University of South Carolina
Scholar Commons

Theses and Dissertations

2018

Minimal Hearing Loss In School-Age Children: Prevalence And Relationship To Reading Impairment

Laura Peek
University of South Carolina

Follow this and additional works at: https://scholarcommons.sc.edu/etd

Part of the Speech Pathology and Audiology Commons

Recommended Citation

Peek, L.(2018). *Minimal Hearing Loss In School-Age Children: Prevalence And Relationship To Reading Impairment.* (Master's thesis). Retrieved from https://scholarcommons.sc.edu/etd/4774

This Open Access Thesis is brought to you by Scholar Commons. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of Scholar Commons. For more information, please contact digres@mailbox.sc.edu.

MINIMAL HEARING LOSS IN SCHOOL-AGE CHILDREN: PREVALENCE AND RELATIONSHIP TO READING IMPAIRMENT

by

Laura Peek

Bachelor of Health Science
University of Florida, 2016

Bachelor of Science
University of Florida, 2016

Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Speech Pathology in

Speech Pathology

The Norman J. Arnold School of Public Health

University of South Carolina

2018

Accepted by:

Krystal Werfel, Director of Thesis

Suzanne Adlof, Reader

Jason Wigand, Reader

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

© Copyright by Laura Peek, 2018
All Rights Reserved.

ABSTRACT

Purpose: The two-fold purpose of this study was to determine if a) students with reading impairments fail hearing screenings at higher rates than students without reading impairments and b) if the pattern of simple view of reading classification differs across hearing screening results.

Method: This project included 19 students with reading impairments and 17 students with typically reading skills in grades 2 through 11. Each participant completed a hearing screening and a complete battery of language and literacy tests to determine their hearing screen status and simple view classification.

Results: Results of a chi square test comparing reading status and hearing screen status were not statistically significant ($p = 0.74$), but indicated a trend in the predicted direction, with 52.6% of impaired readers and 23.5% of normal readers failing their hearing screening. Results of a chi square test comparing simple view classification and hearing screen status indicated a significant relationship ($p = .043$). Individuals who failed their hearing screening were most likely to present in the mixed reading disability group.

Conclusions: Students who fail a hearing screening at 15 dB HL are not likely to be good readers and are significantly more likely to have a mixed reading disability than those who did not fail. More information is needed to conclude if students with reading impairment are significantly more likely to fail a hearing screening than those without.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

MHL..Minimal hearing loss

OAE ....Otoacoustic emissions

PA ....Phonological awareness

CHAPTER 1

INTRODUCTION

Reading Impairment

Reading impairment is a pervasive problem in today's educational environment. Children with reading impairments comprise the largest category of students who receive special education services in the United States (Kena et al., 2015). Reading impairment, therefore, poses a problem for both the children it affects and the professionals that serve them. The current research project aims to uncover one potential cause of reading impairment, minimal hearing loss, ultimately allowing professionals to better understand the needs of the children they serve.

The impact of reading impairment on a child's success is well documented in the literature. Reading impairments are known to have long-term negative outcomes in academic, occupational, and social settings (Kutner et al. 2007). In fact, only 68% of students with reading impairments in the U.S. finish high school with a regular diploma. Outcomes for students with reading impairments in the state of South Carolina are even worse than the national average. Less than half of students with reading impairments in South Carolina graduate from high school (Cortiella & Horowitz, 2014). Consequently, South Carolina has the highest dropout rate for students with reading impairments in the nation. Thus, there is a vital need to understand what is leading to these high rates of reading impairment and what can be done to better serve the students it affects. In order to do that, the underlying factors that contribute to poor reading outcomes need to be explained.

A Simple View of Reading

It has long been held that reading is more than decoding words from a page. It can be argued that without understanding, reading is not occurring. One long-standing, evidence-based model of the skill of reading is that reading is the product of decoding and linguistic comprehension (Gough & Tunmer, 1986). This model, known as the simple view of reading, tells us that these two separate skills interact and have a multiplicative relationship on one's reading ability. Therefore, without decoding or comprehension, reading is not taking place.

This simple view of reading allows us to understand the different ways in which reading can go wrong. As it stands, reading disability could result in three different ways: from an inability to decode, an inability to comprehend, or a combination of the two (Gough & Tunmer, 1986). Difficulty decoding results in dyslexia, difficulty with comprehension results in a specific comprehension deficit or hyperlexia, and difficulty with both results in what has been called a garden variety, or mixed, reading disability (Gough & Tunmer, 1986).

Since the simple view of reading was proposed in the 1980s, multiple studies have shown that decoding and listening comprehension are correlated but separate skills and that differences in these skills leads to the existence of each of these simple view categories (Braze, Tabor, Shankweiler, & Mencl, 2007; Catts, Adlof, & Ellis Weismer, 2006; Dreyer & Katz, 1992). One such study, conducted by Catts et al. in 2006, examined the language abilities of children with specific comprehension deficits and compared them to typical readers and children with specific decoding deficits. Results of this study showed that those with specific comprehension deficits had deficits in language comprehension but normal abilities in phonological processing, while poor decoders were characterized by the opposite pattern of language abilities (Catts et al., 2006). The ability of each of these categories to exist in isolation lends to the idea that deficits in different skills should have effects on a reader's simple view classification.

Individuals with dyslexia present with difficulty decoding written words despite normal intelligence and sensory function, sufficient opportunity for learning, and an absence of severe disability (Vellutino, 1979). This inability to decode does not affect linguistic comprehension of written text in those with dyslexia. In multiple studies performed across time, dyslexic readers have shown extremely limited decoding skills, as measured by reading nonsense words (Firth, 1972; Rack, Snowling, & Olson, 1992; Torgesen, Wagner, & Rashotte, 1994; Vellutino, 1979). This inability to decode is very likely related to deficits in phonemic awareness (Gough & Tunmer, 1986).

In contrast, individuals with hyperlexia, also known as poor comprehenders, present with above average decoding skills and below average comprehension (Gough & Tunmer, 1986). Following the simple view of reading, these students are thought to exhibit poor listening comprehension skills. Since this category was proposed, various studies have been conducted to confirm its existence (Catts et al., 2006 & Healy, 1982). Through separate testing of decoding and comprehension skills, these studies have shown adequate decoding skills in the presence of inferior comprehension in children with specific comprehension deficits. Notably, Healy (1982) found students with early and exceptional skill in decoding but average or inferior comprehension to have a listening comprehension age that was equivalent to their reading comprehension age. These studies provide evidence for dissociation between these skills that can result in a specific comprehension deficit.

The final category of impaired reading as described by the simple view is garden variety, or mixed, reading disability. Although the existence of dyslexia and hyperlexia demonstrate that skills in comprehension are not always accompanied by skills in decoding and vice versa, these skills are typically correlated (Aaron, Joshi, & Williams, 1999; Gough & Tunmer, 1986; Shankweiler et al., 1999). Because a poor decoder tends to be a poor comprehender, the simple view of reading provides this final type of reading impairment in which children struggle with both decoding and comprehension. This makes up the largest “poor reader” category.

Language Predictors of Reading

Research has long confirmed the language basis of reading (Catts, Fey, Tomblin, & Zhang, 2002; Mattingly, 1972; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Language predictors of reading can be placed in to two main categories: phonological aspects of language and nonphonological aspects of language. Phonological aspects of language, including phonological awareness, underlie the development of decoding and word recognition (Adams, 1990; Stahl & Murray, 1994; Wagner & Torgesen, 1987). Nonphonological aspects of language, including vocabulary and syntax knowledge, underlie the development of reading comprehension (Cutting & Scarborough, 2006; Senechal, Ouellette, & Rodney, 2006). Based on the simple view of reading, we would expect these aspects of language to differentially affect reading skills. Children with deficits in solely phonological aspects of language should present with dyslexia, children with deficits in solely nonphonological aspects of language should present with specific comprehension deficits, and children with mixed deficits should present with a mixed reading disability. Intervention targeted at the underlying skills of each deficit category should, hypothetically, be effective in improving outcomes for the children who display these deficits.

Even with best practice based on this research, however, there are still a significant number of children who do not respond to intervention (Al Otaiba, 2001; Blachman, 1997; Torgesen, 2000). One evidence based intervention to promote early literacy and decoding skills is phonological awareness training. Despite overall evidence for the positive effects of phonological awareness training on early literacy, investigators have reported that as many as 30% of students who are at risk for reading difficulties (Blachman, 1994, 1997; Brown & Felton, 1990; Juel, 1994; Mathes, Howard, Allen, and Fuchs, 1998; Torgesen, Morgan, & Davis, 1992) and as many as 50% of children who have special needs (Fuchs et al., 2002; O'Connor, 2000) may not benefit from generally effective phonological and decoding instruction. A review of the literature on children who are nonresponsive to early literacy intervention conducted by Al Otaiba and Fuchs in 2002 indicated that a majority of unresponsive students demonstrated poor phonological awareness. This leaves us needing to explore other factors that might underlie the phonological difficulties of students who don't respond to what we know is best instruction.

Minimal Hearing Loss

The current study aims to look at one possible contributor to the widespread reading difficulties facing today's children that has been relatively unexplored to date:

minimal hearing loss. Children with moderate to profound hearing loss are known to experience difficulties in various areas of language and literacy (Bess & McConnell, 1981; Davis, 1990; Davis, Sheperd, Stelmachowicz, & Gorga, 1981; de Villiers, 1992; Holt, 1993; Karchmer, 1991). However, the effects and prevalence of minimal hearing loss are much less known. Minimal hearing loss encompasses several diagnostic categories (Bess & Gravel, 2006; Niskar et al., 1998): (a) permanent bilateral pure-tone averages (500, 1000, 2000 Hz) between 16 and 40 dB HL, (b) permanent unilateral hearing loss (normal hearing in one ear; pure-tone average greater than 20 dB HL in affected ear), (c) unilateral or bilateral permanent high-frequency hearing loss (air conduction thresholds greater than 25 dB HL at two or more frequencies above 2000 Hz), or (d) permanent or temporary conductive hearing loss due to fluid in the ears (e.g., because of an ear infection).

Children who fall in to any of the above mentioned categories often go undiagnosed due to multiple challenges that prevent discovery at earlier ages (Dodd-Murphy, Murphy, & Bess, 2014). The identification of minimal sensorineural hearing loss may be missed at newborn hearing screenings because these screening methods are less sensitive to hearing loss below a moderate degree (Holstrum & Gaffney, 2005; Johnson et al., 2005; Joint Committee on Infant Hearing, 2007). Additionally, pure tone screening, the method used for identifying hearing loss in school-aged children has referral criteria that is less effective for identifying students with MHL. National guidelines recommend screening at 20 dB HL for 1000, 2000, and 4000 Hz in each ear (American Academy of Audiology, 2011; American Speech-Language Hearing Association, 2016). In practice, the most common referral criterion levels are 20 and 25 dB HL, which leaves many children meeting the criteria for MHL undiagnosed (Bamford et al., 2007; Meinke & Dice, 2007). In addition to threshold levels already too high to identify MHL, many examiners often fail to refer when a child fails a hearing screening due to the acoustic environment testing occurs in or concerns about referral rates (AAA, 2011; Allen, Stuart, Everett, & Elangovan, 2004; Bamford et al., 2007).

Children with minimal hearing loss are able to hear environmental sounds and conversational speech under normal listening conditions but may have difficulty with certain specific speech sounds (Clark, 1981). As phonological decoding requires an individual to manipulate speech sounds, it logically follows that an inability to detect certain speech sounds may lead to specific deficits in phonological aspects of language for children with minimal hearing loss. Additionally, these children can experience difficulty understanding speech in unfavorable listening conditions (Bess, Dodd-Murphy, & Parker, 1998). Classrooms, unfortunately, do not provide optimal listening environments for students. According to the Acoustical Society of America, the speech intelligibility rating in many U.S. classrooms is 75% or less, meaning that listeners with normal hearing can understand only 75% of the words read from a list (Acoustical Society of America, 2010). This intelligibility rating is even lower for students with any type of hearing impairment.

The effects of difficulties with speech recognition on a child's education have been documented in children with higher levels of hearing loss as well as unilateral hearing loss (Crandell, 1993). Many professionals have discussed the potential impact that minimal hearing loss can have on a child. A review of the current research is indicative of a higher prevalence and more significant psychoeducational effects than was previously thought.

Preliminary results of studies conducted in University of South Carolina Written Language Lab have indicated that over half (55.6%) of middle school students with reading impairment failed their hearing screening (Straley & Werfel, 2017). This rate is significantly higher than that seen in the normal reading group (16.7%) (Straley & Werfel, 2017). In this study, all of the children in the reading impaired group had difficulties at the word level (decoding), with two also having difficulties at the text level (comprehension). Similar deficits in reading achievement in students with minimal hearing loss were reported by Bess and colleagues in 1998. As determined in their study, 3rd grade students with minimal hearing loss exhibited significantly lower scores than their normal hearing peers on the Comprehensive Test of Basic Skills, 4th edition subtests for reading vocabulary, reading total, language mechanics, basic battery, word analysis, spelling, and science (Bess et al., 1998). Additionally, 37% of all children with minimal hearing loss had failed at least one grade (Bess et al., 1998). The retention rate increased with increasing grade and by 9th grade, 47.4% of students with minimal hearing loss had failed at least one grade (Bess et al., 1998). These rates were all significantly higher than the district norms for retention.

In 1968, Quigley and Thomure examined 116 school-aged children who exhibited hearing loss but were not enrolled in special education services. Notably, this study found that even students with hearing levels less than 15 dB HL, a level that would not constitute a "fail" on a hearing screening, performed lower than expected on educational testing. Similarly, in 1985, Blair, Peterson, and Viehweg looked at the educational performance of 24 children with mild sensorineural hearing impairment and found that third and fourth grade students with mild hearing loss performed poorer than the control group on multiple subtests of the Iowa Test of Basic Skills. Shortly after, Davis, Elfenbein, Schum, and Bentler (1986) conducted a prospective study on 40 children with mild to moderately severe hearing impairments. In this study, they demonstrated the very significant finding that the degree of hearing loss was not a reliable predictor of a child's language ability or educational performance. Together, these studies present mixed evidence for the link between hearing levels and reading outcomes. They provide evidence of the fact that any child with hearing loss is at a risk for educational difficulties and should be treated as such. As evidenced by the current research, a trend can be seen in which language and literacy skills, in particular, pose a problem for children with minimal sensorineural hearing loss that is not explained by their general cognitive ability.

Theoretical Mechanism

Research suggests that minimal hearing loss can have an impact on a child's educational success, especially in the areas of language and literacy. The question now is why. One skill that is imperative to the success of young readers is phonological awareness, as it prefaces the ability to decode. A vast amount of the recent research into individual differences predictive of reading ability has focused on this concept. Phonological awareness refers to an individual's understanding of the sounds of a language and their ability to manipulate them (Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997). Recent research suggests that this ability to manipulate sounds is causally related to the acquisition of reading skills. Studies have shown that phonological awareness skills in pre-reading preschool children are predictive of reading ability several years later (Bradley & Bryant, 1985; Mann, 1984; Mann & Liberman, 1984). Notably, recent evidence confirms a core phonological deficit as the leading cause of dyslexia (Catts, McIlraith, Bridges, & Nielsen, 2017; Snowling, 1998; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). Its dissociation from general cognitive ability helps to explain a reading ability lower than what cognitive ability would predict (Hatcher, Snowling, & Griffiths, 2002; Wagner et al. 1993).

The fact that children with minimal hearing loss are able to hear environmental sounds and most conversation but may have difficulty with some specific speech sounds leads us to believe that their difficulty with literacy arises from a deficit in phonological decoding. If a child cannot hear all speech sounds, it logically arises that they will be missing out on the ability to manipulate those speech sounds for decoding as needed to become a proficient reader. This would put these children into the simple view classification of dyslexia or mixed reading disability.

Research Questions

The present study aimed to define the relationship between minimal hearing loss and reading impairment in school-age children. Two specific questions came out of this centralized goal:

1: Do students with reading impairments fail hearing screenings at higher rates than students without reading impairments?

2: Does the pattern of simple view classification differ across hearing screen results?

CHAPTER 2

METHOD

Participants:

This project included 19 students with reading impairment and 17 students with typical reading skills: 9 in elementary school, grades 2 through 4; 26 in middle school, grades 5 through 8; and 1 in high school, grades 9 through 12. Of the 19 students with reading impairment, 4 were in elementary school, 14 were in middle school, and 1 was in high school. Students in kindergarten and first grade were excluded from this study due to floor effects on reading measures (Catts, Petscher, Schatschneider, Bridges, & Mendoza, 2009). Reading impairment was operationally defined below the 25th percentile on the Basic Skills and/or Reading Comprehension scales of the Woodcock Reading Mastery Test-III (WRMT-III; Woodcock, 2011). A failed hearing screening was operationally defined as a threshold below 15 dB at any frequency in either ear. Participants in each group had nonverbal intelligence in the average or above average range, as measured by the Test of Nonverbal Intelligence-4 (TONI-4; Brown, Sherbenou, & Johnsen, 2010) and had no additional reported diagnoses, such as specific language impairment, cognitive impairment, autism, or moderate to profound hearing loss. Chi Square tests performed across groups determined participants were not significantly different across gender, grade, ear infection history, presence of tinnitus, ethnicity, or race (See Table 1). Participants were recruited through flyers at local schools, pediatrician offices, and public libraries.

Table 2.1

Demographic Information by Group

Demographic Variable	NR	RI	*p*	*d*
Percent Female	53	42	0.516	-
Mean Grade	5.4	6.1	.827	-
Percent History of Ear	18	32	.335	-
Infection				
Percent Minority	12	26	.074	-
Tinnitus	1	1	.863	
Average Maternal	18.17(3.72)	18.26(2.2)	.930	-
Education*				0.03
Nonverbal Intelligence*	103.82(8.974)	104.32(9.256)	.873	-
				0.05
Core Language*	101.82(20.48)	99.95(16.06)	.760	.10

Note: NR = normal reading, RI = reading impairment; * reported in mean (standard deviation)

Procedure:

All participants completed a hearing screening and a battery of language and literacy measures on-site at the university clinic. A graduate student in speech-language pathology completed all literacy and audiological screening measures. Hearing screenings were conducted in a sound proof booth using the Daisy software application on a Cello diagnostic audiometer. Each participant initially underwent otoscopy and tympanometry screening. Immediately following, participants' air conduction thresholds were obtained at 500, 1000, 2000, 4000, 6000, and 8000 Hz at 15 dB HL. To obtain a threshold, each tone was initially presented at 15 dB HL. If the participant responded, the tone was presented 10 dB lower. If the participant did not respond, the tone was presented 5 dB higher. This was done until 2 responses were recorded at the same intensity level. This process was repeated for each frequency in each ear.

Additionally, all participants completed a battery of literacy measures that further assess specific literacy skills, including decoding, comprehension, and fluency (see Table 2). Administration order was counterbalanced across participants. All testing measures were double scored to ensure fidelity of scoring.

Table 2.2

Test Measures by Literacy Domain

Literacy Domain	**Measure**
Untimed Word Identification	Woodcock Reading Mastery Test-III (Woodcock, 2011)
Timed Word Identification	Test of Word Reading Efficiency, 2nd Edition
Untimed Phonological Decoding	Woodcock Reading Mastery Test-III (Woodcock, 2011)
Timed Phonological Decoding	Test of Word Reading Efficiency, 2nd Edition
Reading Comprehension	Woodcock Reading Mastery Test-III (Woodcock, 2011)
Listening Comprehension	Woodcock Reading Mastery Test-III (Woodcock, 2011)
Language	Clinical Evaluation of Language Fundamentals, 5th Edition
Nonverbal Intelligence	Test of Nonverbal Intelligence, 4th Edition

Measures

All measures had adequate reliability (>.80) reported in test manuals.

Word reading. Four measures were utilized to measure word reading skills. Two of these measures were timed and two were untimed; two measures addressed word identification and two addressed phonological decoding.

Word identification. Untimed single word identification (e.g., real word reading) was measured using the Word Identification subtest of the Woodcock Reading Mastery Test-III. In this subtest, the participant reads isolated words from lists of increasing difficulty.

Timed single word identification was measured using the Sight Word Efficiency subtest of the Test of Word Reading Efficiency, 2nd Edition (TOWRE-2). This test measures an individual's ability to pronounce printed words accurately and fluently. In this test, the individual is given a list of words and told to read as many as they can in 45 seconds.

Phonological decoding. Untimed phonological decoding was measured using the Word Attack subtest of the Woodcock Reading Mastery Test-III. In this subtest, the participant reads aloud from a list of increasingly complex nonsense words.

Timed phonological decoding was measured using the Phonemic Decoding Efficiency subtest of the Test of Word Reading Efficiency, 2nd Edition (TOWRE-2). This test measures an individual's ability to pronounce phonemically regular nonwords accurately and fluently. In this test, the individual is given a list of made-up words and told to read as many as they can in 45 seconds.

Reading comprehension. Reading comprehension was measured using the Passage Comprehension subtest of the Woodcock Reading Mastery Test-III. In this subtest, the participant reads a sentence with a word missing and is instructed to fill in the blanks according to the meaning of the surrounding sentences or phrases. Picture cues are included for the first third of the items.

Listening comprehension. Listening comprehension was measured using the Listening Comprehension subtest of the Woodcock Reading Mastery Test-III. In this subtest, the participant listens to passages either read by the examiner or played from an audio CD and verbally responds to questions about the content.

Language. Language was measured using the Clinical Evaluation of Language Fundamentals, Fifth Edition (CELF-5). This is a test of expressive and receptive language. The following subtests were administered: word classes, formulated sentences, recalling sentences and semantic relationships. These subtests combine to create a Core Language Score that includes both expressive and receptive language skills.

Nonverbal intelligence. Nonverbal intelligence was measured using the Test of Nonverbal Intelligence, 4^{th} Edition (TONI-4). This is a test of cognitive ability using nonverbal formats and pointing responses to measure general intelligence. In this test, the participant is instructed to point to the response item that goes best with the stimulus item.

Data Analysis

For purposes of data analysis, each participant was placed in a group based on the simple view of reading. Typical reading was classified as falling above the 25^{th} percentile on all reading measures. Dyslexia was classified as falling above the 25^{th} percentile on listening comprehension, but below the 25^{th} percentile on any word-level subtest. Specific comprehension deficit was classified as falling below the 25^{th} percentile on reading comprehension, but above the 25^{th} percentile on all word-level subtests. Finally, mixed reading disability was classified as falling below the 25th percentile on listening comprehension and below the 25th percentile on any word-level subtest. Listening comprehension was used to classify dyslexia and mixed reading disability due to the potential effects of decoding deficits on comprehension.

The study aimed to determine if students with reading impairment fail hearing screenings at higher rates than students without reading impairments and if the pattern of simple view classification differs across hearing screen result. Groups were compared across reading impairment status and hearing screen result as well as across simple view group and hearing screen result to test these questions. A chi square test was performed to examine the relation between each of these groups.

CHAPTER 3

RESULTS

The first purpose of this study was to determine if students with reading impairments fail hearing screenings at higher rates than students without reading impairments. Results of a chi square test comparing reading status and hearing screen status were not statistically significant, but indicated a trend approaching significance in the predicted direction $\mathbf{X}^2$ (2, N = 36), p = .074. 10 out of 19, or 52.6% of, impaired readers failed their hearing screening, while only 4 out of 17, or 23.5% of, normal readers did the same (see Figure 3.1).

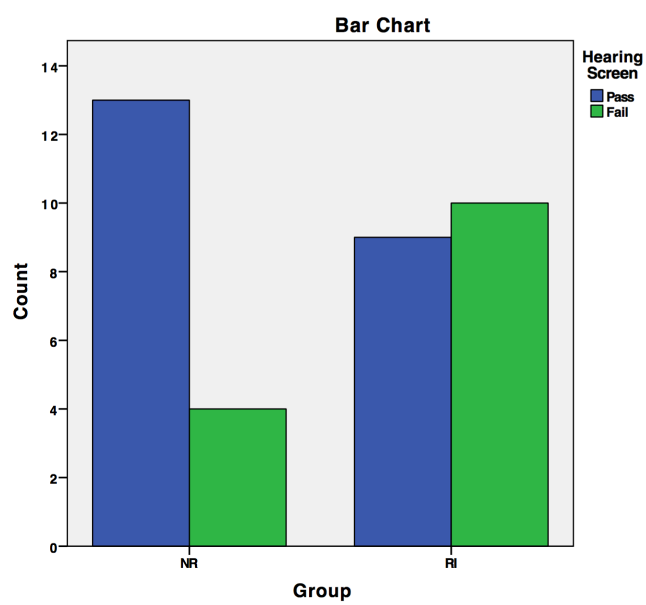

Figure 3.1

Hearing Screen Status Compared to Reading Impairment Status

The second purpose of this study was to determine if the pattern of simple view classification differs across hearing screen results. Results of a chi square test comparing simple view classification and hearing screen status indicated a significant relationship χ^2 (3, N = 36), p = .043. Results indicated that children who passed their hearing screening are significantly more likely to be good readers and that children who failed their hearing screening are significantly more likely to have a mixed reading disability (see Figure 3.2).

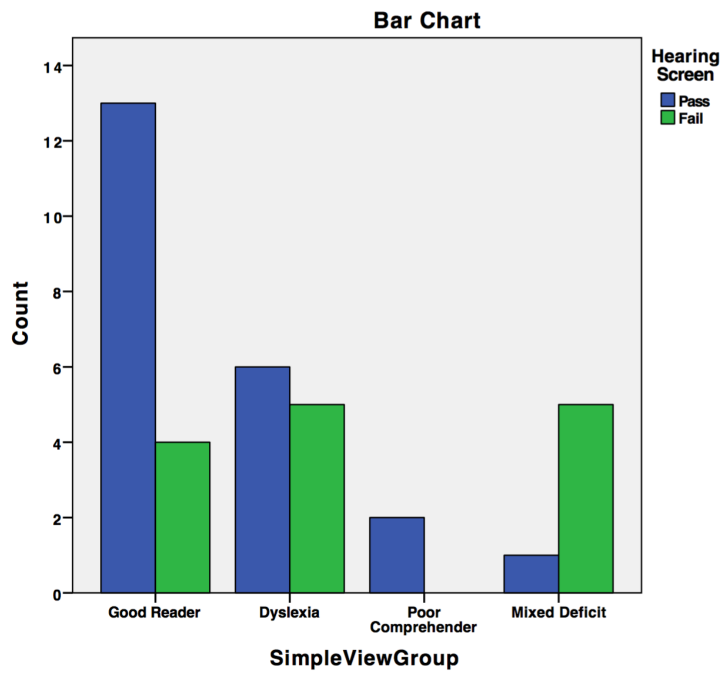

Figure 3.2

Hearing Screen Status Compared to Simple View Classification

Post-Hoc Analysis

Although not an initial research question, an additional trend was observed following exploratory data analysis. In the tested sample, more children with reading impairment failed hearing screenings in high frequencies in the right ear. Of those with reading impairment who failed their hearing screening, 70% failed at the high frequencies in the right ear, compared to 20%, 30%, and 40% failing at other right frequencies, other left frequencies, and high left frequencies, respectively (see Figure 3.3). This poses an interesting relationship between hearing status and language and literacy skills. While the sample size is not yet large enough to show significant results, this relationship is something to consider moving forward.

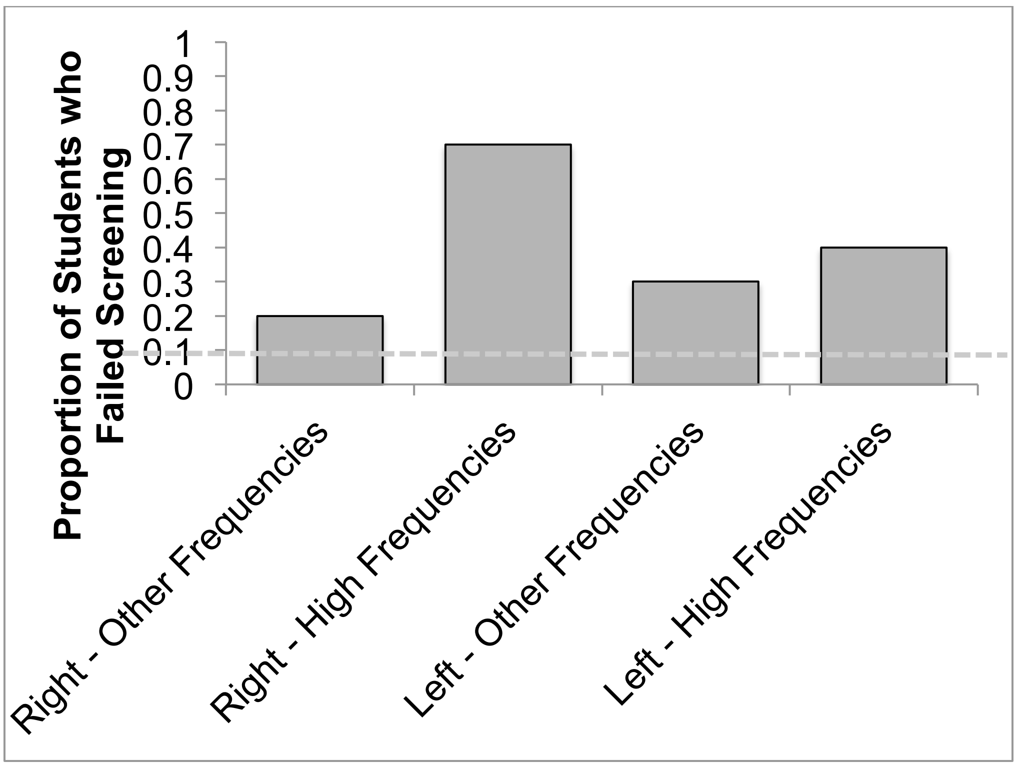

Figure 3.3

Hearing Screen Fails in Participants with Reading Impairment

CHAPTER 4

DISCUSSION

This study built upon research previously conducted in the University of South Carolina Written Language Lab to investigate the prevalence of minimal hearing loss in children with reading impairment and the relationship between hearing status and reading impairment category based on the simple view of reading. Because previous research conducted in the lab has indicated a higher prevalence of minimal hearing loss in children with reading impairment in middle school, we aimed to determine if this relationship was maintained when a wider population sample was used. Thus, the purpose of this study was to determine a) if students with reading impairment failed hearing screenings at a higher rate than students without reading impairment and b) if the pattern of simple view classification differed across hearing screen results.

Based on previous research regarding the psychoeducational characteristics of children with minimal hearing loss and the contributions of different language skills to reading, we hypothesized that students who failed their hearing screening would exhibit reading impairment at a higher rate than students who did not. Additionally, we hypothesized that students exhibiting minimal hearing loss would present in the dyslexia category under the simple view of reading. Our hypotheses were partially supported by the results of this study. In our sample, impaired readers failed their hearing screening at a higher rate than normal readers, although this relationship did not quite reach statistical significance. Additionally, hearing screen status had a significant relationship to simple view classification, although the pattern of relation was a different one than predicted.

When addressing our first research question, we found the overall rate of minimal hearing loss to be 39% in the tested sample. This rate is similar to overall rates of minimal hearing loss demonstrated in past studies. Of the students with reading impairment, 52.6% failed their hearing screening compared to 24% of those without reading impairment. Although this difference was not statistically significant ($p = .074$), the relationship poses clinical significance and warrants further research. As was the case in Bess et al. (1998), none of the children in our study had been previously identified as having hearing loss and no parents reported prior concerns regarding their child's hearing. Given the increasing body of evidence on the psychoeducational effects of minimal hearing loss and its proposed relationship to literacy, a hearing screen is of vital importance to consider when children have a reading impairment. Identifying the presence of minimal hearing loss in children with reading impairment could potentially explain why some students are nonresponders to evidence based reading intervention.

When addressing our second research question, we found a significant relationship ($p = .043$) between hearing status and simple view classification. Of those who failed their hearing screening, 26% were good readers, 29% fell in the dyslexia category, 0% were poor comprehenders, and 36% were mixed deficit poor readers. In comparison, of those who passed their hearing screening, 59% were good readers, 27% fell in the dyslexia category, 9% were poor comprehenders, and 5% were mixed deficit poor readers. While these results did not support our initial hypothesis that those who failed their hearing screening would more likely present in the dyslexia category, they did show that if you failed the hearing screening, it was very unlikely that you were a good reader. In our sample, those who failed the hearing screening were more likely to be mixed deficit poor readers, meaning they struggled with both decoding and comprehension. This relationship warrants further exploration to determine the reading profile of children presenting with minimal hearing loss.

Finally, while we did not go in to this study with any preconceived notions about how hearing screen results would present across ears and frequencies, post-hoc analysis demonstrated students with reading impairment failed hearing screens in the right high frequencies more than any other. This relationship is interesting, but not surprising, given what we know about how the brain processes auditory input. The left hemisphere of the brain contains the auditory processing center where speech is processed. Because input from the right ear is processed contralaterally in the left hemisphere, most individuals demonstrate right ear dominance. Simply put, when presented with simultaneous auditory input to each ear, most individuals will present with enhanced reporting of the stimulus presented in the right ear (Brancucci et al., 2004; Hugdal, 2003; Kimura, 1967; Nachshon, 1978; Shankweiler & Studdart-Kennedy, 1967). It is also significant to note that the children with reading impairment were more likely to fail in the higher frequencies. Standard hearing screenings do not test above 4000 Hz, so many of these children would be missed. This relationship warrants further research to determine how best to identify these children.

These results have clinical implications for both the way we intervene for children with reading impairment and the way we perform hearing screenings for school-age children. As previously mentioned, a valid and reliable hearing screening should be considered as a first step before beginning intervention for a student with reading impairment. Results from this study suggest students with reading impairment are more likely to exhibit minimal degrees of hearing loss than are students with typical reading skills. Testing the hearing of students diagnosed with reading impairment can help educators and interventionists make the most appropriate recommendations for ways to move forward. As recent research suggests, a significant number of students are not responding to intervention grounded in the most current evidence. We pose the idea that minimal hearing loss may be a factor influencing this rate of nonresponders. The majority of our participants who failed their hearing screening demonstrated deficits in phonological decoding (10 out of 14). This matches the recent evidence suggesting the majority of nonresponders to early literacy intervention present with deficits in phonological awareness. Addressing the hearing loss may be a necessary step in intervention for these children.

Additionally, our results indicating a significant effect of hearing screen status on simple view classification demonstrate a need to consider the way minimal hearing loss affects literacy skills. In our sample, it was found that individuals who failed their hearing screening were more likely to present with a mixed reading disability. This indicates we may need to rethink our hypothesis of minimal hearing loss affecting only phonological skills. While phonological skills were affected in 10 out of 14 of the individuals who failed their hearing screening, deficits were not restricted to phonological decoding, as we had initially thought they would be. Further consideration of this relationship is warranted to best understand the literacy profile of children presenting with minimal hearing loss.

These results also have clinical significance in the way we perform hearing screenings for school-age children. While routine hearing screenings occur at most schools, the way that they are performed is not always sufficient. In this study, we screened at 15 dB and found a relationship between failing the hearing screening and presence of reading impairment. This type of screening, however, is not what happens in practice. As previously discussed, the most common referral criterion for pure tone screening is 20 or 25 dB HL and these screenings do not occur in optimal listening environments. Given the results of this study, we argue that pure-tone hearing screenings for school-age children should be performed at 15 dB HL in a sound treated room. Because failing the hearing screening is associated with reading impairment, utilizing a lower referral threshold could potentially allow these students to be identified earlier, leading to better language and literacy outcomes.

As with any study, limitations should be considered when interpreting these findings. This study contained a small sample size of 36 participants. Additionally, the sample was not population-based. Our students were recruited from various schools throughout the community. While this was the best design as a first step in the scope of a thesis project, there are limitations to not having a population-based sample. Future research should evaluate if these results can be replicated with a larger, population-based sample. It should also be noted that language and literacy testing was not conducted in a sound treated room. Future testing in this area should implement use of an FM soundfield system in testing rooms to ensure optimal listening environments for all participants. To further validate the study's findings, future researchers should evaluate the reliability of air conduction testing and consider using OAEs as an objective measure to test for hearing status. Finally, future research should more deeply evaluate environmental factors associated with reading outcomes that may lead to minimal hearing loss. While we did not find significant differences in the proportion of minorities and history of ear infections between the normal and poor reading groups, these proportions would likely have been statistically significant with a larger sample size.

The results of this study provide preliminary evidence for a higher prevalence of minimal hearing loss in children with reading impairment and a relationship between hearing status and simple view classification. Future research should evaluate these results in a larger, population-based sample. Additionally, a phonological awareness measure should be added for future testing to determine a possible relationship between minimal hearing loss and PA skills. This may help to provide a clearer picture of the reading impairment category of children with minimal hearing loss.

Reading is a complex skill and there are many ways it can go wrong for school-aged children. We pose minimal hearing loss as one potential factor that may be influencing the high prevalence of reading impairment seen in today's students. As determined by this study, students who fail a hearing screening at 15 dB HL are not likely to be good readers and are significantly more likely to have a mixed reading disability than those who did not fail the screening. More information is needed to conclude if students with reading impairment are significantly more likely to fail a hearing screening than those without, as the current study found a relationship that was promising but not statistically significant.

REFERENCES

Aaron, P. G., Joshi, M., & Williams, K. A. (1999). Not all reading disabilities are alike. *Journal of Learning Disabilities, 32*(2), 120-137.

Adams, M. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Allen, R. L., Stuart, A., Everett, D., & Elangovan, S. (2004). Preschool hearing screening: Pass/refer rates for children enrolled in a Head Start program in eastern North Carolina. *American Journal of Audiology, 13*(1), 29-38.

Al Otaiba, S. (2001). Children who do not respond to early literacy instruction: A longitudinal study across kindergarten and first grade. *Reading Research Quarterly, 36*(4), 344-346.

Al Otaiba, S. & Fuchs, D. (2002). Characteristics of children who are unresponsive to early literacy intervention: A review of the literature. *Remedial and Special Education, 23*(5), 300-316.

American Academy of Audiology, Subcommittee on Childhood Hearing Screening. (2011). *American Academy of Audiology clinical practical guidelines: Childhood hearing screening.* Retrieved from https://audiology-web.s3.amazonaws.com/migrated/ChildhoodScreeningGuidelines.pdf_5399751c9ec216.42663963.pdf

American National Standards Institute/Acoustical Society of America. (2010). S12.60.2010/Part 1. *Acoustical performance criteria, design requirements, and guidelines for schools, Part 1: Permanent schools.* New York. NY.

American Speech-Language Hearing Association. (2016). *Childhood Hearing Screening.* Available from https://www.asha.org/Practice-Portal/Professional-Issues/Childhood-Hearing-Screening/.

Bamford, J., Fortnum, H., Bristow, K., Smith, J., Vamvakas, G., Davies, L., … Hind, S. (2007). Current practice, accuracy, effectiveness and cost-effectiveness of the school entry hearing screen. *Health Technology Assessment, 11*(32), 1-168.

Bess, F., Dodd-Murphy, J., & Parker, R. (1998). Children with minimal sensorineural hearing loss: Prevalence, educational performance, and functional status. *Ear and Hearing, 19,* 339-354.

Bess, F. & Gravel, J. (2006). *Foundations of pediatric audiology.* San Diego, CA: Plural.

Bess, F. H. & McConnell, F. E. (1981). *Audiology, Education and the Hearing Impaired Child.* St. Louis: The C.V. Mosby Company.

Blachman, B. A. (1994). What we have learned from longitudinal studies of phonological processing and reading, and some unanswered questions: A response to Torgesen, Wagner and Rashotte. *Journal of Learning Disabilities, 27,* 287-291.

Blachman, B. (1997). Early intervention and phonological awareness: A cautionary tale. In B. Blachman (Ed.), *Foundations of reading acquisition and dyslexia* (pp. 408-430). Mahwah, NJ: Erlbaum.

Blair, J. C., Peterson, M. E., & Viehweg, S. H. (1985). The effects of mild sensorineural hearing loss on academic performance of young school-age children. *The Volta Review, 87,* 87-93.

Bradley, L. & Bryant, (1985). *Rhyme and reason in reading and spelling.* Ann Arbor: University of Michigan Press.

Brancucci, A., Babiloni, C., Babiloni, F., Galderisi, S., Mucci, A., Tecchio, F., et al. (2004). Inhibition of auditory cortical responses to ipsilateral stimuli during dichotic listening: Evidence from magnetoencephalography. *European Journal of Neuroscience, 19*(8), 2329-2336.

Braze, D., Tabor, W., Shankweiler, D. P., & Mencl, W. E. (2007). Speaking up for vocabulary reading skill differences in young adults. *Journal of Learning Disabilities, 40,* 226-243.

Brown, I. S. & Felton, R. H. (1990). Effects of instruction on beginning reading skills in children at risk for reading disability. *Reading and Writing: An Interdisciplinary Journal, 2,* 223-241.

Brown, L., Sherbenou, R. J., & Johnsen, S. K. (2010). Test of Nonverbal Intelligence, Fourth Edition. Pearson Education.

Catts, H. W., Adlof, S. M., & Ellis Weismer, S. (2006). Language deficits of poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research, 49,* 278-293.

Catts, H. W., Fey, M. E., Tomblin, J. B., & Zhang, X. (2002). A longitudinal investigation of reading outcomes in children with language impairments. (2002). *Journal of Speech, Language, and Hearing Research, 45*(6), 1142-1157.

Catts, H. W., McIlraith, A., Bridges, M. S., Nielsen, D. C. (2017). Viewing a phonological deficit within a multifactorial model of dyslexia. *Reading and Writing, 30*(3), 613-629.

Catts, H. W., Petscher, Y., Schatschneider, C., Bridges, M. S., & Mendoza, K. (2009). Floor effects associated with universal screening and their impact on the early identification of reading disabilities. *Journal of Learning Disabilities, 42*(2), 163-176.

Clark, J. (1981). Uses and abuses of hearing loss classification. *ASHA, 23,* 493-500.

Cortiella, C., & Horowitz, S. H. (2014). *The State of Learning Disabilities: Facts, Trends and Emerging Issues.* New York: National Center for Learning Disabilities, 2014.

Crandell, C. (1993). Speech recognition in noise by children with minimal degrees of sensorineural hearing loss. *Ear and Hearing, 14*(3), 210-216.

Cutting, L. & Scarborough, H. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific Studies of Reading, 10,* 277-299.

Davis, J. M. (Editor) (1990). *Our Forgotten Children: Hard of Hearing Pupils in the Schools* (pp. 1-2). Washington, DC: U.S. Department of Education.

Davis, J. M., Elfenbein, J., Schum, D., & Bentler, R. A. (1986). Effects of mild and moderate hearing impairment on language, educational, and psychosocial behavior of children. *Journal of Speech and Hearing Disorders, 51,* 53-62.

Davis, J. M., Shepherd, N. T., Stelmachowicz, P. G., & Gorga, M. D. (1981). Characteristics of hearing-impaired children in the public schools: Part II-Psychoeducational data. *Journal of Speech and Hearing Disorders, 46,* 130-137.

De Villiers, P. A. (1992). Educational implications of deafness: Language and literacy. In R. D. Eavey & J. O. Klein (Eds.), *Hearing Loss in Childhood: A Primer* (pp. 127-135). Report of the 102nd Ross Conference on Pediatric Research, Columbus, OH: Ross Laboratories.

Dodd-Murphy, J., Murphy, W., & Bess, F. H. (2014). Accuracy of school screenings in the identification of minimal sensorineural hearing loss. *American Journal of Audiology, 23,* 365-373.

Dreyer, L. G. & Katz, L. (1992). An examination of the 'Simple View of Reading'. *Yearbook of the National Reading Conference, 41,* 169-176.

Firth, I. C. (1972). *Components of Reading Disability.* Doctoral dissertation, University of New South Wales, Sydney NSW.

Fuchs, D., Fuchs, L. S., Thompson, A., Al Otaiba, S., Yen, L., Yang, N. J., et al. (2002). Exploring the importance of reading programs for kindergartners with disabilities in mainstream classrooms. *Exceptional Children, 68,* 295-311.

Gough, P. B. & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*(1), 6-10.

Hatcher, J., Snowling, M., & Griffiths, Y. M. (2002). Cognitive assessment of dyslexic students in higher education. *British Journal of Educational Psychology, 72,* 119-133.

Healy. J. M. (1982). The enigma of hyperlexia. *Reading Research Quarterly, 17*(3), 319-338.

Holstrum, J. & Gaffney, M. (2005, July). *Are early hearing detection and intervention systems missing children with minimal hearing loss?* Paper presented at the

National Workshop on Mild and Unilateral Hearing Loss, Breckenridge, CO.

Holt, J. A. (1993). Stanford Achievement Test-8th Edition [Reading Comprehension Subgroup Results]. *American Annals of the Deaf, 128,* 172-175.

Hugdahl, K. (2003). Dichotic listening in the study of auditory laterality. In K. Hugdahl & R. J. Davidson (Eds.), *The asymmetrical brain* (pp. 441-475). Cambridge, MA: MIT Press.

Johnson, J., White, K., Widen, J., Gravel, J., Vohr, B., James, M., … Meyer, S. (2005). A multisite study to examine the efficacy of the otoacoustic emission/automated auditory brainstem response newborn hearing screening protocol: Introduction and overview of the study. *American Journal of Audiology, 14,* S178-S185.

Joint Committee on Infant Hearing. (2007). Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. *Pediatrics, 120*(4), 898-921.

Juel, C. (1994). At-risk university students tutoring at-risk elementary school children: What factors make it effective? In E. H. Hiebert & B. M. Taylor (Eds.), *Getting reading right from the start: Effect early interventions* (pp. 39-62). Boston: Allyn & Bacon.

Karchmer, M. A. (1991). *Stanford Achievement Test Norms for Hearing Impaired Students.* Washington, DC: Gallaudet University, Office of Demographic Studies.

Kena, G., Musu-Gillette, L., Robinson, J., Wang, X., Rathbun, A., Zhang, J., Wilkinson-Flicker, S., Barmer, A., & Dunlop Velez, E. (2015) *The Condition of Education 2015* (NCES 2015-144). U.S. Department of Education, National Center for Education Statistics. Washington, DC.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. *Cortex, 3,* 163-178.

Kutner, M., Greenberg, E., Jin, Y., Boyle, B., Hsu, Y., & Dunleavy, E. (2007). *Literacy in Everyday Life: Results from the 2003 National Assessment of Adult Literacy (*NCES 2007-480). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Mann, V. A. (1984). Longitudinal prediction and revention of early reading difficulty. *Annals of Dyslexia, 34,* 117-136.

Mann, V. A. & Liberman, I. Y. (1984). Phonological awareness and verbal short-term memory. *Journal of Learning Disabilities, 17*(10), 592-599.

Mathes, P. G., Howard, J. K., Allen, S. H., & Fuchs, D. (1998). Peer-assisted learning strategies for first grade readers: Responding to the needs of diverse learners. *Reading Research Quarterly, 33,* 62-94.

Mattingly, I. (1972). Reading, the linguistic process, and linguistic awareness. In J. Kavanagh & I. Mattingly (Eds.) *Language by ear and by eye: The relationships between speech and reading* (pp. 133-147). Cambridge, MA: MIT Press.

Meinke, D. K. & Dice, N. (2007). Comparison of audiometric screening criteria for the identification of noise-induced hearing loss in adolescents. *American Journal of Audiology, 16*(2), S190-S202.

Nachshon, I. (1978). Handedness and dichotic listening to nonverbal features of speech. *Perceptual and Motor Skills, 47*(3 Pt 2), 1111.

Niskar, A., Kieszak, S., Holmes, A., Esteban, E., Rubin, C., & Brody, D. (1998). Prevalence of hearing loss among children 6 to 19 years of age: The third national health and nutrition examination survey. *JAMA, 279,* 1071-1075.

O'Connor, R. E. (2000). Increasing the intensity of intervention in kindergarten and first grade. *Learning Disabilities Research & Practice, 15*(1), 43-54.

Quigley, S. P. & Thomure, F. E. (1968). *Some Effects of Hearing Impairment upon School Performance.* Springfield, IL: Illinois Office of Education.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonwords reading deficit in developmental dyslexia: A review. *Reading Research Quarterly, 27*(1), 28-53.

Senechal, M., Ouelette, G., & Rodney, D. (2006). The misunderstood giant: On the predictive role of early vocabulary to future reading. In D. Dickinson & S. Neuman (Eds.), *Handbook of Early Literacy Research.* New York, NY: Guilford Press.

Shankweiler, D., Lundquist, E., Katz, L., Stuebing, K. K., Fletcher, J. M., Brady, S., Fowler, A., Dreyer, L. G., Marchione, K. E., Shaywitz, S. E., & Shaywitz, B. A. (1999). Comprehension and decoding: Patterns of association in children with reading difficulties. *Scientific Studies of Reading, 3*(1), 69-94.

Shankweiler, D., & Studdert-Kennery, M. (1967). Identification of consonants and vowels presented to left and right ears. *Quarterly Journal of Experimental Psychology, 19*(1), 59-63.

Snowling, M. (1998). Dyslexia as a phonological deficit: Evidence and implications. *Child Psychology and Psychiatry Review, 3*(1), 4-11.

Stahl, S. A. & Murray, B. A. (1994). Defining phonological awareness and its relationship to early reading. *Journal of Educational Psychology, 86*(2), 221-234.

Straley, S. & Werfel, K. L. (2017, June). Minimal hearing loss in middle school:

Prevalence and relationship to reading impairment. Annual Symposium on Research in Child Language Disorders, Madison, WI.

Torgesen, J. (2000). Individual differences in response to early interventions in reading: The lingering problem of treatment resisters. *Learning Disabilities Research & Practice, 15*(1), 55-64

Torgesen, J. K., Morgan, S., & Davis, C. (1992). The effects of two types of phonological awareness training on word learning in kindergarten children. *Journal of Educational Psychology, 84,* 364-37

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (1994). Longitudinal studies of phonological processing and reading. *Journal of Learning Disabilities, 27,* 276-286.

Torgesen, J. K., Wagner, R. K., Rashotte, C. A., Burgess, S., & Hecht, S. (1997). Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second-to fifth grade-children. *Scientific Studies of Reading, 1*(2), 161-185.

Vellutino, F. R. (1979). The validity of perceptual deficit explanations of reading disability: A reply to Fletcher and Satz. *Journal of Learning Disabilities, 12*(3), 160-167.

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45*(1), 2-40.

Wagner, R. K. & Torgesen, J. K., (1987). The nature of phonological processing and its ` causal role in the acquisition of reading skills. *Psychological Bulletin, 101*(2), 192-212.

Wagner, R. K., Torgesen, J. K., Laughon, P., Simmons, K., & Rashotte, C. A. (1993). Development of Young Readers' Phonological Processing Abilities. *Journal of Educational Psychology, 85*(1), 83-103.

Woodcock, R. (2011). Woodcock Reading Mastery Test, Third Edition. Pearson Education.