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Exploration of Early Spelling in Children with Hearing Loss

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EXPLORATION OF EARLY SPELLING IN CHILDREN WITH HEARING LOSS

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ABSTRACT

Purpose: The purpose of this study was to determine differences in spelling errors between children with normal hearing and children with hearing loss in kindergarten.

Method: Participants included 21 children with normal hearing and 23 children with hearing loss. All children used spoken English as their primary language. The children with hearing loss all utilized a hearing amplification device. Participants completed three single-word spelling assessments, a language assessment, and an oral reading assessment. An independent samples t-test was used to determine if the groups had differences in the number of spelling errors and whether a difference was observed within the Spelling Sensitivity Score (Masterson & Apel, 2010). Additionally, proportions of unanalyzable spellings and no spelling attempts made between the groups were compared. A mixed-effects model comparison was used to examine the specific language skills that predicted spelling for each group, and a Mann-Whitney U was used to examine the differences in proportions of errors between the two groups within the Multilinguistic Coding System.

Results: Children with normal hearing produced more errors of mental graphemic representation compared to children with hearing loss ($p = 0.041$). Children with normal hearing did not significantly differ from children with hearing

loss in the number of errors, unanalyzable spellings and no spelling attempts made, or the Spelling Sensitivity Score.

Discussion: The current study provides evidence that children with hearing loss in kindergarten do not significantly differ in their spelling errors compared to children with normal hearing, aside from a fewer proportion of mental graphemic representation errors. With these data, in combination with previous research conducted, speech-language pathologists can further individualize treatment to focus on these specific error patterns. Additionally, this focus of treatment can help better prepare children with hearing loss for spelling and writing tasks in later grades. Future research should be conducted to determine when in elementary school the differences in spelling errors are initially seen.

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LIST OF ABBREVIATIONS

AIC ..... Akaike Information Criterion

C-SSS ..... Computerized Spelling Sensitivity Score

CHL ..... Children with Hearing Loss

CNH ..... Children with Normal Hearing

M ..... Mean

MGR ..... Mental Graphemic Representation

MK ..... Morphological Knowledge

MLC ..... Multilinguistic Coding

OPK ..... Orthographic Pattern Knowledge

PA ..... Phonological Awareness

PALS-K ..... Phonological Assessment Literacy Screening – Kindergarten

SD ..... Standard Deviation

SK ..... Semantic Knowledge

SSS ..... Spelling Sensitivity Score

SSS-E ..... Spelling Sensitivity Score Overall Element Score

SSS-Spelling List ..... Spelling Sensitivity Score – Spelling List

SSS-W ..... Spelling Sensitivity Score Overall Word Score

TWS-5 ..... Test of Written Spelling – 5th Edition

CHAPTER 1

INTRODUCTION

Spelling is a skill that we are taught in early elementary school and an important skill that a person carries with them throughout his/her life. Spelling in the English language is often difficult due to the sheer fact that there is often not a direct, one-to-one correspondence between phonemes and graphemes with English using over 170 graphemes/grapheme sets (i.e., -tch, -igh, etc.) to represent 44 phonemes (Moats, 1995). Additionally, spelling rules such as the "silent -e" and "change the -y to -i" can make spelling more difficult for individuals who have not mastered those rules (Moats, 1995). However, once the rules of English spelling are learned, the majority of English words are in fact predictable in spelling (Moats, 1995). Additionally, the linguistic skills necessary for spelling are the same linguistic skills that are necessary for reading (Ehri, 2000). This paper reviews two opposing theories behind spelling acquisition, typical spelling errors in children, spelling errors in children with hearing loss, and explores two types of analysis methods for spelling. The research questions explored within this paper are:

1. Do kindergarten children with hearing loss exhibit more spelling errors than children with normal hearing?

2. Do children with hearing loss produce more unanalyzable spelling attempts or no spelling attempts compared to children with normal hearing?
3. Do kindergarten children with hearing loss differ on the Spelling Sensitivity Score compared to children with normal hearing?
4. Do kindergarten children with hearing loss exhibit different proportion of error types using the Multilinguistic Coding System than children with normal hearing?

1.1 Theories of Spelling Acquisition

Children begin to learn to spell words when starting elementary school (i.e., kindergarten). How children acquire the skills to learn how to correctly spell has been heavily researched (Apel & Masterson, 2001; Gentry, 2004, Henderson & Templeton, 1986; Masterson & Apel, 2010; Treiman & Bourassa, 2000; Wolter, 2017; Wolter, Wood, & D'Zatko, 2009). Two prominent and opposing theories on the acquisition of spelling skills for children have been widely studied are the stage theory and the repertoire theory.

1.1A Stage Theory. According to stage theory, spelling is acquired through the mastery of discrete stages, starting from preschool and continuing into middle school and beyond (Genrty, 2004; Henderson & Templeton, 1986; Moats, 1995). These stages give insight to the characteristics of children's strategies as they gain mastery and progress in spelling (Henderson & Templeton, 1986). The names of the stages vary between researchers; however, the main concept of each stage is similar. Gentry (2004) breaks the stages into two phases, the learning to spell phase with five levels, starting from pre-kindergarten to the middle/end of first

grade, and the correct and automatic spelling phase, starting from the end of second grade to the end of eight grade. According to Henderson & Templeton (1986), the stage a child is in can predict the type of errors the child will make and to determine the particular word feature a child must focus on more in order to jump to the next stage.

The stages within the stage theory rely on three principles of the English spelling system; alphabetic, within-word pattern, and meaning (Henderson & Templeton, 1986). The English spelling system is alphabetic in that the English letters (graphemes) match up to sounds (phonemes), and English graphemes appear in a left-to-right, sequential manner (Henderson & Templeton, 1986). The within-word pattern principle explains that the sound that a letter(s) represent depends on the position of the letter(s) in a syllable and the surrounding letters (Henderson & Templeton, 1986). In the English spelling system, the principle of meaning refers to the fact that words or parts of words can have the same or similar meaning being spelled in the same fashion but is dependent on the context (Henderson & Templeton, 1986). For example, “bear” and “bare” are homophones but are spelled differently; “bear” refers to the animal such as a black bear, brown bear, etc., while “bare” always refers to being uncovered such as a bare table or a bare arm. “Bear” will always be spelled B-E-A-R in the context of an animal and “bare” will always be spelled B-A-R-E in the context of an object being uncovered.

Gentry’s (2004) first phase is broken into five stages based on development. This phase is where the child learns the alphabetic principle (Gentry, 2004). Stage

0 is the stage in which a child has no ability to use letters for conventional spelling (Gentry, 2005). The first stage where we see some sort of spelling occur is in the pre-communicative/pre-literate stage where a child begins to write strings of letters on paper though there is no phoneme to grapheme correspondence (Gentry, 2004; Henderson & Templeton, 1986; Moats, 1995). Children in this stage have learned when a story is being read, what writing is, and know how to write letters and the names of the letters (Henderson & Templeton, 1986; Moats, 1995). Additionally, this stage reflects a child's concept of form and the function of print (Henderson & Templeton, 1986). The second stage, the semiphonetic or letter-name-sound correspondence stage, is when children begin to spell words alphabetically through a one-to-one phoneme to grapheme correspondence showing partial phonemic awareness (Gentry, 2004; Henderson & Templeton, 1986; Moats, 1995). Children typically spell using selective consonants, specifically consonants in their name or the same consonant, to represent words or syllables in an abbreviated version of the word (Moats, 1995). Children in this stage are also in the beginning stages of formal reading instruction where their knowledge of sight words grow (Henderson & Templeton, 1986). Sight words then become the stepping stone from stage one to stage two and allows children to become ready for formal spelling instruction (Henderson & Templeton, 1986).

When children demonstrate full phonetic awareness by choosing one letter for each sound in the word, children are in the third stage, or the phonetic stage, of spelling (Gentry, 2004; Moats, 1995). Children in this stage have not yet differentiated between long versus tense vowels and will represent the vowel with

the one letter for one sound (Moats, 1995). The fourth stage, the transitional stage, is where children spell, write, and decode syllables or words through the use of phonetic patterns, though these spellings are not correct as children use the wrong patterns for spelling, writing, and decoding (Gentry, 2004; Moats, 1995). Henderson and Templeton (1986) split this stage into two smaller stages. In the first portion of the stage, children begin to move beyond phoneme to grapheme correspondence to form the within-word principle and begin to learn about the meaning of words through spelling (Henderson & Templeton, 1986). In this stage, children begin to learn the rules of spelling by seeing the spelling in their readings (Henderson & Templeton, 1986). Mastery of within-word patterns of monosyllabic words is necessary for the child to move to the next stage (Henderson & Templeton, 1986). In the last portion of this stage children begin to learn the spelling of polysyllabic words (Henderson & Templeton, 1986).

The second phase, which spans from second to eighth grade, is divided based on instructional level for learning correct spelling of high-frequency words that are specific to that grade level (Gentry, 2004). This phase overlaps with Henderson & Templeton's (1986) stage 5. In this stage, the idea of meaning with similar spellings develops, such as homophones in spoken English, extensively with base, or root, words and the affixes that attach, such as the change from "jump" to "jumped" (Henderson & Templeton, 1986). Moats (1995) describes this stage as the morphophonetic spelling stage in which a child transitions from the phonetic spelling of morphemes, inflections, homophones, compounds, and basic prefixes and suffixes, to the correct spelling.

1.1B Repertoire Theory. Repertoire theory states spelling development consists of the predominant use of a particular process at different points in time and these processes are not done at the complete exclusion of others, unlike the stage theory (Treiman & Bourassa, 2000; Wolter, 2017). For the repertoire theory, when children spell words, they rely on one or possible more sources of linguistic knowledge on how to properly spell words (Masterson & Apel, 2010; Wolter, Wood, & D'Zatko, 2009). Additionally, the degree to which a child uses the different sources of linguistic knowledge changes over time (Wolter, 2017; Wolter, Wood, & D'Zatko, 2009).

The sources of linguistic knowledge that a child has in their repertoire to utilize during spelling include phonological awareness, orthographic pattern knowledge, morphological knowledge, and the development of mental graphemic representation (Apel & Masterson, 2001; Wolter, 2017). Phonological awareness, or more specifically phonemic awareness for spelling skills, refers to the understanding that words are composed of phonemes that are both separable and manipulable (Wolter, 2017). Orthographic pattern knowledge refers to the ability to translate phonemes to graphemes which requires the understanding of the general spelling rules and patterns (Apel & Masterson, 2001; Wolter, 2017). Orthotactic principles, or the positional constraints of phonemes to graphemes, are also a part of orthographic pattern knowledge (Apel & Masterson, 2001). Morphological awareness refers to the knowledge that words are comprised of smaller, meaningful word parts, or morphemes, and includes the reflection on and manipulation of those morphemes (Wolter, 2017). Additionally, the knowledge of

the use of inflectional and derivational morphemes added to base words and how those words are formed involves the use of morphological awareness (Apel & Masterson, 2001; Wolter, 2017). Mental graphemic representations are words that a specific child has been repeatedly exposed to and has been stored in the child's long-term memory (Wolter, 2017). For correct spelling of an MGR, the word must be clear and complete in the child's memory (Wolter, 2017).

Additionally, there are four phases of spelling that children go through; however, children utilize all of the different sources of linguistic knowledge within each of the phases (Wolter, 2017). The four phases include the pre-spelling phase, the early spelling phase, the intermediate spelling phase, and the advanced spelling phase (Wolter, 2017). Children and adults can fluidly go through each phase when learning how to spell new words. In the pre-spelling phase, children show knowledge of mental graphemic representations (MGRs) or the overall picture of a word that they commonly use though they may not be able to align phonemes with letters, use spelling rules, or utilize word affixes (Wolter, 2017). The early spelling phase is when children begin to use phonological awareness and orthographic pattern knowledge with some morphological knowledge skills, such as knowing that plural nouns end with –s (Wolter, 2017). The child's storage of MGRs begins to increase in the phase as well (Wolter, 2017). This phase is typically seen from preschool to first grade. Children in both the intermediate phase, typically for second and third grade students, and the advanced phase, typically from third and fourth grade on, who are considered to be "good" spellers utilize MGRs to spell known words and rely on their orthographic pattern

knowledge, morphological awareness, and phonological awareness, when appropriate, to spell unknown words (Wolter, 2017). The phases are fluid in that a child may spell some words correctly, both simple and complex words that are commonly used, but utilize phonological, semantic, morphological, and/or orthographic pattern knowledge to attempt the spelling of less familiar words (Wolter, 2017). This concept differs from the stage theory in that a child does not have to master a phase to move to the next phase but moves between phases and strengthens the linguistic sources within the phase.

1.2 Typical Spelling Errors

When children first begin spelling words prior to acquiring knowledge of the alphabetic principle, they believe that bigger objects should be a longer word (Bourassa & Treiman, 2001; Treiman & Bourassa, 2000). After children begin to learn the alphabetic principle, they abandon this belief (Bourassa & Treiman, 2001; Treiman & Bourassa, 2000). Additionally, a common error is the deletion of sonorant consonants in a consonant cluster, i.e. spelling “had” as “hand” or “so” for “snow”, relating to phonological awareness deficits (Bourassa & Treiman, 2001). Children in kindergarten begin to apply their phonological knowledge with pronunciation in combination with emerging orthographic pattern awareness knowledge to begin to spell (Bahr, Siliman, Berninger, & Dow, 2012).

A study by Bahr and colleagues (2012) was completed to analyze the types of spelling errors, specifically looking at phonological, orthographic, and morphological errors, seen starting from grade 1 to grade 9 of typical writers. The

total number of incorrect words spelled decreased with each grade, with the highest decline in grades 4 and 5. All of the error types were seen in all of the grades with orthographic pattern awareness errors being the most frequently occurring error throughout all of the grades, accounting for 70% of errors across the grades. Errors of both orthographic pattern awareness and phonological awareness decrease from grade 1 to 9 with orthographic pattern awareness errors decreasing the most in grade 5 and phonological awareness errors decreasing after grade 1. Between grades 4 and 5, errors of morphological knowledge surpassed the amount of errors of phonological awareness. The increase in morphological awareness errors includes the use of inflectional and derivational morphemes; specifically, students in grades 1-4 had issues with inflectional morphemes and errors with the misapplication of the appropriate suffix with the base word in grades 5-9.

1.3 Spelling in Children with Hearing Loss

Typical spelling acquisition and spelling errors made by children with hearing loss have not been as extensively researched compared to children with normal hearing or children with typical development. The little research that has been conducted leaves room for growth to answer lingering questions about the development of spelling skills for children with hearing loss and how to provide appropriate intervention for these children. Additionally, the research that has been conducted includes primarily older children with hearing loss with little research completed on younger children's spelling acquisition and abilities.

In 2016, Werfel completed a study to compare the spelling errors made by children with hearing loss to their hearing counterparts. Children with mild to moderate hearing loss between the grades 3-6 do begin to demonstrate proportionally more errors in phonological awareness and mental graphemic representation compared to children with normal hearing (Werfel, 2016). Additionally, children with cochlear implants in grades 3-6 exhibit greater proportions of errors of phonological awareness and orthographic pattern knowledge compared to children with normal hearing (Werfel, 2016).

In 2015, Apel and Masterson conducted a study to compare children with hearing loss to their peers with normal hearing spelling skills using the Spelling Sensitivity Score (SSS) to determine how their spelling abilities and their linguistic knowledge skills, specifically phonemic awareness, differed. The SSS is an objective system that was created to analyze the different types of linguistic knowledge skills a child utilizes while spelling (Masterson & Apel, 2010; Apel & Masterson, 2015). The SSS revealed that children with hearing loss made more errors related to phonemic awareness limitations and utilized appropriate orthographic pattern knowledge and mental graphic representation less often compared to their peers with normal hearing.

Bowers, McMarthy, Schwarz, Dostal, & Wolbers (2014) conducted a study to gain deeper insight into the linguistic skills that middle school aged children with hearing loss utilize during a spelling task to help determine appropriate intervention targets for children with hearing loss. The study found that children with hearing loss made more phonological errors rather than orthographic errors. Also, the

results indicated that children with hearing loss were more likely to make semantic errors compared to morphological, orthographic, or mental graphemic representation errors in single word spelling.

Bowers, Dostal, McCarthy, Schwarz, & Wolbers (2016) conducted a study to examine the errors that occur within writing samples of middle school aged children with hearing loss over the course of one academic year. In addition to coding for phonological, orthographic, mental graphemic representation, and semantic errors, visual imagery was coded as an error if the child incorrectly wrote a visually similar letter, used a word that was visually similar in American Sign Language (ASL), or drew an incorrect picture instead of writing the word. The results concluded that the children made the most errors in phonological, orthographic, and visual imagery skills, with phonological errors being the main error, relatively consistent over the course of an academic year.

Previous studies have mainly focused on the spelling skills of older children with hearing loss. There has not been research to date that explores the spelling skills of younger children with hearing loss. Due to the lack of research completed for children with hearing loss, we are unsure if children with hearing loss have those significant difference (i.e., phonological awareness, orthographic pattern knowledge, mental graphemic representation, and semantic knowledge [Apel & Masterson, 2015; Bowers et al., 2014; Werfel, 2016]). This study aims to determine if those significant differences occur throughout the child's spelling acquisition and/or what those differences are.

1.4 Methods to Measure Spelling

Traditionally, spelling was measured as either correct or incorrect, creating a score that reflects percentage of accuracy. This way of measuring a child's ability to spell is black and white; they either spell the word correctly or spell it incorrectly. The percentage of accuracy does not evaluate how the word was spelled incorrectly or if there is a pattern of spelling errors and the different linguistic knowledge sources that a child may call upon during spelling attempts (Masterson & Apel, 2010). For example, one child might spell the word "whales" as "wales" and a second child might spell the word "wail." Both children have spelled the word incorrectly but have pulled from different linguistic sources for their spelling that would need to be further addressed with explicit instruction. The first child showed a deficiency in mental graphemic representation with the omission of the "h," while the second child showed a semantic knowledge error with spelling a correct English word along with a morphological knowledge error with the omission of the plural -"s".

Different protocols to analyze the spelling abilities of children have been created and studied; however, the protocols that were created have typically only looked into the phonological awareness piece with respect to children with hearing loss, thus limiting the amount of information researchers can gain when looking for how the multiple linguistic knowledge sources interact together to support a child's spelling (Masterson & Apel, 2010). Two of the protocols that have been created to dive deeper into the different ways in which children use their linguistic knowledge to spell and provide more evidence into what specific types of errors

children are making include the Spelling Sensitivity Score and the Multilinguistic Coding system.

1.4A Spelling Sensitivity Score. The Spelling Sensitivity Score was created to be more sensitive to the increases and uses of the different types of linguistic knowledge a child utilizes while spelling across time (Masterson & Apel, 2010; Apel & Masterson, 2015). These types of linguistic knowledge are phonemic awareness, orthographic awareness, morphological awareness, and mental graphemic representation abilities. The SSS divides target words into individual elements; phoneme, juncture changes, and affixes (Masterson & Apel, 2010). For example, the word “butter” would be divided as B-U-TT-ER, consistent with the number of phonemes present in the word “butter” (Masterson & Apel, 2010). Multimorphemic words are divided into their phonemic elements as shown above; however, the affix and any type of modifications to the juncture are viewed as separate single elements (Masterson & Apel, 2010). For example, the word “hopping” would be divided as H-O-P-P-ING to account for the phonemes /h/, /ɑ/, and /p/ in the root word, the additional “p” that is added when changing the verb “hop” to the adjective “hopping,” and the morpheme -ing (Masterson & Apel, 2010).

The SSS utilizes a scaled scoring system from 0 to 3 for determining the accuracy of the elements spelled (Masterson & Apel, 2010). A score of 3 indicates correct spelling of the element, a score of 2 indicates the spelling is incorrect, though a plausible or legal spelling, a score of 1 indicates the incorrect spelling of the element with no plausible or legal spelling, and a score of 0 indicates the

omission of the element (Masterson & Apel, 2010). The SSS utilizes the same scaled scoring system for determining the accuracy of words spelling (Masterson & Apel, 2010. A score of 3 indicates the correct spelling of a word, a score of 2 indicates adequate orthographic skills with legal but incorrect spelling of a word, a score of 1 indicates illegal spellings of a word that are usually phonologically accurate, and a score of 0 indicates omissions of phonemes (Masterson & Apel, 2010).

Two scores are obtained after analysis of all of the elements from the spelling sample, the SSS-Element (SSS-E) and SSS-Words (SSS-W) (Masterson & Apel, 2010). The SSS-E is calculated by dividing the number of element scores awarded by the total number of elements possible, while the SSS-W is calculated by dividing the number of word points awards by the total number of words in the spelling sample (Masterson & Apel, 2010). The SSS-E and SSS-W scores illustrate the amount of linguistic knowledge underlying sources in which the child is applying in their spelling (Masterson & Apel, 2010). Along with these metric scores, the SSS has the option to chart the development of spelling into the four different categories of omission of an element, illegal spelling, legal spelling, and correct spelling (Apel & Masterson, 2015).

Masterson and Apel (2010) conducted a study to determine the usefulness of the SSS and if the SSS is sensitive enough to capture the child's underlying linguistic knowledge sources used and the development across time/grade levels. In 2010, Masterson and Apel studied the development of children's spelling from kindergarten to first grade in one study and from third to fourth to fifth grade in a

different study. The findings suggested that the SSS was more advantageous in detecting broad changes in the spelling abilities of kindergarten children with a dictated spelling list (Masterson & Apel, 2010). The general changes across time for third, fourth, and fifth graders were found to be similar regardless of grading procedure (SSS versus percent correct/incorrect); however, the SSS provided specific information about the changes in the underlying linguistic knowledge sources employed by children in each grade assessed, including the kindergarten and first grade children (Masterson & Apel, 2010).

1.4B Multilinguistic Coding. The Multilinguistic Coding (MLC) system was created to provide a more detailed analysis of spelling errors, as the SSS (Bowers et al., 2014). Unlike the SSS, the MLC system does not provide scores to interpret the results; the MLC system provides a detailed account of different linguistic errors (Bowers et al., 2014). The MLC system analyzes the child's phonological, orthographic, mental graphemic representation, morphological, and semantic knowledge, as well as provide the errors in those linguistic domains (Bowers et al., 2014).

To code within the MLC system, the spelling of all attempted words is placed in an Excel spreadsheet and coded for the specific type of spelling error (Bowers et al., 2014). The words are first examined to conclude if all of the phoneme sounds for the word are represented; if a sound was missing or two letters are reversed, a phonological awareness error is coded. The next examination is through the representation of regular spelling patterns, or orthographic errors (Bowers et al., 2014). This is examined through two error

codes; if there is an incorrect representation of a regular spelling pattern, an orthographic pattern awareness error is coded, and if there is an incorrect representation of an irregular pattern of English spelling rules, a mental graphemic representation error is coded (Bowers et al., 2014). Modification errors of the root word is coded as a morphological awareness error (Bowers et al., 2014). Words that are spelled incorrectly due to meaning were coded as a semantic awareness error (Bowers et al., 2014).

In 2014, Bowers and colleagues conducted a study to examine which coding method, the SSS or the MLC system, provided the information that educators need to develop better spelling interventions based on the types of linguistic errors children with hearing loss make. The results concluded that the MLC provided a more complex and in-depth analysis of a child's spelling abilities that the SSS did not provide, thus giving more information about the spelling patterns of children with hearing loss (Bowers et al., 2014).

1.5 Purpose of the Current Study

Spelling requires different types of linguistic knowledge sources interacting with each other to correct spell the word (Masterson & Apel, 2010; Apel & Masterson, 2015). Those specific sources used in children with hearing loss have not been widely research, specifically with younger children. In this paper, the researcher set out to explore the different types of spelling errors children with hearing loss exhibit during kindergarten compared to their peers with normal hearing on a single-word spelling assessment and to what proportion

those errors are seen through percent correct, the SSS, and the MLC system. Again, the research questions addressed were:

1. Do kindergarten children with hearing loss exhibit more spelling errors than children with normal hearing?
2. Do children with hearing loss produce more unanalyzable spelling attempts or no spelling attempts compared to children with normal hearing?
3. Do kindergarten children with hearing loss differ on the Spelling Sensitivity Score compared to children with normal hearing?
4. Do kindergarten children with hearing loss exhibit different proportion of error types using the Multilinguistic Coding System than children with normal hearing?

CHAPTER 2

METHOD

This study was approved by the University of South Carolina Institutional Review Board as part of a larger longitudinal study, the Early Language and Literacy Acquisition (ELLA) study.

2.1 Participants

Forty-four participants completed testing during their 6-year-old year; 21 kindergarten children with normal hearing, 10 males and 11 females, and 23 kindergarten children with hearing loss, 9 males and 14 females. The children with normal hearing ages ranged from 6;0 to 6;4 and the children with hearing loss ages ranged from 5;11 to 6;10. Distribution of age was not significantly different [independent t-test ($p= 0.873$, $d= -0.05$, 95% CI= -0.6-0.54)]. Participants were from Florida, Georgia, Illinois, Indiana, Louisiana, New York, North Carolina, South Carolina, Tennessee, Texas, Virginia, and Wisconsin.

The children with hearing loss were diagnosed with permanent hearing loss by an audiologist, used amplification and spoken language, and did not have additional diagnoses known to affect language and literacy acquisition (e.g., autism, Down Syndrome); one child was diagnosed with cerebral palsy. The hearing devices for children with hearing loss are divided as such: ten children with bilateral cochlear implants, eight children with bilateral hearing aids, three children

with bimodal devices (one cochlear implant, one hearing aid), and two children with bone anchored hearing aids. All children with hearing loss received speech and language services at one time with six no longer in speech and language therapy at age 6, per parent report.

Children with normal hearing passed a bilateral hearing screening prior to beginning the study and had no diagnoses known to affect language and literacy acquisition. No children with normal hearing had received language therapy, though two participants received prior services for speech sound disorder, per parent report.

All participants had nonverbal intelligence within the average range, measured by the Primary Test of Nonverbal Intelligence, during their initial testing session (Ehrler & McGhee, 2008). All participants spoke English at least 50% of the time at home and used spoken language during the testing session. Table 2.1 displays demographic information.

2.2 Language, Reading, and Spelling Measures

Participants' language was assessed through the Comprehensive Assessment of Spoken Language – Second Edition, with specific focus on the General Language Ability Index score (CASL-2; GLAI; Carrow-Woolfolk, 2017). Participants reading was assessed through the Woodcock Reading Mastery Test – Third Edition, with specific focus on the Oral Reading Fluency subtest and the Total Reading score (WRMT-III; ORF; Woodcock, 2011). Three single-word spelling assessments were completed by the children in the study, the

Test of Written Spelling – Fifth Edition (TWS-5; Larsen, Hammill, & Moats, 2013), the Phonological Awareness Literacy Screening – Kindergarten, Letter-Sound Knowledge, Spelling (PALS-K; Invernizzi, Juel, Swank, & Meier, 2013), and Spelling Sensitivity Score – Kindergarten/Grade 1 Spelling List (SSS-Spelling List; Apel, Henbest, & Reed, 2017). After completion of the testing, the assessments were initially and double scored by graduate research assistants who worked on the ELLA study. Measures were administered following published administration protocols.

Table 2.1: Demographic Information

	Race	**Ethnicity**	**Other Languages Spoken at home (>50% of time)**
CNH	White – 18 African American – 0 Asian - 1 Asian/White - 1 Native Hawaiian/Pacific Islander/White - 1	Latin or Hispanic – 0	Mandarin (Chinese) Ukranian Farsi
CHL	White – 17 African American - 4 Asian - 1 Asian/White - 0 Native Hawaiian/Pacific Islander/White - 0	Latin or Hispanic – 6	Spanish Albanian American Sign Language Filipino Russian

Note: One participant's parents did not report race or ethnicity; CHN= Children with normal hearing; CHL= Children with hearing loss

2.2A Comprehensive Assessment of Spoken Language – Second Edition. The CASL-2 is an evaluation of an individual's oral language skills based on the Integrative Language Theory for ages 3;0 to 21;11 (Carrow-Woolfolk, 2017). The Integrative Language Theory describes language as having two dimensions; knowledge, which refers the form and content of language, and performances,

which refers to the use of language by an individual (Carrow-Woolfolk, 2017). Participants were given eight subtests; Receptive Language, Synonyms, Expressive Vocabulary, Sentence Expression, Grammatic Morphemes, Sentence Comprehension, Inference, and Pragmatic Language; to contribute to the General Language Ability Index score, which serves as a general measure of an individual's spoken language ability (Carrow-Woolfolk, 2017). 42 participants completed the CASL-2; while two participants completed the CASL-1[1]. Interrater reliability ranges from .86 to .97, with a median agreement of .92 (Carrow-Woolfolk, 2017).

For Receptive Vocabulary, participants were presented with four pictures and instructed to choose the picture that represented what the examiner stated. For Synonyms, the examiner read a word plus four choices and instructed the participants to verbally choose the best answer. For Expressive Vocabulary, participants were presented with a sentence with or without picture support and were instructed to verbally complete the sentence with one word. For Sentence Expression, the examiner presented a picture to the participant and instructed the participant to finish a sentence with a word or phrase or explain a picture. For Grammatic Morphemes, the examiner stated a sentence and instructed the participant to decide if the sentence needed to be fixed then fix the sentence or if the sentence was grammatically correct with or without picture support. For Sentence Comprehension, the participant was presented with four pictures and was instructed to point to the picture that matched what the examiner stated. For Inferences, the participant was instructed to deduce information from a sentence or phrase the examiner stated with or without picture support. For Pragmatic

Language, the examiner read a scenario in which the participant was instructed to respond to a question about the scenario with or without picture support.

2.2B Woodcock Reading Mastery Test – Third Edition. The WRMT-III is a comprehensive battery of nine assessments to measure reading readiness and reading achievement of children from pre-kindergarten to Grade 12 from ages 4;6 to 79;11 (Woodcock, 2011). Participants were given five subtests; Word Identification, Word Attack, Word Comprehension, Passage Comprehension, and Oral Reading Fluency; to contribute to the Total Reading Score, which serves as a broad measure for a participant's reading comprehension skills (Woodcock, 2011). All participants were given Form A and started with Item 1, equivalent for Grade 1, for the Word Identification, Word Attack, Word Comprehension, and Passage Comprehension subtests. Participants were all instructed to read Passage A for Oral Reading Fluency. Forty-two participants completed the WRMT-III; two participants did not complete the WRMT-III due to time constraints. Interrater reliability for the Oral Reading Fluency subtest is .99 for Form A and Form B (Woodcock, 2011).

For Word Identification, participants were instructed to read aloud English words of increasing difficulty. If the participant decoded the word aloud, they were instructed to say the sounds all together. If the participant continued to say the word decoded, the answer was counted as incorrect; for example, /heɪt/ instead of "hate." For Word Attack, participants were instructed to read aloud nonsense words of increasing difficulty. If the participant decoded the word aloud, they were instructed to say the sounds all together. If the participant continued to say the

word decoded, the answer was counted as incorrect; for example, “b-æ-b" for [bæb]. Also, if the participant read the word as an English word, the answer was counted as incorrect; for example, “bob” for [bæb]. Word Comprehension consists of three subsections; Antonyms, Synonyms, and Analogies. For each, single English words were presented to the participant. Participants were instructed to read the word aloud and give a single word response per subsection; for example, “hot” as the antonym for “cold”. Morphological deviations of the word were counted as correct, for example, “loved” for “love” (Woodcock, 2011). For Passage Comprehension, participants were instructed to read a short passage and fill in the blank with one word. The short passages are designed to measure a participant’s ability to analyze the sentence(s) and utilize their comprehension and vocabulary skills to identify the missing word (Woodcock, 2011). For the Oral Reading Fluency task, participants were asked to read Passage A, which contains 80 words, in a natural, reading voice that was not rushed while timed (Woodcock, 2011).

2.2C Test of Written Spelling – Fifth Edition. The TWS-5 is a norm-referenced test of spelling with administration using a dictated word format (Larsen et al., 2013). All participants started at Item 1, equivalent for grades 1-3. The administration was ended when a child incorrectly spelled five words in a row per TWS-5 administration protocol (Larsen et al., 2013). Figure 2.1 displays the differences of the standard score between groups.

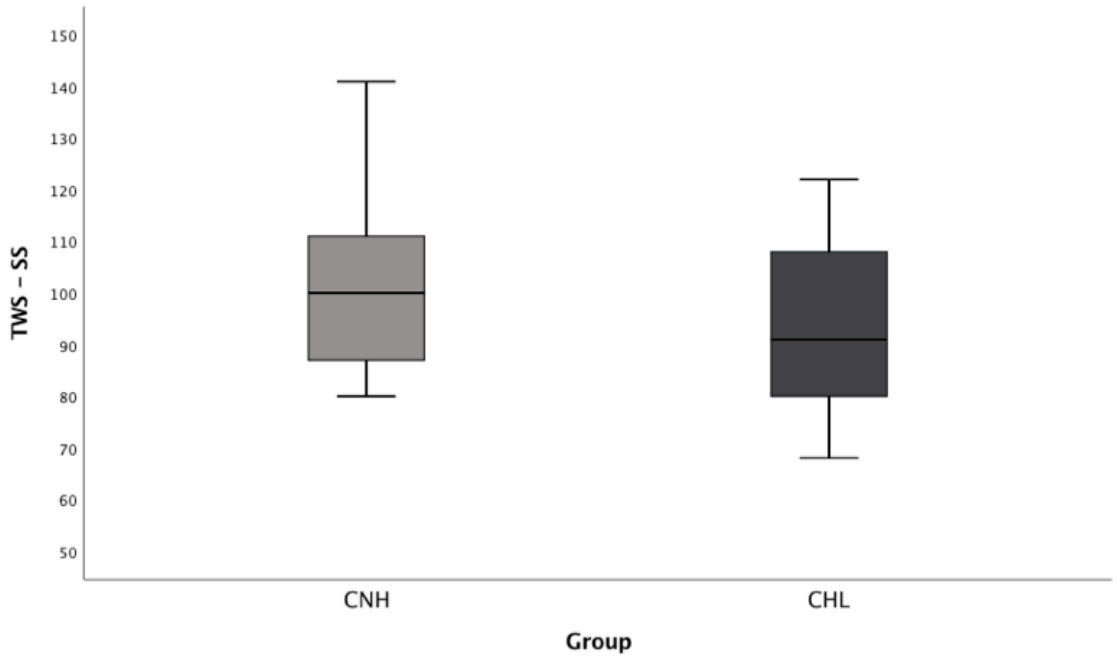

Figure 2.1: Test of Written Spelling – 5 Standard Score Comparison

2.2D Phonological Awareness Literacy Screening – Kindergarten. The PALS-K is a criterion-referenced screening tool that can be used by teachers to determine if a child is above or below benchmark for skills learned in kindergarten (Invernizzi et al., 2013). For administration, the examiner read five CVC words to the child one at a time and the child was instructed to write their response in the space provided. Responses were scored per the scoring procedures. Each grapheme was given a score of 1 if the grapheme was written regardless of kinetic reversals, error of order; for example, “ten” would receive three points and “net” would receive three points (Invernizzi et al., 2013). A bonus point was awarded for

correct spelling of the word (Invernizzi et al., 2013). Static reversals, writing the mirror image of a single letter, are not considered to be an error per scoring protocol (Invernizzi et al., 2013). All participants completed the PALS-K spelling measure. Figure 2.2 displays the differences of the developmental spelling score between groups.

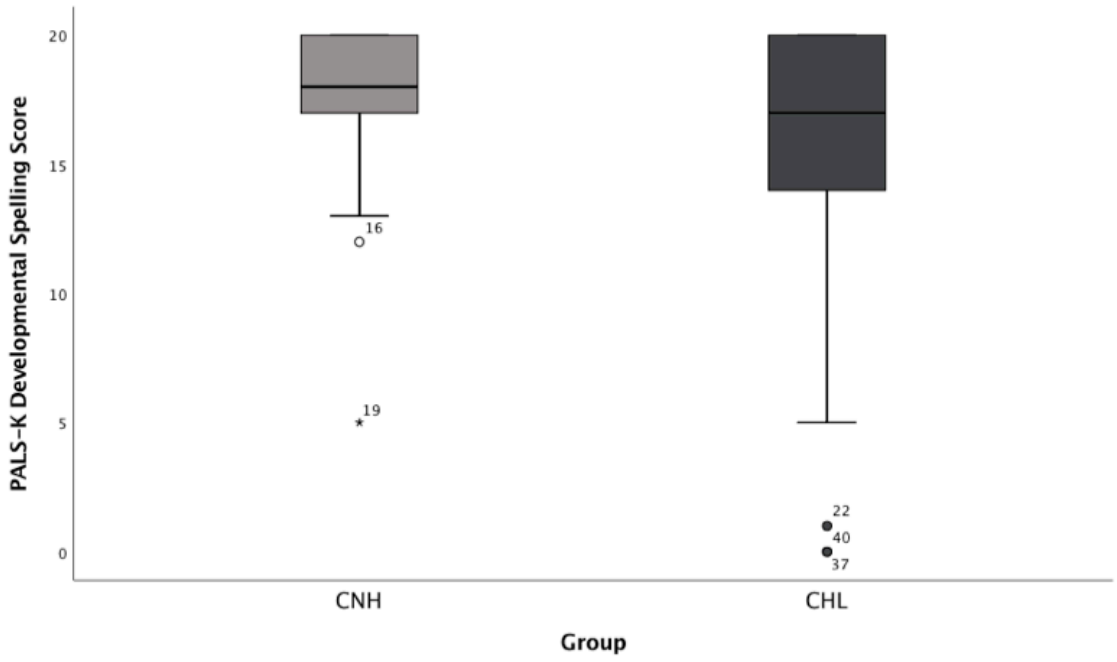

Figure 2.2: Phonological Awareness Literacy Screening – Kindergarten Developmental Spelling Score Comparison

2.2E Spelling Sensitivity Score – Spelling List. The SSS-Spelling List is a list of 25 words varying in elemental units and morphological units dependent on each grade level, listed in Appendix A (Apel et al., 2017). Participants were

administered the Kindergarten/First grade spelling list (Apel et al., 2017). For administration, the examiner read each word aloud to the child, used the word in a sentence, and then the word was read once more. The child was instructed to write their response in the space provided on the record form. The responses were recorded as either correct or incorrect and analyzed using the Spelling Sensitivity Score. All participants completed the SSS-Spelling List (Apel et al., 2017).

2.3 Analysis

2.3A Spelling Sensitivity Score. The researcher created an excel spreadsheet for each participant for the SSS-Spelling List (Apel et al., 2017). The excel spreadsheet included the participant's spelling of the word in column A and the target spelling of the word in column B. A code, created by the researcher, was used to denote a response as non-analyzable (XXX) and for no-attempt (NA).

2.3B Multilinguistic Coding. The researcher created a worksheet from an MLC template (Werfel, 2015) for each participant for the SSS-Spelling List (Apel et al., 2017). The worksheet included the participant's spelling of the word in the first column and the target spelling of the word in the second column. A code, created by the researcher, was used to denote a response as non-analyzable (XXX) and for no-attempt (NA). The worksheet included six columns for possible types of errors; phonological awareness, orthographic pattern knowledge, mental graphemic representation, morphological knowledge, semantic knowledge, and "other" (Werfel, 2015).

The coding of the spelling words followed a coding manual created by Werfel (2015). To be deemed a phonological awareness error, there must be an omission and/or addition of a phoneme to a word (brandsh for brandish) or letter transpositions that change the sound order in a word (engotiate for negotiate; Werfel, 2015). For an error to be one of orthographic pattern knowledge, there must be an illegal phoneme to grapheme correspondence (salut for salute) or an illegal positional constraint of a grapheme (ckollar for collar; Werfel, 2015). A mental graphemic representation error includes a legal but incorrect phoneme to grapheme representation (opake for opaque) or letter transpositions that do not change the sound order in a word (abel for able; Werfel, 2015). A morphological knowledge error includes the omission, addition, or incorrect spelling of an affix (zealus for zealous) or the omission, non-dropping, or incorrect spelling of a juncture (continueity for continuity; Werfel, 2015). For the error to be one of semantic knowledge, there must be a correct spelling of a homophone for the target word (night for knight), correct spelling of a real word with either less than or more than half the phonemes in common with the target word (hug for rug or sun for fountain), or the correct spelling of an alternate verb tense for the target word (know for knew; Werfel, 2015). The type of errors given the “other” code includes the use of non-grapheme elements in the spelling (nine-teen for nineteen) or no spelling attempt made of the word (Werfel, 2015).

CHAPTER 3

PROCEDURES

3A Percent Correct. Percent correct was computed for the SSS-Spelling List (Apel et al., 2017). Each correct spelling received a score of 1 and incorrect spellings received a score of 0. The number of correct spellings was divided by 25 to determine the percentage of correct spelling of the words for each child.

3B Spelling Sensitivity Score. The excel spreadsheet for each participant was individually uploaded and run through the Computerized Spelling Sensitivity System (C-SSS; Masterson & Hrebec, 2011). The C-SSS (Masterson & Hrebec, 2011) populated the SSS-E and the SSS-W scores based on the SSS procedures outlined above (Masterson & Apel, 2010). A dictionary created by Masterson (2010) was utilized which included legal and illegal substitutions for each of the word elements. If the word was not included in the dictionary, the researcher broke the word into elements per the SSS procedures (Masterson & Apel, 2010). Words that were deemed non-analyzable or no attempt was made to spell the word were not included in the SSS analysis as that would skew the overall scores. The SSS-E and SSS-W were averaged for each participant. See Appendix B for an example. The word score of each attempted word was used to further analyze the specific nature of the group differences. The word score was used over the element score because each word was given a whole number (0, 1, 2, 3) while the

element score gave partial numbers (0.15, 2.73, etc.). Each participant was given a participant ID and each word was given a word ID (1-25) to be used in the analysis.

3C Multilinguistic Coding. The researcher coded each worksheet per Werfel's (2015) coding manual, adapted from Bowers et al. (2014). See Appendix C for an example. The sum of the errors was calculated and recorded at the bottom of each sheet. The total number of errors produced in each category were added together to calculate the total number of errors produced overall. To compute the proportion of each category, the number of the individual category was divided by the total number of errors recorded. For example, to calculate the proportion of PA errors, the total number of PA errors was divided by the total number of errors the child produced overall.

3.1 Reliability

All spelling, language, and reading assessments were initially and double scored by graduate research assistants. The interrater reliability was 100% for each spelling, language, and reading assessment. Interrater reliability was conducted for both the SSS and the MLC scoring. A second-year graduate student double scored 30% of the SSS data for reliability. A post-doc student double scored 30% of the MLC data for reliability. Interrater reliability was 99% for the SSS and 86% for the MLC.

To address research question 1 to examine if children with hearing loss exhibit more spelling errors compared to children with normal hearing, an

independent samples t-test was completed using the calculated percent correct from the SSS-Spelling List (Apel et al., 2017). To address research questions 2 to determine if children with hearing loss produce more unanalyzable spelling attempts or no spelling attempts compared to children with hearing loss, a non-parametric median sample was completed using the SSS-Spelling List responses (Apel et al., 2017). To address research question 3 to examine the differences between children with hearing loss and children with normal hearing using SSS, an independent samples t-test was completed to compare the overall SSS-E and SSS-W mean scores. Additionally, a mixed-effects model comparison was completed using the individual SSS word scores to examiner deeper into the specific nature of group differences in the language skills used with word spelling. To address research questions 4 to determine if children with hearing loss exhibit different proportion of error types using the MLC system, a Mann-Whitney U was completed. Additionally, correlational analyses were completed to determine how correlated the SSS-Spelling List (Apel et al., 2017) scores were compared to the TWS-5 standard scores and the correlation between the TWS-5, WRMT-III ORF, and the CASL-2 GLAI standard scores.

CHAPTER 4

RESULTS

4.1 Research Aim 1: Difference in number of spelling errors

When analyzing the accuracy of spelling using percent correct, CNH and CHL did not differ statistically on percentages of errors on the SSS-Spelling List (Apel et al., 2017; see Figure 4.1) CNH spelled on average 24.95% of words correct (SD= 27.68; range= 0-88%), while CHL spelled on average 15.83% of words correct (SD= 18.27; range= 0-56%). This difference was not statistically significant (p= 0.20), and Cohen's *d* effect size was 0.39, indicating a small effect of group on spelling accuracy.

4.2 Research Aim 2: Difference in unanalyzable attempts/no spelling attempts

When comparing the number of unanalyzable spelling attempts and no spelling attempts made, CNH and CHL did not differ significantly in terms of production of the number of unanalyzable attempts or no spelling attempts on the SSS-Spelling List. CNH had a mean of 0.24 (SD= 1.09; range= 0-20%), while CHL had a mean of 1.57 (SD= 5.32; range= 0-96%). This difference was not statistically significant (p= 0.296), and Cohen's *d* effect size was 0.34, indicating a small effect of group on spelling accuracy.

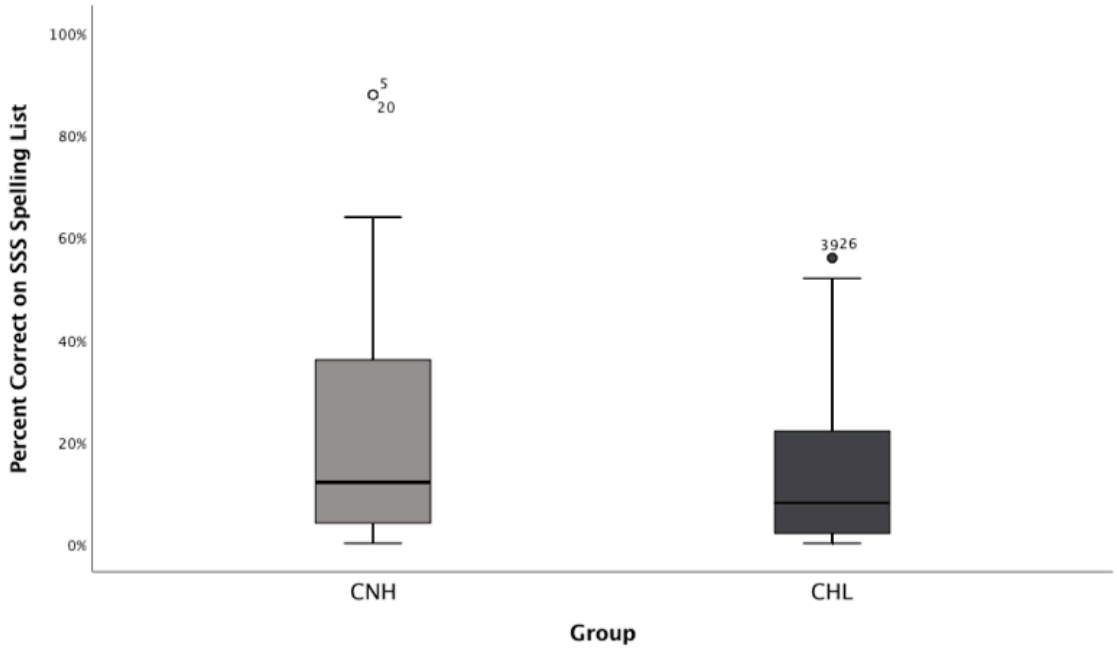

Figure 4.1: Spelling Sensitivity Score Spelling List Percent Correct Comparison

4.3 Research Aim 3: Difference with Spelling Sensitivity Score

4.3A Spelling Sensitivity Score – Overall Word Score. When comparing the means from the SSS-W between CNH and CHL, scores between the groups did not significantly differ (see Figure 4.2). CNH had a mean SSS-W of 1.36 (SD= 0.75; range= 0-2.80), while CHL had a mean SSS-W of 1.12 (SD= 0.62; range= 0-2.12). This difference was not statistically significant (p= 0.259), and Cohen's *d* effect size was 0.35, indicating a small effect of group on spelling accuracy.

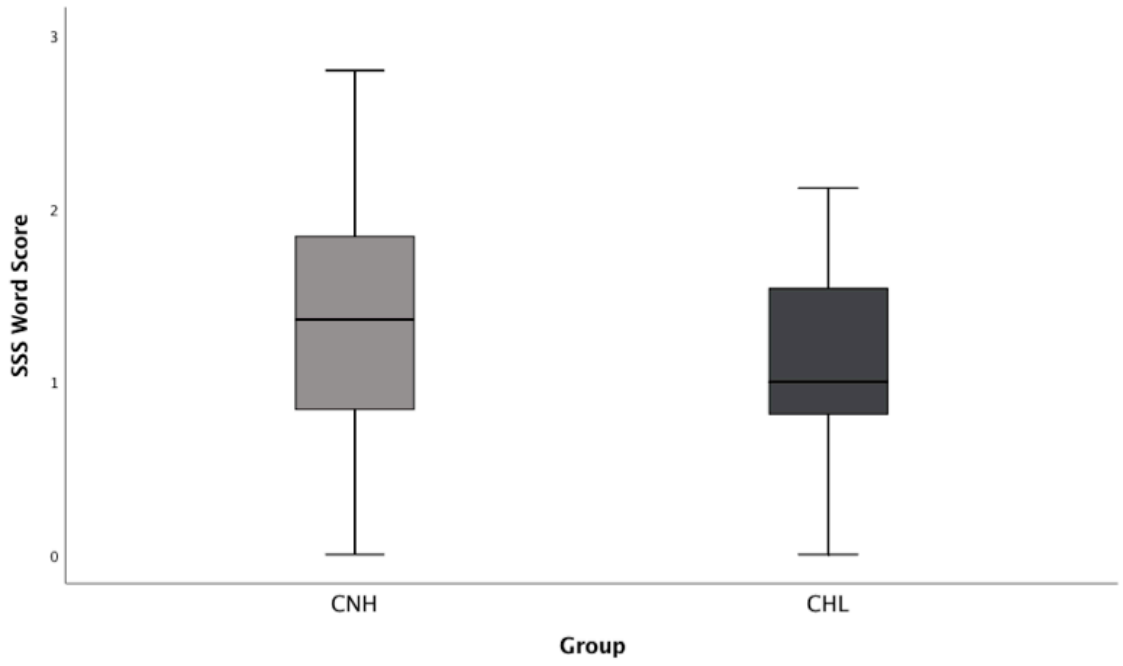

Figure 4.2: Spelling Sensitivity Score Overall Word Score Comparison

4.3B Spelling Sensitivity Score – Overall Element Score. When comparing the means from the SSS-E between CNH and CHL, scores between both the groups did not significantly differ (see Figure 4.3). CNH had a mean SSS-E of 2.12 (SD= 0.58; range= 0.59-2.93), while CHL had a mean SSS-E of 1.81 (SD= 0.72; range= 0.33-2.64). This difference was not statistically significant (p= 0.125), and Cohen's *d* effect size was 0.47, indicating a small effect of group on spelling accuracy.

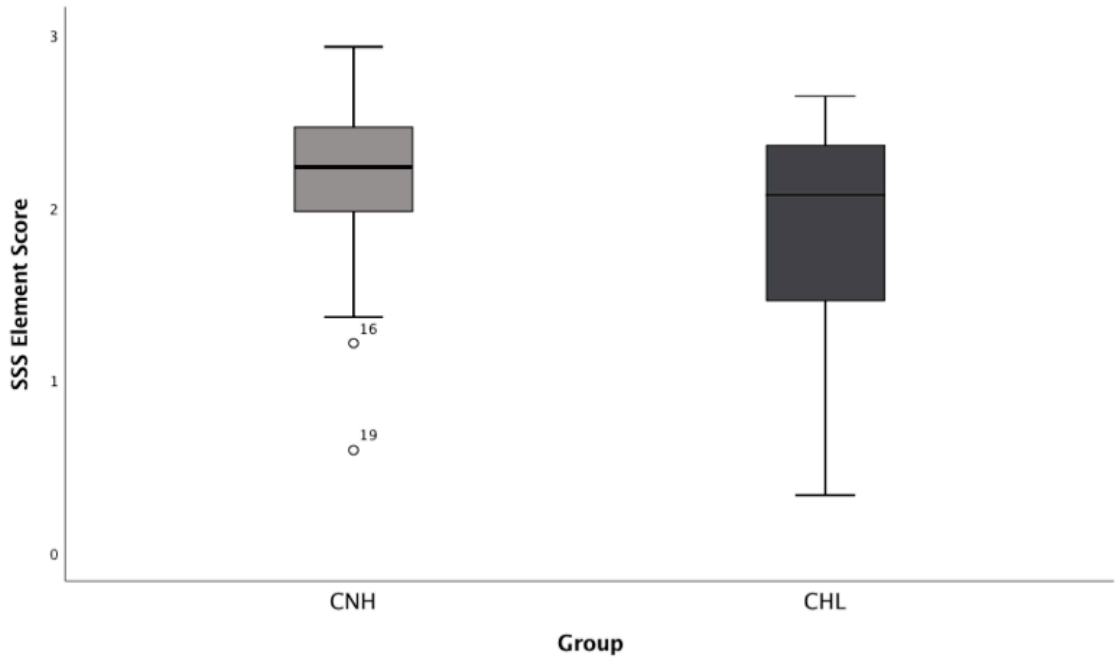

Figure 4.3: Spelling Sensitivity Score Overall Element Score Comparison

4.3C Spelling Sensitivity Score – Word Score. To further examine the specific language skills that were utilized while spelling, a mixed-effects model comparison was completed. Each participant ID and word ID were entered as random effects in the null models while the group was entered as the fixed effect. See Appendix D for further information on how the syntax was computed. Group was not seen as a significant predictor of word score compared with the null model for any of the word scores; word score 0 [change in Akaike information criterion (ΔAIC)= -1.78, $X2$= 0.82, p= 0.365], word score 1 (ΔAIC= -1.9, $X2$= 0.08, p= 0.7826), word score 2 (ΔAIC= -1.38, $X2$= 0.62, p= 0.4314), and word score 3

(ΔAIC= -0.2, *X*2= 1.8, p= 0.1795). Table 4.1 displays the model comparison statistics for each word score.

Table 4.1 Model comparisons for mixed-effects models for each word score

Model	βgroup	ΔAIC	*X2*	*p*
1. Word score 0, null model				
2. Word score 0, including group	0.09			
		-1.78	0.82	0.365
3. Word score 1, null model				
4. Word score 1, including group	0.02			
		-1.9	0.08	0.7826
5. Word score 2, null model				
6. Word score 2, including group	-0.01			
		-1.38	0.62	0.4313
7. Word score 3, null model				
8. Word score 3, including group	-0.09			
		-0.2	1.8	0.1795

Note: ΔAIC = change in Akaike information criterion when group was added as a predictor.

4.4 Research Aim 4: Proportion of errors with Multilinguistic Coding System

When analyzing the differences in proportion of errors through MLC, CHL demonstrated more appropriate use of the underlying linguistic knowledge of MGR compared to CNH (p= 0.041). CNH and CHL did not differ in proportion of errors for the other categories; PA errors (p= 0.589), OPA errors (p= 0.366), MK errors (p= 0.69), SK errors (p= 0.612), and “other” errors (p= 0.334). Figure 4.4 displays the proportion of errors with the use of MLC.

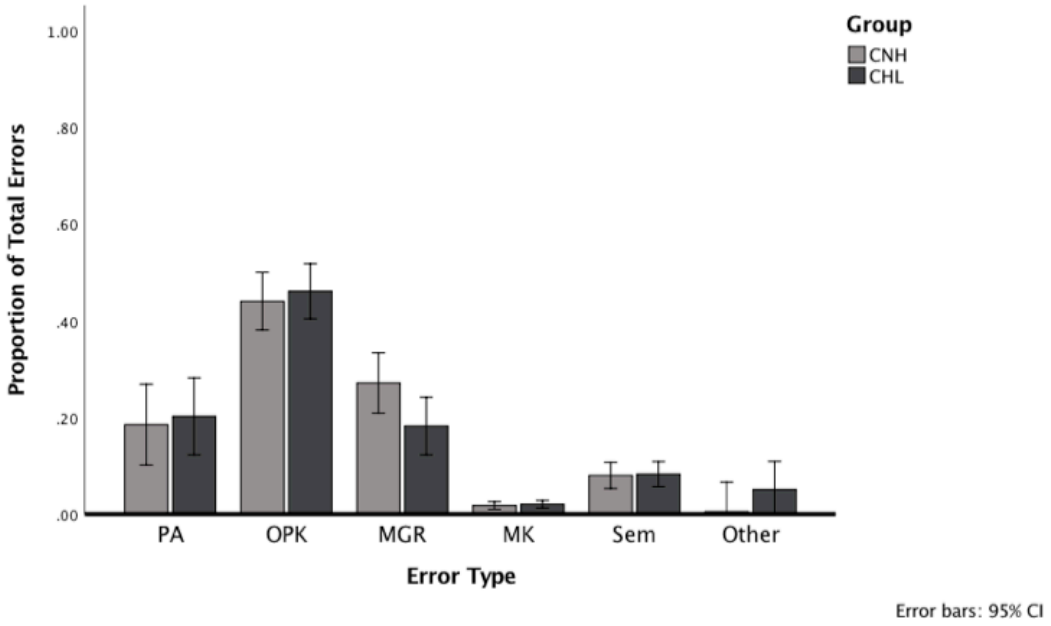

Figure 4.4: Proportion of Total Errors with Multilinguistic Coding

4.5 Correlational analyses.

Correlational analyses were completed to determine how correlated spelling was to language and reading skills. The TWS-5 standard scores of each group were correlated with to the SSS-W and SSS-E overall scores, the CASL-2 GLAI standard scores, and the WRMT-III Total Reading standard scores. The TWS-5 standard scores were found to be highly correlated with the SSS-W overall scores, SSS-E overall scores, CASL-2 GLAI standard scores, and the WMRT-III Total Reading standard scores. Table 4.2 displays the significance values by assessment and group.

Table 4.2 TWS-5 Correlations with Other Study Assessments

	SSS-W	SSS-E	CASL-2 GLAI	WRMT-III Total Reading
CNH	0.94**	0.83**	0.62**	0.92**
CHL	0.85**	0.80**	0.49*	0.77**

Note: *p<0.05, **p<0.01

CHAPTER 5

DISCUSSION

The purpose of this paper was to determine whether differences in spelling errors occur between children with normal hearing and children with hearing loss in kindergarten. The spellings were analyzed via three methods, percent correct, SSS, and MLC, to determine the accuracy of spelling between the two groups. SSS and MLC were used, in addition to percent correct, to further analyze types of linguistic knowledge children in kindergarten are utilizing and/or are deficient in to help shape the intervention of spelling for children with hearing loss. Results from this study revealed that children with hearing loss produce a significantly lower proportion of mental graphemic representation errors compared to children with normal hearing as seen using the MLC system, possibly indicating that children with hearing loss have a stronger mental picture of the spelling of a word in kindergarten compared to children with normal hearing. However, children with normal hearing and children with hearing loss did not show significant differences in the number of spelling errors overall and in the number of non-spelling attempts and unanalyzable spelling attempts. Children with hearing loss did not significantly differ in their SSS-E and SSS-W score when compared to children with normal hearing. Additionally, when looking further into how children are utilizing linguistic knowledge via the word score given in the SSS, children with hearing loss and children with normal hearing did not significantly differ. Children

with hearing loss did not make significantly different proportions of errors in phonological awareness, orthographic pattern knowledge, morphological knowledge, semantic knowledge, and "other" when compared to children with normal hearing utilizing the MLC system.

The findings of the present study indicate that the errors that are seen in these grades as well as middle school-aged children with hearing loss, phonological awareness, orthographic pattern knowledge, mental graphemic representation, and semantic knowledge (Apel & Masterson, 2015; Bowers et al., 2014; Werfel, 2016), have not yet emerged for younger children. Additionally, the present study did not find the same magnitude of effect size when compared to previous research. Apel & Masterson (2015) found a large effect size (*d*= 1.00) between groups when comparing the SSS-W score and a large effect size (d= 1.11) between groups when comparing the SSS-E score. The present study also demonstrated that children with hearing loss are not making the same distribution of errors compared to the study completed by Werfel in 2016 which found significant differences in phonological awareness errors, orthographic pattern knowledge, mental graphemic representation, and morphological knowledge.

Additionally, this study further supports the concept that spelling should not be viewed as only correct or incorrect. This way of quantifying spelling skills does not allow one to see what linguistic skills a child is utilizing and/or not utilizing, which is important for intervention purposes of both speech-language pathologists and teachers in the classroom. When looking at percent correct, there was not a significant difference found between the two groups which in turn does not allow

for a deeper analysis into the what the child needs intervention in to be successful at spelling. With the SSS and the MLC system, one can see what underlying linguistic skills that a child needs further intervention to be successful. Through the analysis completed within this study, the MLC system was found to be more sensitive in identifying the specific underlying linguistic skills that children with hearing loss utilize when compared to the SSS.

5.1 Implications for Intervention

Results from this study concluded that kindergarten children with normal hearing and with hearing loss do not significantly differ in their spelling abilities, though children with hearing loss show a lesser amount of errors when spelling words that have a clear picture within their head (i.e., mental graphemic representations). Previous research has shown that children with hearing loss in middle school begin to show deficits in phonological awareness, orthographic pattern knowledge, and semantic awareness (Apel & Masterson, 2015; Bowers et al., 2014) compared to their hearing counterparts. Due to the previous research results and results gained from this study, intervention for children with hearing loss should be targeted towards explicit instruction in phonological awareness, specifically in the understanding that each sound requires a letter or set of letters, orthographic pattern knowledge, and semantic knowledge. With interventions in place to target these deficits in earlier grades that we typically see later on, children with hearing loss' spelling skills should improve in later grades.

Additionally, the correlational analyses completed indicated that reading, language, and spelling are highly correlated for both children with hearing loss and children with normal hearing. This correlation between reading and spelling allows for additional intervention options, such as emergent literacy and further literacy skills for speech-language pathologists, educators, and parents. Children learn spoken language through incidental exposure; however, they learn reading and spelling skills through explicit exposure. Increases in reading abilities will additionally have a positive impact on a child's spelling skills.

5.2 Limitations

The participants with hearing loss included in this studied utilized the communication modality of listening and spoken language as their primary mode. It would be interesting to compare spelling abilities of children with hearing loss who use the different types of communication modalities available (i.e, listening and spoken language, total communication, manually coded English, sign language). Amplification devices used by the participants varied; thus, the results cannot be generalized to one specific hearing device. The sample size of the present study is relatively small. These findings should be replicated in a larger sample of young children with hearing loss. Additionally, the spelling assessments administered were single-word spelling assessments. This type of spelling assessment is typical for how spelling is taught and tested in school; however, this spelling task does not generalize well to how spelling is completed outside of school. Outside of school, spelling is rarely completed one word at a time and utilizes contextual clues to determine the correct spelling of words. It would be

interesting to determine if the same types of errors are seen when completing a story-type writing assessment to allow for contextual clues. The findings from this study should be interpreted with those limitations in mind.

5.3 Future Directions

Future studies should be done to confirm the results indicated by this study with a larger group of participants that mirror the current demographics of the United States to further generalize the results to both the populations of children with normal hearing and children with hearing loss. Future research should also include determining which types of errors are seen across the different types of hearing devices, such as, cochlear implants, hearing aids, and bone anchored hearing aids. Unilateral, bilateral, and bimodal should be discussed when looking at the spelling errors in children with hearing loss to determine if the errors produced are consistent. Additionally, the type of communication modality should be explored further when generalizing the spelling abilities of children with hearing loss.

Research on spelling for children with hearing loss has not been completed across subsequent grades leading up to middle school. In order to determine the grade in which the shift from errors in mental graphemic representation to errors in phonological awareness, orthographic pattern knowledge, and semantic knowledge (Apel & Masterson, 2015; Bowers et al., 2014), research concerning the spelling skills of children in grades 1 through 5 will need to be completed. The information from the grade specific research will help to further influence the

intervention received by children with hearing loss regarding their spelling skills which in turn influences the reading and language skills of children.

In conclusion, kindergarten children with hearing loss do not appear to differ significantly in the overall spelling errors compared to children with normal hearing when viewing spelling in the conventional correct/incorrect scoring procedures. The MLC system shows the most sensitivity to the proportion of errors the children make, as well as, the type of linguistic sources children utilize while spelling, though the SSS is sensitive to changes in spelling abilities (Masterson & Apel, 2010). Both the MLC system and SSS, and other systems that look deeper into the underlying linguistic skills, should be utilized in addition to the conventional scoring method to determine the appropriate spelling intervention for children with hearing loss and children with normal hearing. More research needs to be completed in order to generalize these results, gain more understanding of the spelling abilities of children with and without hearing loss throughout elementary school, and to determine the best course of intervention for individual children with hearing loss to increase their spelling abilities, which in turn will positively influence their reading and language skills.

REFERENCES

Apel, K., Henbest, V. S., & Reed, P. (2017). *The development of orthographic knowledge: Exploring results*. Paper presented at the annual conference of the Society for Scientific Studies of Reading, Halifax, Nova Scotia, CAN.

Apel, K. & Masterson, J. J. (2015). Comparing the spelling and reading abilities of students with cochlear implants and students with typical hearing. *Journal of Deaf Studies and Deaf Education, 20*(2), p 125-135. doi:10.1093/deafed/env002.

Apel, K. & Masterson, J. J. (2001). Theory-guided spelling assessment and intervention: A case study. L*anguage, Speech, and Hearing Services in Schools, 32*, 182-195.

Bourassa, D. C. & Treiman, R. (2001). Spelling development and disability: The importance of linguistic factors. *Language, Speech, and Hearing Services in Schools, 32*, p 172-181.

Bowers, L. M., Dostal, H., McCarthy, J. H., Schwarz, I., & Wolbers, K. (2016). An analysis of deaf students' spelling skills during a year-long instructional writing approach. *Communication Disorders Quarterly, 37*(3), p 160-170. doi:10.117/1525740114567528.

Bowers, L., McCarthy, J. H., Schwarz, I., Dostal, H., & Wolbers, K. (2014). Examination of the spelling skills of middle school students who are deaf or hard of hearing. *The Volta Review, 114*(1), p 29-54.

Ehri, L. C. (2000). Learning to read and learning to spell: Two sides of a coin. *Topics in Language Disorders, 20*(3), 19-36.

Gentry, J. R. (2004). *The science of spelling: The explicit specifics that make great readers and writers (and spellers)*. Heinemann: Portsmouth, NH.

Henderson, E. H. & Templeton, S. (1986). A developmental perspective of formal spelling instruction through alphabet, pattern, and meaning. *The Elementary School Journal, 86*(3), p 304-316.

Masterson, J. J. & Apel, K. (2010). The spelling sensitivity score: Noting developmental changes in spelling knowledge. *Assessment for Effective Intervention, 36*(1), 31-45. doi:10.1177/1534508410380039.

Masterson, J. & Hrebec. B. (2011). Computerized Spelling Sensitivity System. Missouri State University.

Moats, L. C. (1995). *Spelling: Development, disability, and instruction*. York Press, Inc: Timonium, MD.

Treiman, R. & Bourassa, D. C. (2000). The development of spelling skill. *Topics in Language Disorders, 20*(3), p 1-18.

Werfel, K. L. (2015). *Multilinguistic Coding manual*.

Werfel, K. L. (2016). Proceedings from Society for the Scientific Study of Reading. *Spelling in Children who use Cochlear Implants.*

Werfel, K. L. (2016). *Characterizing Spelling Errors in School-Age Children with Mild to Moderate Hearing Loss*.

Wolter, J. A. (2017). Spelling and word study: A guide for language-based assessment and intervention. In T. Ukrainetz (Ed.), *School-Age Language Intervention: Evidence-Based Practices* (pp. 527-563). Austin, TX: Pro-Ed.

Wolter, J. A., Wood, A., & D'Zatko, K. (2009). The influence of morphological awareness on first-grade children's literacy development. *Language, Speech, and Hearing Services in the Schools, 40*(3), 1-13.

APPENDIX A

SSS- SPELLING LIST

1. Rake
2. Nine
3. They
4. Ship
5. Pool
6. Reach
7. Whales
8. Unite
9. Jet
10. Head
11. Hang
12. Putting
13. Bowl
14. Fire
15. Cute
16. Leaf
17. Why
18. Shut
19. Bake
20. Then
21. Cure
22. Pie
23. White
24. Key
25. Jog

APPENDIX B

SPELLING SENSITIVITY SCORE

Target	TargetEleme	Spelling	AA	AB
rake	r aCe k	fake	WordScore	ElementScore
nine	n iCe n	ninhte	1	2.33
they	th ey	thay	1	1.67
ship	sh i p	ship	2	2.5
pool	p oo l	pool	3	3
			3	3

APPENDIX C

MULTILINGUISTIC CODING SYSTEM

Item	Spelling	Type of Error					
		Phonological Awareness	Orthographic Pattern Knowledge	Mental Graphemic Representation	Morphological Knowledge	Semantic Knowledge	Other
rake	**fake**					1	
nine	**ninhte**	1	1				
they	**thay**		1				
reach	**resh**		2				
whales	**whalss**		2				

APPENDIX D

SYNTAX FOR MIXED-EFFECTS MODEL

Word Score 0

```
> m0 = lmer(WordScore_0~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
> m0.null = lmer(WordScore_0~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
>anova(m0, m0.null)
```

Word Score 1

```
> m1 = lmer(WordScore_1~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
> m1.null = lmer(WordScore_1~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
>anova(m1, m1.null)
```

Word Score 2

```
> m2 = lmer(WordScore_2~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
> m2.null = lmer(WordScore_2~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
>anova(m2, m2.null)
```

Word Score 3

```
> m3 = lmer(WordScore_3~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
> m3.null = lmer(WordScore_3~(1 l PID)+(1
l TargetID)+Group,data=R_Database,REML=FALSE)
>anova(m3, m3.null)
```