTI is that the multi-tiered service delivery model will reduce the number of students in special education, while identifying children whose needs could truly benefit from special education services. The use of RTI could also have future implications for college populations.

Cognitive Structures

A large amount of research has been conducted in an attempt to identify anatomical structures and brain areas involved in reading and reading disabilities. In most individuals, the left cerebral hemisphere is dominant in speech and language processes whereas the right hemisphere is responsible for visuo-spatial and other non-verbal cognitive functions. Data collected through neuroimaging technologies, such as Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI), suggests that skilled word reading is associated with the development of a highly integrated cortical system (Pugh, Sandak, Frost, Moore, Rueckl, & Mencl, 2005). This evidence has shown that the cortical system is heavily relied upon to perform several processes in reading including orthographic, phonological, and lexico-semantic processing.

Normal Reading Development

The cortical system is located in the brain's left hemisphere, and within this system, there are three systems implicated during reading tasks (ventral, dorsal, and anterior). Some studies suggest that the left auditory cortex is specialized for processing speech early in development (Coch, Dawson, & Fischer, 2007). Right hemispheric posterior areas are used to assist in the visual processing of stimuli. In the earliest stages of normal reading development, the dorsal and anterior systems, along with right hemispheric processes, appear to predominate during initial reading acquisition (Pugh et al., 2005). This is reflective of the whole-word approach to reading involving the recognition of larger phonological units and patterns.

Around the age of 10.5 years, the left hemisphere ventral sites become more active signifying that higher order reading skills are being performed (Shaywitz et al., 2002). During this stage of normal reading development, all three cortical systems and right hemisphere posterior areas are activated to process visual and auditory word forms. Additionally, the single-word approach to reading is implemented by decoding smaller phonological units in language (Stanovich, 1992). During adulthood, the left hemisphere ventral system is heavily relied upon for reading skills, such as rapid recognition of printed words, while the right hemisphere posterior area, dorsal system, and anterior system play diminished roles in reading.

The ventral system includes a left inferior occipito-temporal area where functional imaging data has revealed high brain activity during word and nonword reading tasks (Shaywitz et al., 1998; Tarkiainen, Helenius, Hansen, Cornelissne, & Slamenlin, 1999). Research has suggested that the occipitotemporal (OT) region is related to the acquisition of reading skills and the ventral system is often referred to as the "skill zone" (Shaywitz et al., 2002).

The dorsal temporo-parietal system consists of the angular gyrus, supramarginal gyrus (SMG), and the superior temporal gyrus (Wernicke's area). These areas have proven critical in the mapping and visual integration of print onto the phonological and semantic structures of language (Black & Behrmann, 1994). The angular gyrus plays a role in reading comprehension by forming associations between word sounds and written symbols of language. The supramarginal gyrus is responsible for associating sounds with their meaning. Wernicke's area is located on the posterior aspect of the superior temporal gyrus and is responsible for auditory processing of speech. Wernicke's aphasia or receptive aphasia can result from damage to the left hemisphere auditory processing areas and can result in the partial or total inability to decode spoken words.

Furthermore, the dorsal system is thought to be important in phonological processing and in decoding new or unfamiliar words. It has been demonstrated that in skilled readers brain activity measured in the Wernicke's Area is higher when reading pseudowords compared to familiar words (Price, Wise, & Frackowiak, 1996; Simos et al., 2002; Xu, et al., 2001). Additionally, researchers have found that the inability to read (alexa) appears to result from lesions on or around the angular gyrus (Damasio & Damasio, 1983; Henderson, 1986). It has been hypothesized that the temporoparietal system and the anterior system work closely together to decode new words during normal reading development (Pugh et al., 2000).

The anterior system is located in the inferior frontal gyrus which is centered in and around Broca's Area. This system is associated with phonological memory and articulation in reading tasks. Cognitive functions that involve the anterior system include: sequencing and control of speech-gestural articulatory recoding, silent reading and naming, syntactic processing and retrieval, and decoding low-frequency words (irregular/exception words) and pseudowords (Brunswick et al., 1999; Fiez & Petersen, 1998; Poldrack et al., 1999; Pugh et al., 2001). Broca's area is specialized for expressive language and is essential for the production of coordinated speech sound. Broca's area also involves the integration of motor movements related to the production of speech and sounds with phonemic awareness and phonological knowledge. Functional imaging research has suggested a relationship between the anterior system and reading disabilities (Brunswick et al., 1999). This literature has shown that the anterior system appears to be relied upon more heavily by individuals with reading disabilities. It is postulated that these findings result when reading disabled individuals compensate for underdeveloped or abnormal functioning in the left hemisphere posterior systems (Pugh et al., 2001).

Abnormal Reading Development

When comparing normal readers with reading disabled readers, the literature has revealed brain activation differences in the ventral, dorsal, and anterior regions. Under-activation of areas in the dorsal and ventral systems has been observed in children as early as the end of their kindergarten year and signified abnormal reading development (Simos et al., 2002). Some researchers have suggested that a ventral disruption is a critical signature of reading disability (Paulesu et al., 2001; Salmelin, Service, Kiesila, Uutela, & Olson, 1996). During phonological processing tasks in child and adults with reading disabilities, functional imaging studies have observed disruptions in the dorsal and ventral systems (Pugh et al., 2000; Shaywitz et al., 1998, 2002). These areas are under-activated on tasks that involve processing linguistic stimuli (words and pseudowords) and on tasks that require decoding (Pugh et al., 2005).

Genetic Contribution of Phonological Skills

Research has confirmed a genetic contribution to phonological and orthographic skills (Muter, 2003). The heritability estimates are recorded at the level of approximately 0.55-0.60, with estimates for reading comprehension being much lower (DeFries, Alarcon, & Olson, 1997). Gayan and Olson (1999) conducted a twin study that investigated heritability of different components of reading. Phonological awareness was estimated at a heritability level of 0.89, which was significantly higher than other reading components. Since phonological skills are employed in the development of orthography, it is suggested that the phonological processing ability is inherited and that phonological skills are being reflected by the heritability estimates.

Hypotheses

Considering developed theory and relevant empirical findings that those individuals with reading difficulties and high intelligence display problems taking the phonological approach to reading; whereas, individuals with reading difficulties and low intelligence had fewer phonological problems (Johnson & Morrison, 2007). Furthermore, it has been shown that poor readers with high intelligence outperformed poor readers with low intelligence on reading and spelling tasks (Metz et al., 2003). It was hypothesized that (a) the High Verbal group would have an advantage in real word spelling and real word reading accuracy levels over the Average Verbal group (b) the Low Verbal group would have an advantage in nonword spelling and nonword reading accuracy over the Average Verbal group (c) the High Verbal group would have an advantage in real word spelling and real reading accuracy levels over the Low Verbal group

(d) the Low Verbal group would have an advantage in nonword spelling and nonword reading accuracy levels over the High Average group.

CHAPTER 3: METHODOLOGY

Participants

Three hundred and eighty-four participants were drawn from a database and consisted of college students who had received a formal diagnosis of a reading disability. In terms of gender, 235 (61.2%) participants identified as men, whereas 149 (38.8%) participants identified as women. Three hundred and ten (80.7%) participants self-identified as White/Non-Hispanic, 62 (16.1%) self-identified as African-American, 7 (1.8%) self-identified as Mexican American/Latino, and 5 (1.3%) self-identified as "Other." The mean age of participants was 21.12 years. With regard to class standing, 231(60.2%) were freshmen, 77(20.1%) were sophomores, 38 (9.9%) were juniors, 28 (7.3%) were seniors, and 10 (2.6%) were graduate students.

Procedure

Data for the current study were obtained from an archival sample of men and women adults over the age of eighteen. The population consisted of high school seniors and college students who received a formal diagnosis of a reading disability. The college population included freshman, sophomores, juniors, seniors, graduate, and non-traditional students. At the time of assessment, participants were seeking academic accommodations for college courses. Participants were informed before undergoing testing that their testing data may be used for experimental purposes; however, no identifying information was disclosed. Each participant was administered a neuropsychological battery of tests and completed a comprehensive intake. The test administrators met the requirements set forth by the APA Ethical Code of Conduct (2011) and were supervised by a licensed psychologist specializing in neuropsychology. Following the evaluation, the assessment results were entered into a database.

The archival database provides only pooled responses, allowing no identifying information to be disclosed. Individuals who were missing data regarding the presence or absence of a reading disability were excluded. Participants met the criteria for the diagnosis of a reading disability under both the Individuals with Disabilities Education Act (IDEA) and the DSM-IV-TR criteria. Verbal Comprehension Index (VCI) scores were used to determine which group participants were assigned to. There were no statistical analyses comparing the groups using the VCI scores. The participants were placed in one of three groups based on their VCI scores on the WAIS-III or WAIS-IV. These are the High Verbal group (110 or above), Average Verbal group (90-109), and Low Verbal group (89 or below). The numerical value for each category was determined by examining previous research assessing reading disabilities using the WAIS-III, and these values correspond to the categorical system used by all Georgia public universities (Johnson & Morrison, 2007).

Measures

According to the literature, specific subtest scores were extracted as adequate outcome measures of reading skill and intelligence. Prior to the year 2009, participants were administered the Wechsler Adult Intelligence Scale Third Edition (WAIS-III) as a measure of intelligence. The Wechsler Adult Intelligence Scale Fourth Edition (WAIS-IV) was administered to all participants after this date. The instruments chosen are hypothesized to measure specific processes associated with reading. The achievement measures administered include subtests from Wide Range Achievement Test- Fourth Edition (WRAT-4) and the Woodcock-Johnson Test of Achievement-Third Edition (WJ III ACH). The Word Attack and Spelling of Sounds subtests have been shown to be adequate measures of phonological and orthographic coding ability (Sattler, 2001). The measures used in the current study derive standard scores based on a normal distribution with a mean of 100 and a standard deviation of 15.

Wechsler Adult Intelligence Scale

Intelligence quotient, or IQ, is a score based on a person's performance on a standardized test intended to assess intelligence. Intelligence tests assess a broader scope of cognitive abilities and experiences when compared to achievement tests. The most widely used intelligence measure for adults is the Wechsler Adult Intelligence Scale (WAIS), and it is currently in its fourth edition. The Wechsler Adult Intelligence Scale is considered the "Gold Standard" for intelligence testing (Sattler, 2001). In the current study, participants' scores on the WAIS-III and WAIS-IV were used. The WAIS-III was standardized on 2,450 individuals believed to be representative of the United States population. The WAIS-IV used a standardization sample of 2,200 individuals ranging in age from 16 to 90 years (Sattler & Ryan, 2009). These measures have demonstrated excellent reliability and validity, and test-age equivalent scores can be compared with mental-age or test-age scores from other tests making the results easy to compare against other scores (Sattler, 2001).

Approximately 47% of the items on the WAIS-III are found on the WAIS-IV. Sattler and Ryan (2009) stated that it is plausible that the research on the WAIS-III generally applies to the WAIS-IV. A study conducted on 288 individuals found a 0.91 correlation between the Verbal Comprehension Index (VCI) on the WAIS-III and the VCI on the WAIS-IV (Sattler & Ryan, 2009). The WAIS-III and WAIS-IV's Verbal Comprehension Index (VCI) is comprised of the subtests Similarities, Vocabulary, Information, and Comprehension. The VCI assesses an individual's acquired knowledge and application of this knowledge, which is known as crystallized intelligence. The specific skills assessed by the VCI are comprehension of verbal stimuli, semantic reasoning, and the expression of thoughts and ideas with words (Sattler & Ryan, 2009).

Achievement tests are heavily dependent upon formal learning acquired in school or at home. These measures assess more specific skill areas compared to intelligence tests. Intelligence tests examine a person's ability to apply information in a new and different way; however, achievement tests are considered measures of acquired and factual information (Sattler, 2001). Many theorists believe that reading ability and IQ are strongly correlated (Swanson, 1989).

Woodcock-Johnson-III Tests of Achievement (WJ-III ACH)

The Woodcock-Johnson III Tests of Achievement (WJ III ACH) battery (Woodcock, McGrew, & Mather, 2001) is intended to test individuals aged 2 to 90+ years old and measures their achievement and cognitive abilities. The WJ III ACH contains twenty-two subtests and was standardized on a sample of 8,818 individuals believed to represent the U.S. population. The reliability of the achievement subtests has internal consistency rates between the upper 0.80's and the 0.90's (Schrank, McGrew, & Woodcock, 2001). Validity studies indicate that the content, concurrent, and construct validity are adequate for subtests within the achievement portion of the battery (McGrew & Woodcock, 2001).

The WJ III ACH assesses multiple subjects including reading, mathematics, writing, and factual knowledge. It can be used to determine an individual's academic strengths and weaknesses and whether discrepancies exist between IQ and academic abilities. In addition, these measures provide age and grade equivalent scores, percentile ranks, confidence intervals, discrepancy scores, and a Relative Proficiency Index (RPI).

Word Attack

The Woodcock-Johnson III Tests of Achievement battery (Woodcock, McGrew, & Mather, 2001) Word Attack subtest measures skills in applying phonic and structural analysis skills to the pronunciation of unfamiliar printed words. The test items are nonwords or low-frequency words that are phonically consistent with patterns in English orthography. The administration and scoring of this test followed the standardized guidelines set forth in the Woodcock Johnson Technical Manual (McGrew, Schrank, & Woodcock, 2007). The test contains thirty-two scored items (3 letter identification and 29 nonword) that progress in difficulty. The Word Attack subtest is reported to have a median reliability of 0.87 in the adult age range (Schrank, McGrew, & Woodcock, 2001). Word Attack was selected because of the strong empirical support indicating that adults with learning disabilities have weak non-word reading skills (Bruck, 1990; Ramus et al., 2003; Shaywitz et al., 2003; Stothers & Klein, 2010). A nonword measure was selected in order to reduce the types of compensation strategies that may be employed based upon participant differences in reading experiences and word knowledge (Olson, Forsberg, Wise, & Rack, 1994, as cited in Lyon; Stothers & Klein, 2010).

Participants were not asked to complete the first three items measuring letter identification due to the age and education administration guidelines. Based on participants' first response, each item was given a score of "1" if correct and a "0" if incorrect. There was no time limit imposed. During administration, participants were informed that the words they would be reading aloud were not real words. Participants were instructed to read the non-words aloud according to how they thought the words would be pronounced if they were real words. This test measured participants' abilities to apply English language phonic conventions in a single-word reading task (Stothers & Klein, 2010). The items on this test are presented visually in groups of six and seven. Each participant completed two practice items, and they were given feedback when answers were incorrect. The feedback consisted of the examiner stating the correct pronunciation of the nonword and asking the participant to repeat the practice item a second time. Responses on practice items were not included in this study. The Word Attack basal rule of the lowest six items correct and ceiling rule of the highest six items incorrect were followed during test item administration.

Spelling of Sounds

Spelling of Sounds measures spelling skills, specifically, those involved in phonological and orthographical coding (McGrew, Schrank, & Woodcock, 2007). The subtest items are nonwords or low-frequency words that progressively become more complex and require increased knowledge of spelling patterns. Spelling of Sounds is reported to have a median reliability of 0.82 in the adult range (Schrank, McGrew, & Woodcock, 2001).

Participants were not asked to complete the five items measuring single letter and sound correspondence due to the age and education administration guidelines. On the first seven nonwords, participants can receive up to three points for correct spelling of a nonword. On items thirteen through twenty-eight participants received “1” for correct spellings and “0” for incorrect spellings. There was no time limit imposed. During administration, participants were informed that the words they would be spelling were not real words. Participants were instructed to listen to the audio recording and spell the words according to how they thought the word should be spelled. The audio recording pronounces each test item twice. Each participant completed two practice items, and they were given feedback when answers were incorrect. The feedback consisted of the examiner stating the correct spelling of the nonword and asking the participant to repeat the practice item a second time. Responses on practice items were not included in this study. The Spelling of Sounds basal rule of the lowest four items correct and ceiling rule of the highest four items incorrect were followed during test item administration.

Wide Range Achievement Test Fourth Edition

The Wide Range Achievement Test Fourth Edition (WRAT4) measures basic academic skills in word reading, sentence comprehension, spelling, and math computation. There are two alternative test forms. A representative national sample consisting of over 3,000 individuals ranging in age from 5 to 94 years was used to standardize the norms on the WRAT4 (Wilkinson & Robertson, 2006). The median coefficient alpha subtest reliability coefficients range from 0.87 to 0.93 (Wilkinson & Robertson, 2006). Furthermore, the WRAT4 has demonstrated an acceptable level of concurrent validity.

Word Reading

The Word Reading Subtest measures letter and word decoding through letter identification and word recognition. The internal consistency reliability coefficient of Word Reading has shown to be 0.92 (Wilkinson & Robertson, 2006). This subtest consists of sections (1) Letter Reading and (2) Word Reading. Participants in this study were not asked to complete the Letter Reading section due to the age and education administration guidelines. The Word Reading section is made-up of fifty-five words that increase in difficulty. Participants were given the Word Reading List and instructed to read each word aloud moving across the page. Correct responses were scored as a "1" and incorrect responses were scored as "0." Full credit of fifteen points was given for the Letter Reading Section and was added to the Word Reading Section score to total the Letter Reading Raw Score. The maximum possible raw score for this subtest is seventy points.

Spelling

The Spelling subtest measures the ability to encode sounds into written form using a dictated spelling format with both letters and words. This subtest has been shown to have an internal consistency reliability coefficient of 0.90 to 0.91 (Wilkinson & Robertson, 2006). The Spelling subtest consists of two sections: (1) Letter Writing and (2) Spelling. Participants in this study were not asked to complete the Letter Writing section due to the age and education administration guidelines. The Spelling section is made-up of forty-two words that progressively become more orthographically and phonologically complex. During administration, the examiner pronounces each word aloud, uses the word in a sentence, and then pronounces the word again. Participants recorded their responses on the WRAT4 Response Forms. Full credit of thirteen points was given for the Letter Writing Section and added to the score of the Word Writing Section to total the Spelling Raw Score. The maximum possible raw score for this subtest is fifty-five points.

Design

A Multivariate Analysis of Variance (MANOVA) was conducted to analyze mean differences among three reading groups on measures of spelling and word reading scores for real words and nonwords. The independent variable was verbal IQ group and it had three levels (High Reading, Average Reading, and Low Reading). The dependent variables were spelling and word reading each consisting of two levels (real word and nonword).

Considering developed theory and relevant empirical findings, it was hypothesized that (a) the High Reading group would have an advantage in real word spelling and real word reading accuracy levels over the Average Reading group, (b) the Low Reading group would have an advantage in nonword spelling and nonword reading accuracy over the Average Reading group,

(c) the High Reading group would have an advantage in real word spelling and real reading accuracy levels over the Low Reading group, (d) the Low Reading group would have an advantage in nonword spelling and nonword reading accuracy levels over the High Reading group.

CHAPTER 4: RESULTS

Preliminary Findings

Gender Differences. Literature suggests that gender differences do exist when examining reading ability and performance (Chipere, 2014). A multivariate analysis of variance (MANOVA) was conducted to examine gender differences among different indices of reading. The dependent variables included subscales scores from established achievement tests: word attack, spelling of sounds, WRAT reading, WRAT spelling, letter-word identification, and passage completion. Results revealed a non-significant overall effect for gender (λ (6, 372) = 1.64, $p > .05$, $\eta^2 = .03$). Furthermore, follow-up ANOVAs revealed non-significant gender effects for each of the six dependent variables. The means and standard deviations for variables by gender are reported in Table 1.

Correlations. To examine covariance among the reading subscales, we analyzed a series of bivariate correlations. All reading scales were significantly related to one another in the expected direction and to the expected degree. While some scales appear highly correlated the results indicate that each reading subscale is measuring something unique; essentially, each variable consists of unique variance. A correlation matrix is reported in Table 2.

Proposed Findings

Verbal Comprehension Index (VCI) scores were used to determine group assignment. The participants were placed in one of three groups based on their VCI scores on the WAIS-III or WAIS-IV. Groups were established based upon the standard deviations of the WAIS-III and WAIS-IV. The High Reading group is characterized by standard scores of 110 or above. The Average Reading group is characterized by standard scores of 90 to 109. The Low Reading group is characterized by standard scores of 89 or below. The numerical value for each category was determined by examining previous research assessing reading disabilities using the WAIS-III, and these values correspond to the categorical system used by all Georgia public universities (Johnson & Morrison, 2007). A MANOVA was utilized to determine subscale score differences among these three groups. Based on the hypotheses, four dependent variables were included in this analysis: word attack, spelling of sounds, WRAT reading, and WRAT spelling. In addition, we added two exploratory subscale scores (not included in the study's hypotheses) as dependent variables: letter-word reading and passage comprehension. In total, there were six dependent variables.

Overall, results indicated that, as expected, there was a significant main effect for differences in mean levels of reading subscale scores reported by the three levels of reading groups of participants, λ (12, 740) = 16.22, $p = .00$, $\eta^2 = .208$.

Follow-up univariate ANOVA's were conducted to analyze individual mean differences among subscales scores: word attack, spelling of sounds, WRAT reading, WRAT spelling, letter-word identification, and passage comprehension. Results indicated that the three groups significantly differed on all six reading subscales variables (word attack $F(2, 375) = 8.06$, $p = .00$, $\eta^2 = .041$; spelling of sounds $F(2, 375) = 17.52$, $p = .00$, $\eta^2 = .085$; WRAT reading $F(2, 375) = 35.88$, $p = .00$, $\eta^2 = .161$; WRAT spelling $F(2, 375) = 13.72$, $p = .00$, $\eta^2 = .068$; letter-word identification $F(2, 375) = 32.05$, $p = .00$, $\eta^2 = .146$; passage comprehension $F(2, 375) = 83.45$, $p = .00$, $\eta^2 = .308$).

Table 3 displays post-hoc analyses, using Tukey's Least Square Differences. Of note, the High Reading group scored significantly higher than the Low Reading and Average reading groups on all six subtests of reading. The Average Reading group scored significantly higher on spelling of sounds, WRAT reading, letter-word identification, and passage comprehension when compared to the Low Reading group. The Low Reading and Average Reading groups scores' did not significantly differ on the word attack and WRAT Spelling subtests. These findings are partially consistent with the study's hypotheses.

CHAPTER 5: DISCUSSION

Overview

The primary purpose of the current study was to determine if individuals of diverging levels of verbal intellectual functioning display profile differences with regard to accuracy for spelling and single word reading of regular words and nonwords. A secondary goal of the current study was to expand upon the limited literature available on the cognitive profile patterns of reading disabled adults with postsecondary education. As part of this goal, we sought to provide insight as to whether these deficits are exhibited more overtly on measures of orthographic or phonological pronunciation and sequencing. Identifying the specific deficits displayed in populations with reading disabilities assists in formulating interventions targeted at areas of weakness and in determining appropriate academic accommodations. In light of these goals, the current research examined the following inquires: a) whether the High Reading group would have an advantage in real word spelling and real word reading accuracy levels over the Average Reading group, b) if the Low Reading group would have an advantage in nonword spelling and nonword reading accuracy over the Average Reading group, c) whether the High Reading group would have an advantage in real word spelling and real reading accuracy levels over the Low Reading group, and d) if the Low Reading group would have an advantage in nonword spelling and nonword reading accuracy levels over the High Reading group.

Gender Differences

Gender differences in reading subscales were analyzed through a MANOVA. Results revealed non-significant mean differences between male and female performance scores on six reading subscales. These findings suggest that men and women tend to perform equally on different reading tasks. These findings are consistent with previous research which found no gender differences on reading tasks when assessing college students with reading difficulties (Wolff, 2009). Historically, there has been a link between gender and performance scores, such as males are superior in math-related tasks while females have more dominant language skills. However, gender superiority has been shown to vary according to age and the measures being used (Vogel, 1990). Gender differences seem to be more apparent in early childhood. It is hypothesized that in early childhood, a child's gender leads to differential expectations by teachers and parents with respect to academic outcomes. With increasing age, gender expectations may become less influential leading to minimal performance differences between males and females in college-aged populations. However, it is unclear what mechanisms are responsible for reduced adherence to gender expectations with regard to academic and other performance based outcomes. Future work investigating if and how gender expectations are minimized during adolescence and the effects of reduced gender expectations on academic achievement is warranted.

Advantages for High Verbal IQ Group

The results in our study revealed that individuals in the high reading group performed better in real word reading and spelling tasks when compared to individuals in the low reading group. This is consistent with previous research that compared poor readers with high IQs to poor readers with low IQs and found that the high IQ group outperformed the low IQ group on real word reading and spelling tasks (Metz, Marx, Weber, & Scheider, 2003). It is believed that individuals, diagnosed with reading disabilities, with higher intelligence have developed additional skills and strategies to aid in spelling and reading. Furthermore, this population is likely to have intensive exposure to the semantics, phonology, orthography, vocabulary, and word-specific knowledge to perform complex reading and spelling tasks. Future research should investigate the types of assessments that are most effective at measuring phonological and orthographic skills while reducing the use of compensation strategies with individuals with higher verbal intelligence. Implementing these assessments will allow us to gain a more accurate cognitive profile and a better understanding of whether specific deficits are more prominent with high verbal intelligence levels.

Advantages for Low Verbal IQ Group

Based on prevailing literature, it was expected that the low reading group would have an advantage in nonword reading and spelling (Johnson & Morrison, 2007). Our results did not support these predictions. Instead, individuals in the high reading group outperformed the low reading group on nonword reading and spelling tasks. This is inconsistent with some of the literature that has found that individuals with higher IQ experience more difficulties using the phonological approach to reading when compared to individuals with lower IQ (Ackerman & Dykman, 1993).

Our results may be attributed to the procedures associated with the measurement of nonword reading and spelling. The organization of the items on the nonword subtests required the examinee to become increasing reliant on phonological and orthographic skills as the test progressed. This may have given an advantage to individuals in the high reading group by allowing them to employ compensation strategies (i.e., application of previous word knowledge and experience) during the first parts of the subtests. Essentially, allowance for compensation tactics may mask group differences and even the direction of group differences in the current study. Future research should investigate the how types of compensation alter effect reading group differences on nonword and spelling tasks. In addition, researchers may need to investigate the usefulness of compensation strategies in promoting better reading outcomes in individuals with lower levels of reading.

General Implications

There is little consensus among professional opinion regarding the conceptual framework and approaches to assessment and diagnosis of reading disabilities. Furthermore, there has been limited research conducted on adult populations with reading difficulties. Our study aimed to provide foundational insights on how to establish a better system of identifying and classifying adults with reading disabilities in order to provide appropriate academic accommodations and suggestions for intervention.

Our results did not support previous findings that there are specific phonological and orthographic profiles indicative of reading disabilities with low average and high average verbal intelligence levels. This finding may have implications when implementing the discrepancy model to diagnose a reading disability with college students due to the linear relationship found between verbal intelligence and specific reading skills. Furthermore, due to the population, it can be difficult to determine an initial learning diagnosis due to previous interventions, post-secondary knowledge, and learned compensation strategies. These factors may cause cognitive deficits to be less pronounced when compared to an individual's intelligence score, which in turn leads to disproportionate levels of misdiagnosis.

Additionally, our results indicated that treatment and academic accommodations should be individualized rather than based on cognitive profiles that have been found to accompany the varying levels of intelligence. Remediation should target an individual's specific area(s) of weakness to improve reading skills. Identifying and targeting each student's individual needs allows for a more concentrated approach in teaching and for determining the most appropriate intervention strategies. This approach may lead to improvements in deficit areas over time and allow the individual to be more successful in reading and in the classroom.

Rural Implications

One unique component of the current study was a focus on reading difficulties in a sample of college-students residing in predominantly rural areas. Examining reading difficulties from a rural perspective is important for many reasons. First, in the large metropolitan statistical areas (MSA) group, areas consisting of with one million or more persons, approximately 7.1% of children identified as having a learning disability. Areas not considered an MSA have considerably higher rates with an estimated 10.3% of children having some type of a learning disability (Bloom, Cohen, & Freeman, 2011). Second, other characteristics were linked to increased rates of learning disabilities in the NHIS study, including a family income of less than $35,000, a "poor" poverty status, fair or poor health status, and a family structure where the father or both parents were absent from the household. In terms of racial differences, African Americans and children with two or more races demonstrated higher rates of learning disabilities. Many of these characteristics associated with higher prevalence rates of learning disabilities appear to be disproportionally represented in rural populations. Third, level of cognitive impairment can vary according to the resources available and community factors. In rural areas, an individual with a learning disability may encounter difficulties accessing community supports and mental health services. Rural residents often lack sufficient knowledge about the signs of learning disabilities and how to access treatment. This can delay early diagnosis and treatment, thereby, increasing the likelihood that the impairment will interfere with future functioning and overall attitudes (Baird, Scott, Dearing, & Hamill, 2009). Finally, there is an increased likelihood that learning difficulties will be central to the individual's self-image and quality of life among individuals residing in rural areas (Scorgie, Kildal, & Wilgosh, 2010). Severe learning problems typically are accompanied with some form of communication impairment (Johnson, Douglas, Bigby, & Iacono, 2010). These impairments can impede the individual's ability to form close social connections, fulfill social etiquette expectations, and participate in valued social roles in rural communities. The limited range of professional supports in rural areas can hinder an individual's integration and affiliation with the community (Sondenaa, Rasmussen, Nottestad, & Lauvrud, 2010).

The current study aimed to advance this field further by examining reading performance of college students enrolled in a rural based university. The results confirmed a linear pattern of reading performance where individuals with higher verbal intelligence performed better on all tasks that measured components of reading. Our results suggested that students with higher verbal intelligence levels possess the skills necessary to excel at reading related tasks. Furthermore, this is important because it is unclear if these linear patterns of reading performance are apparent in rural emerging adult samples. Future research should examine rural and non-rural populations to determine if reading differences occur and formulate effective interventions specific to each population.

Limitations

The present study had several limitations worth noting. First, the generalizability of the findings is limited as the participants were derived exclusively from college students. The demographics for our population indicate that the majority of participants were aged 18 to 23 and identified their ethnicity as Caucasian. Therefore, it would be inappropriate to generalize the results of this study to ethnically diverse (e.g., Mexican American) and non-traditional college students. It is important that future research replicate the findings using a more culturally diverse sample of traditional and non-traditional college students. Another limitation was that participants were assessed by different examiners across time. This may have influenced the rapport between examiners and participants along with how participants responded to test items. In future studies, it is important that researchers measure for administrator characteristics so that they can be statistically controlled for in subsequent analysis. Another limitation of the present study was the procedures associated with measurement and group classification. Nonword measures are believed to assess an individual's single-word reading skills while minimizing the roles of previous reading experiences and knowledge on reading scores (Stothers & Klein, 2010). In the current study, the organization of the items on the word attack and spelling of sounds subtests requires the examinee to become increasing reliant on phonological and orthographic processes as the test progresses. For example, previous word knowledge may be used during beginning items on the test to help recognize similarities between non-words (e.g., grawl) and real words (crawl) while assisting in the pronunciation and spelling of the target word. As a result, future studies may benefit from developing an assessment tool consisting strictly of nonwords that are not easily decoded using alphabetic knowledge and compensatory strategies. Another limitation was the use of different versions of IQ measures. Participants assessed prior to 2008 were administered the WAIS-III, while participants after this date completed the WAIS-IV. Although the WAIS-III and WAIS-IV have been shown to be highly correlated, the use of the same IQ measure for all participants may have resulted in slightly different classification groups (Sattler & Ryan, 2009). Lastly, the research design of grouping participants into the High Reading (110 or above), Average Reading (90-109), and Low Reading (89 or below) may have limited our results. Future research should investigate and identify IQ cutoff scores that help separate groups in a more significant manner.

This would increase the distinction between groups, which may result in more accurate and meaningful findings.

General Conclusions

Much of previous research conducted on reading disabilities and nonword reading skills has involved younger children or adults without postsecondary education. Our study aimed to provide a better understanding of adult reading disabled populations with post-secondary education. Our results did not support previous findings that there are specific phonological and orthographic profiles indicative of reading disabilities with low average and high average verbal intelligence levels. Due to the linear relationship found between verbal intelligence and specific reading skills, cognitive deficits may be less pronounced making it difficult to identify and diagnose reading disabilities. Future research should investigate whether the discrepancy model is the most effective model to employ when identifying reading disabilities in college students. Additionally, our results indicated that treatment and academic accommodations should be based on an individual's cognitive profile rather than deficits typically associated with reading disabilities.

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Table 1

Means, Standard Deviations, and Minimum and Maximum Scores for Word Attack, Spelling of Sounds, WRAT Reading, WRAT Spelling, Letter-Word Identification, and Passage Comprehension in Men and Women

Variables (N)	Mean (SD)	Min-Max Scores
Men		
Word Attack (n = 234)	86.69 (11.34)	43.00 – 120.00
Spelling of Sounds (n = 234)	86.71 (11.02)	31.00 – 116.00
WRAT Reading (n = 233)	90.48 (12.59)	53.00 – 124.00
WRAT Spelling (n = 233)	89.59 (12.97)	55.00 – 121.00
Letter-Word Identification (n = 235)	89.72 (10.36)	50.00 – 116.00
Passage Comprehension (n = 235)	97.68 (9.87)	66.00 – 123.00
Women		
Word Attack (n = 148)	84.87 (11.81)	48.00 – 120.00
Spelling of Sounds (n = 147)	86.97 (11.46)	53.00 – 120.00
WRAT Reading (n = 148)	88.89 (11.70)	58.00 – 120.00
WRAT Spelling (n = 148)	89.80 (11.56)	59.00 – 132.00
Letter-Word Identification (n = 148)	89.45 (10.36)	47.00 – 116.00
Passage Comprehension (n = 148)	96.11 (9.70)	68.00 – 134.00

Table 2

Inter-correlations among Measures of Word Attack, Spelling of Sounds, WRAT Reading, WRAT Spelling, Letter-Word Identification, and Passage Comprehension for College Students Diagnosed with Reading Disabilities

Variables	WA	SoS	WRdg	WSpell	L-WID	PC
WA	---	.58**	.68**	.62**	.74**	.36**
SoS		---	.58**	.52**	.66**	.36**
WRdg			---	.65**	.75**	.45**
WSpell				---	.68**	.34**
L-WID					---	.54**
PC						---

Note: * Correlation is significant at the .05 level.

** Correlation is significant at the .01 level

Word Attack (WA), Spelling of Sounds (SoS), WRAT Reading (WRdg), WRAT Spelling (WSpell), Letter-Word Identification (L-WID), Passage Comprehension (PC)

Table 3

Means and Standard Deviations by Reading Level and Reading Performance

	Reading Level Group		
Variable	Low Reading	Average Reading	High Reading
	A (N = 71)	B (N = 229)	C (N = 78)
Word Attack			
Mean	83.29^{C}	85.22^{C}	90.23^{AB}
SD	(1.33)	(0.75)	(1.27)
Spelling Sounds			
Mean	82.45^{BC}	86.03^{AC}	92.46^{AB}
SD	(1.26)	(0.70)	(1.20)
WRAT Reading			
Mean	83.28^{BC}	88.80^{AC}	98.35^{AB}
SD	(1.33)	(0.74)	(1.26)
WRAT Spelling			
Mean	86.16^{C}	88.50^{C}	95.56^{AB}
SD	(1.41)	(0.79)	(1.35)
Letter-Word Identification			
Mean	84.66^{BC}	88.44^{AC}	96.49^{AB}
SD	(1.12)	(0.62)	(1.07)
Passage Comprehension			
Mean	87.68^{BC}	97.09^{AC}	104.95^{AB}
SD	(0.97)	(0.54)	(0.92)

Note: Group A = Low Reading; B = Average Reading; C = High Reading. A superscript A indicates that the mean differs significantly from the Low Reading Mean. A superscript B indicates that the mean differs significantly from the Average Reading Mean. A superscript C indicates that the mean differs significantly from the High Reading Mean according to Tukey's Least Significant Difference.