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Spelling errors in children who are deaf

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by

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This is a descriptive study that analyzes the spelling abilities as well as a specific spelling error made by children between the ages of 5 and 9 who are deaf and wear cochlear implants.

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Introduction and Review of the Literature

Allman (2002) succinctly describes spelling as a skill that requires "an understanding of a range of phoneme-grapheme relationships and morphemic relationships, as well as the semantic and syntactic influences upon words" (p. 47). In other words, in order to be a successful speller, an individual must be able to make connections between letters and sounds as well as comprehend how morphemes (or the smallest units of linguistic meaning) can be connected. Successful spelling also involves awareness of word and sentence meaning as well as sentence formation (Gunning, 2008).

In order to understand how individuals spell, it is important to first examine the typical developmental course for spelling in hearing children. Essentially, hearing children have a spelling foundation that allows them to associate letters (graphemes) with sounds (phonemes). The literature reports that this grapheme-phoneme relationship is vital for literacy (i.e. spelling and reading) proficiency (Harris and Moreno, 2004). Gunning (2008) outlines the stages of typical spelling development. The first stage is called the prealphabetic (or prephonemic) stage. In this stage, children understand that letters are used to convey information, but they do not understand that letters are associated with specific sounds. According to Johnson, Padak, and Barton (1994), children using prephonemic spelling do not have well-defined word boundaries nor do they incorporate conventional print directionality into their written expression. Gunning (2008) identifies the next spelling stage as the alphabetic (or letter) stage. In this stage, children begin employing the alphabetic principle, meaning that they understand that letters represent sounds. When children are in the alphabetic stage of spelling, they use auditory information in order to spell a word. In the beginning of this stage, children may use a single letter to represent an entire word. Children in this stage may also use the initial and final consonants to represent

an entire word (Allman, 2002). They may then progress to using single letters for syllables and then for individual phonemes. In the beginning of the alphabetic stage, students typically use consonants only to spell words. In time, they begin to incorporate vowels into their spelling. Students typically employ two specific strategies at the alphabetic stage. In order to spell most consonants and long vowels, students use "a letter to represent the sound heard in the letter's name" (p. 111). For example, '*seat'* would be spelled *'SET.'* To help them spell short vowel sounds, children use the 'close to' approach; in this approach, students "use the long-vowel name that is closest to the point in the mouth where the short vowel to be spelled is articulated" (p. 111). When using this tactic, students might spell the word *'hit'* as *'HET'* because short *i* is articulated 'close to' the same place where the long *e* is formed in the mouth. As children are exposed to more written language, they begin to recognize certain conventions of written language. They then enter the third stage in the development of spelling; this stage is known as the consolidated alphabetic stage (or the within word pattern or orthographic stage). In this stage, children begin to deviate from relying solely on sound to guide their spelling and begin to incorporate orthographic rules into their spelling. For example, children in the consolidated alphabetic stage may begin to use double vowels and the final *e* marker. Johnson, Padak, and Barton (1994) refer to this third developmental spelling stage as transitional spelling; it is at this stage that children are usually beginning to read. In this stage, children begin to overgeneralize the spelling rules with which they have become familiar. For example, '*daisy'* may be spelled as *'DAYZEE'* (p. 360). Gunning (2008) classifies the final developmental spelling stages as syllable juncture and derivational constancy. It is in these stages that students are able to consistently use spelling conventions in order to spell multisyllabic words. Ultimately, children begin to incorporate visual aspects and word meanings into their spelling.

Gunning (2008) briefly addresses three abstract concepts that a child must grasp in order to be able to spell. First, students must understand that letters correspond with sounds. Next, children must be familiar with letter patterns in words; for example, at this level of understanding, children recognize the different ways to represent the long *e* sound. Finally, understanding that words have similar meanings can help guide children's spelling; for example, even though they have different pronunciations, words such as '*civilize*' and '*civilization*' have similar meanings and similar spellings.

Bouffler (1984) has identified ten strategies that people utilize in order to spell. In the first strategy, an individual uses auditory input in order to spell a word. In order to accomplish this, a person must have letter-sound relationship knowledge. The second spelling strategy is used primarily by children. Children still use phonetic information in this approach, but they overstress the sounds in the word which results in frequent inclusion of sounds that are not actually in the word. A third approach to spelling utilizes the 'close to' method in which children substitute sounds with sounds that are produced in similar places in the vocal mechanism. A fourth spelling strategy uses meaning to assist an individual in spelling. As previously mentioned, a person uses this strategy to spell words that have similar meanings. A person can also rely on his/her visual memory in order to spell a word correctly. However, when using this strategy, one is more likely to mix up or leave out letters in a word. In the sixth strategy, an individual uses a previously learned orthographic rule and applies it to the spelling of a new word. Spelling may also be influenced by the words around it. Laminack and Wood (1996) provide the example of the word '*any*' appearing under the word '*envelope*' being spelled as '*ENY*' (p. 15). Another spelling strategy involves using additional resources to spell a word. These resources can be other people or other written material (including reference books such as

dictionaries and thesauruses). Another strategy that a speller can use when he/she is faced with spelling an unknown word is to simply substitute another word that he/she does know how to spell in place of the unknown word. A final strategy is to let the reader decide if a word is spelled correctly. The writer simply spells the word the way he/she thinks that it should be spelled and essentially requires the reader to make a mental decision when reading the word about whether or not it is spelled correctly.

Sutcliffe, Dowker, and Campbell (1999) allege that a proficient speller is one who combines phonologic (or sound-based) information and orthographic (or spelling rule-based) information. In essence, when children are spelling, they are attempting to associate an expressive language with which they are already familiar (whether spoken or signed) and that language (or possibly another language, in the case of ASL-users) in print form (Mayer, 2007). Homer and Olson (1999) clarify this statement by saying that in order to achieve this association, children must unite expressive linguistic features (i.e. spoken or signed language) as well as "conventional print categories" (p. 418) (i.e. the rules of a written language). Mayer (2007) questions the extent to which an individual must be familiar with a language in order for spelling development to occur; however, she acknowledges that at least minimal familiarity is necessary. When a child is required to spell a word that he/she does not know how to spell, one strategy that he/she uses is to employ his/her rudimentary knowledge of sound-symbol relationships. This strategy often results in invented spellings. Mayer claims that invented spellings provide keen insight into a child's understanding of the connection between expressive and written language. Overall, invented spellings are driven by phonologic (or sound-based) information rather than orthographic (or spelling rule-based) information. Allman (2002) claims that invented spellings

are one way to assess a child's phonemic awareness, or a child's knowledge of the individual sounds in words.

Numerous articles have examined the extent to which deaf children have and are able to use phonological information. Geers (2006) asserts that a child who is deaf or hard of hearing has the unique dilemma of having an "incomplete spoken language system" (p. 244) as well as an impaired auditory sense (Allman, 2002). According to Miller (2005), a disadvantaged auditory sense includes considerably reduced speech perception; consequently, diminished speech perception results in impaired or relatively nonexistent phonological memory development. In other words, the ability to detect and discriminate individual sounds is impaired in children who are deaf because of their diminished perception of speech. These facts lead one to question how spelling develops in children who are deaf. In order to answer this question, one must analyze the characteristic features of spelling of children who are deaf or hard of hearing.

The research shows conflicting results as to whether children who are deaf follow a similar developmental trajectory as hearing children when learning to spell. Some research reports that spelling development is parallel in the two populations (Wakefield, 2006; Williams, 2004; Johnson, Padak, & Barton, 1994; Dodd, 1980). One study that reports similarities between spelling development for hearing impaired and hearing children was conducted by Dodd in 1980. Dodd found that the deaf subjects in her study "performed as well as a hearing control group" (p. 439) on various spelling tasks. She claims that even though deaf children have an impaired auditory sense, they can glean phonological information from visual information (i.e. lipreading). Dodd supports previous findings that say that "the phonological strategies used by deaf children are similar to those used by normal children" (p. 438). It is important to note that Dodd's subjects were pre-lingually deafened children who had profound deafness; Dodd does not

comment on their mode of communication nor their amplification devices, if applicable. Conversely, some studies report wide dissimilarities in regards to spelling development between the two populations (Allman, 2002; Mayer & Moskos, 1998). It is consistently documented that the spelling errors made by children who are deaf are different than the spelling errors made by hearing children. It is important to note that the majority of the research conducted with individuals who are deaf has primarily examined individuals who use sign language. These studies have yielded several characteristics of spelling in children who are deaf. One key feature of this spelling is the predominant use of visual information (Allman, 2002; Mayer & Moskos, 1998; Wakefield, 2006; Dodd, 1980). Conversely, hearing spellers tend to use phonological information (or sound-based) information when they spell, capitalizing on sound-symbol relationships.

Allman (2002) explored the visual information used by deaf children by examining the invented spellings of kindergarten and first-grade children who are deaf and use Total Communication (a combination of signed and spoken languages). Overall, Allman found that the deaf/hard of hearing children in his study seemed to employ a variety of visual strategies in order to spell words. These strategies included lipreading, signing, and fingerspelling. Lipreading (or noting the place of articulation for a word) can help deaf children determine vowel spellings in words. In regards to using the vocal mechanism to assist in spelling, Hanson (1986) observed that deaf individuals can use even inexact speech to help them approximate the written form of a word. Allman (2002) also reported that sign cues can assist children in spelling. They often use the information conveyed in an initialized sign to help them determine a word spelling. An initialized sign is one in which the first letter of the word is incorporated into the sign. Additionally, signs can help children determine word endings such as *'-ing'* and *'-ed.'*

Finally, Allman noticed that one of the most salient connections that deaf children have to print is fingerspelling. Padden and Ramsey (1998) highlight two specific techniques that make fingerspelling an advantageous tool to deaf spellers. In the first technique, called 'chaining,' a teacher fingerspells a word, points to the printed word, and then fingerspells the word again. In the second technique, called 'sandwiching,' a teacher signs a word, fingerspells the word, and then provides the sign for the word again.

Allman (2002) noted three general features about the spelling of children who are deaf. Firstly, rather than including only the first (and perhaps last) letters of a word (as hearing children typically do in the alphabetic stage of spelling development), the spelling of children who are deaf is more sequential. For example, they may write *'ROE'* for *'road'* (p. 54) rather than '*R*' or '*RD*,' thereby indicating that they visually remember some of the letters in the word but are not benefitting from the sounds in the word. Secondly, children who are deaf have a difficult time including vowel sounds, particularly long vowel sounds (which appear early in typical spelling development), in their written material. This is due in large part to the fact that long vowel sounds are difficult to see on the mouth, as the distinction between these phonemes is formed mostly by the tongue in the mouth. Thirdly, children who are deaf make consistent letter substitutions for letters that look similar on the mouth. For example, if a child uses lipreading in order to glean phonemic information, then he/she is likely to confuse phonemes such as /p/ and /b/ since the place of production for these two plosives is identical.

Harris and Moreno (2004) claim that "deaf children have difficulty in remembering ordered sequences of items that are phonologically encoded by hearing children, and relatively poor performance on [a short-term memory] task might indicate a difficulty with the deployment of phonological encoding" (p. 255). In other words, in order to spell a word correctly, an

individual must remember the specific order of letters within that word and that order is best remembered through verbal rehearsal; because individuals who are deaf are often unable to auditorily access speech sounds, then they must rely primarily on their visual memory of the word (whether how it looks in written format, when fingerspelled, or when pronounced on the mouth). Harris and Moreno looked at the prevalence of phonetic errors in the spelling of hearing as well as deaf children. Phonetic errors are errors in which a child "attempt[s] to represent all the sounds in a word but do[es] not respect the rules of English orthography when [he/she does] so" (p. 256). For the most part, the researchers found that the hearing subjects in their study made more phonetic errors in their spelling thus indicating that they were utilizing phonologic information when attempting to spell a word. The deaf subjects in their study made a larger percentage of non-phonetic errors thus leading the researchers to postulate that children who are deaf do not use phonologic coding to the same degree that hearing children do. Sutcliffe, Dowker, and Campbell (1999) studied deaf children from signing schools and similar to Harris and Moreno, they found that in general, the students made mostly non-phonetic spelling errors and regularly omitted consonants from their spelling. They also discovered that many of the words that their subjects spelled only included the first letter of the word. They concluded that this is most likely due to the use of initialized signs.

Mayer and Moskos (1998) conducted a longitudinal study that examined spelling development in deaf children, all of whom used some form of manual communication. They maintain that children who are deaf use visual-spatial information when recalling how to spell a word as opposed to hearing children who use speech/auditory information when recalling how to spell a word. Mayer and Moskos refer to the spelling strategy that hearing children use as an 'inner ear.' Conversely, they refer to the spelling strategy that deaf children use as an 'inner eye'

(p. 160). They identify three principle spelling strategies that deaf children use when attempting to spell a word: print-based, speech-based, and sign-based. When using a print-based strategy, a child is relying on his/her visual memory of printed letters and words. The researchers note that this strategy can be largely disadvantageous to children. Due to an inability for deaf children (specifically ones who do not use any form of amplification) to access sound-symbol relationships to decode a word (which results in a reliance on visual information), words are virtually meaningless. Rather than functioning as linguistic units that represent concepts, words are merely random strings of letters which results in words being more difficult to remember. Mayer and Moskos explicitly define speech-based information as "on the mouth information" (p. 170). The employment of lipreading as a strategy can help a child estimate the length of a word as well as determine the first consonant sound and perhaps even medial vowel sounds in a word. Finally, the children in the Mayer and Moskos study used a sign-based strategy, meaning that they capitalized on signed words that incorporate actual letters into the sign (such as the word *'class'* which uses the *c* handshape). While this strategy can at times be beneficial, it can also be detrimental to a deaf child's spelling. For example, the signed word *'drink'* uses the *c* handshape, therefore leading some deaf children to think that the written form of *'drink'* starts with the letter *c* (p. 172).

Mayer (2007) examined written language samples from deaf children, and through specific analysis of invented spellings found some predominant strategies that children who are deaf use when they are connecting spoken/signed language and written language. These strategies include "mapping handshapes onto English words, using lip patterns as cues to the beginning sounds of words, and linking finger spelling to text" (p. 418). In her assessment of the spelling of deaf children, Mayer notes the use of initialized signs to help determine a word's

spelling. She says that deaf children use the handshape to determine the first letter and then complete the word with random letters because the sign does not allow the child to make any more connections between the expressive (i.e. signed) form of the word and the written form. Mayer notes that this reliance on handshapes indicates an orthographic (or rule-based) concept of spelling because it signifies letter knowledge, a link between signed letters and written letters.

Wakefield (2006) examines the awareness that deaf children have of English spelling patterns by examining their spelling errors. She highlights the tendency of children who are deaf to use 'anagram'-like spelling. These types of errors are made when a child uses the "correct, or near-correct, selection of letters for a word" (p. 175) but writes them in the incorrect order, comparable to an anagram. For example, a child who makes an 'anagram'-like spelling error may write the word *'forest'* as *'FORSET.'* Similar to other researchers, Wakefield acknowledges deaf children's use of visual memory as a spelling aid. She specifically defines 'visual memory' as memory for "the word shape or the actual list of letters contained in the word" (p. 186). When deaf children make 'anagram'-like errors, Wakefield claims that they are heavily relying on visual memory to help them remember how to spell the word. Wakefield also reports that children who are deaf frequently omit consonants and make a larger percentage of non-phonetic errors in their spelling than hearing children. A non-phonetic, or phonologically implausible, error (in which the word is spelled in such a way that it is nowhere near the correct spelling) indicates that a child is not using "sound similarity" which demonstrates "no use of phonological coding" (p. 175).

The majority of the literature about spelling development in children who are deaf focuses on individuals who use sign language and who use either hearing aids or no amplification device at all. However, it is important to note that there are many

communication/educational options for individuals who are deaf. As a result, it is difficult to generalize spelling development research findings to all individuals who are deaf. Research addressing spelling in children who are deaf or hard of hearing and use cochlear implants is sparse at best. One study that looks at literacy development in children who use cochlear implants was conducted by Watson (2002). Watson predicted that children who are deaf and use amplification (specifically cochlear implants) in order to develop spoken language skills will have literacy (i.e. reading and spelling skills) development similar to hearing children. Watson examined the literacy skills of children who had received cochlear implants before the age of five years with the intent of discovering if profoundly deaf children have literacy skills that are equal to their hearing age-mates. However, it is important to note that Watson did not use a control group in her study; consequently, there was no group with which to compare the literacy results of her deaf subjects. Watson also did not address the communication method used by the participants in her study. Ultimately, she found that some of the deaf children in her study were able to use "phonological strategies . . . to guide their spelling [which] demonstrates an understanding of the English spelling system and the ability to use their hearing to make phonological representations for spelling" (p. 95). Based on some of the phonetically plausible spelling errors made by some of the deaf participants, Watson concluded that the cochlear implants that the participants use allow the children to access speech sounds and therefore make sound-symbol connections. In other words, Watson claims that a cochlear implant allows a deaf child to use phonological strategies (or strategies based on sounds) in order to spell. However, Watson failed to report any data or statistics for the alleged phonological errors; as a result, the literature regarding spelling in deaf children who wear cochlear implants is still severely limited.

Due to the "improved speech perception afforded by cochlear implantation," (Harris and Moreno, 2004, p. 254) children's spelling abilities should look more similar to their hearing peers than to peers who are deaf and who do not use cochlear implants. Additionally, children who are educated using the auditory-oral approach are taught to use their hearing abilities (afforded by amplification) to develop their spoken language and listening skills. As a result, they may be more attuned to phonological information (i.e. speech sounds). The current study compares the spelling abilities of children who are deaf and use cochlear implants and who are educated at an auditory-oral school to the spelling abilities of hearing peers.

Aside from assessing the accuracy/inaccuracy of the words that the participants spelled, the current study also focuses on a specific part of words: syllable-initial consonant clusters. The research on how children spell this particular word element has examined children with hearing. Treiman (1991) states that young children often omit the second phoneme of a syllable-initial consonant cluster because they "tend to treat the onsets of spoken words as units" (p. 346). In other words, young spellers have a tendency to use the first letter of a syllable-initial consonant cluster to represent the whole consonant cluster. For example, a young speller may write the word '*BOW*' for '*blow*.' Treiman acknowledges that "children who lack awareness of the separate phonemes in spoken words [(i.e. children who are deaf)] have difficulty learning and using relations between phonemes and letters" (p. 346). By omitting the second phoneme of a syllable-initial consonant cluster, a child is indicating that he/she lacks the phonemic awareness skills necessary to analyze the cluster into its constituent phonemes. Treiman's research supports that this is a developmentally-appropriate error for young spellers to make.

The purpose of the current study is to answer the following two questions: 1) How well do children who are deaf and use cochlear implants spell words as compared with hearing

children of the same age? And 2) What types of errors do children who are deaf and use cochlear implants make on a specific part of words (i.e. syllable-initial consonant clusters), and how do these errors compare to what the literature has reported on hearing children? The researcher chose to investigate consonant clusters because the spelling errors made by the deaf children might reveal some information about if they use phonological information in spelling. For example, a syllable-initial consonant cluster spelled with an interior omission error (such as spelling '*blow*' as '*BOW*') is a developmentally-appropriate error for hearing children to make and is viewed as a partial phonological error.

Method

Participants

Twenty subjects (10 males, 10 females) participated in this study. The participants of this study were children between the ages of 5 and 9. These children had either unilateral or bilateral cochlear implants. The participants were recruited from local auditory-oral schools for children who are deaf; consequently, their primary mode of communication was spoken language.

Materials

The experimenter administered the Woodcock Johnson Psychoeducational Battery-III Tests of Achievement, subtest seven (Spelling) (2001) to each participant individually in his/her school setting. The examiner recorded the correctness/incorrectness of the child's responses on a protocol form. The child recorded his/her responses on his/her own protocol form. Each child was given a sticker at the end of the testing session as a reward.

Procedure

Two local auditory-oral schools were contacted and asked if they would agree to participate in the current study. Once they granted permission, the schools provided a list of

those children eligible to participate, based on the pre-determined participant criteria. Letters describing the study were sent home to these children's parents/guardians by the researcher (*see Appendix A*). If parents/guardians agreed to have their child participate in the study, then they returned a signed consent form (*see Appendix B*) to the child's school, who in turn gave it to the experimenter. The letter and the informed consent forms described the task and assured participant anonymity.

Each participant was tested individually at a convenient time (previously established with the child's classroom teacher) at the child's school. The researcher informed the child that he/she would be writing some words. The researcher also told the child that if he/she wanted to take a break or stop at any point, then he/she could do so. Depending on the child's age, the researcher began the test at a variable start point determined by the test. Depending on the starting point, the child was instructed to copy a series of evaluator-made markings and letters. The evaluator then directed the child to independently write specific letters (capital and lower case) and then to spell specific words. For each word, the evaluator asked the child to spell the word, dictated an example sentence containing the word (provided by the test), and then repeated the word. The basal score was six correct items; the ceiling was six incorrect items. After the child answered six consecutive items incorrectly, the examiner stopped the test. Following the testing session, each subject was offered a sticker in exchange for his/her participation.

Results

The responses from each child were assessed using software that was provided by the Woodcock Johnson Psychoeducational Battery-III Tests of Achievement. This software compared the results for each participant to a normative group of hearing children. The

chronological age of each participant was recorded so that he/she was compared to hearing age-mates from the normative group.

The mean standard score for all of the participants was 100.6, with 100 being the average score for hearing children, with a standard deviation of 15 (*see Appendix C*). Spelling age equivalence was also reported for each subject. The average difference between the chronological ages and the spelling age equivalent scores for all of the subjects was 0.48 months (*see Appendix D*). In other words, children scored, on average, 0.48 months better than what would be expected for their chronological age. The chronological ages and the age equivalent scores for each child were set up as ratios. A ratio of 1.0 indicated complete age-appropriate performance. The mean ratio between the children's age equivalent scores and their chronological ages was 1.02. This indicates that, on average, the subjects were achieving age-appropriate spelling skills. However, it is important to note the wide variability within the current sample. Overall, 11 participants (55%) had a ratio of 1.0 or higher (or had age equivalent scores that were higher than their chronological ages), indicating that they were achieving at or above age-appropriate spelling skills. Nine participants (45%) had a ratio of less than 1.0 (or had age equivalent scores that were lower than their chronological ages), indicating that they were achieving below age appropriate spelling skills.

A specific error analysis was conducted on words containing syllable-initial consonant clusters. The spelling subtest of the Woodcock Johnson Psychoeducational Battery-III Tests of Achievement contained five words with syllable-initial consonant clusters: /gr/ in '*green*,' /fl/ in '*floor*,' /pl/ in '*plain*,' /kr/ in '*crystal*,' and /kr/ in '*concrete*.' Because some of these words occurred later in the test list, not all of the children spelled all of these cluster words. In all, 30 cluster spellings were examined. Twenty-one of these words were spelled correctly, and nine

were spelled incorrectly. It is important to note that for these words, the only portion that was judged as correct/incorrect was the syllable-initial consonant cluster; the remainder of the word was not assessed. The researcher did an error analysis on the syllable-initial consonant cluster words that were spelled incorrectly. These words were assessed for internal omissions (i.e. the second consonant was omitted), external omissions (i.e. the initial consonant was omitted), and other errors (i.e. errors that did not fall into either of the aforementioned categories). Of the nine incorrect cluster spellings, seven of the errors were internal omissions. For example, one subject wrote the word '*GEEN*' rather than writing the word '*green*.' Of the nine incorrect cluster spellings, none of the errors were external omissions. Finally, of the nine incorrect cluster spellings, two of the errors were categorized as 'other' errors. These errors did not seem to follow a specific pattern. For example, rather than writing the word '*green*,' one subject wrote the letter '*T*.'

Discussion

This study proposed two questions. First of all, how well do deaf children with cochlear implants spell words as compared with hearing children of the same age? Because the Woodcock Johnson Psychoeducational Battery-III Tests of Achievement is normed on typically-developing, hearing children, it is possible to address this question based on the resultant standard scores as well as the age equivalent scores. Based on the average standard score of 100.6, the participants scored within the average range for hearing children of the same age (based on an average range of 85-115) for their spelling abilities. It is important to note that 100.6 is the *average* score, and not all subjects fell within the average range. The range for the standard scores of all the subjects was 58-127, thus indicating that there was considerable variability within the sample. It is also important to notice that on average, the participants of

the current study performed at 0.48 months above the developmental spelling level where their hearing age-mates typically perform. In other words, on average, the subjects had spelling abilities that were slightly higher than their hearing age-mates. Again, this is an average score. Fifty-five percent of the subjects achieved at or above age-appropriate spelling skills, which is only a slight majority. Forty-five percent of the subjects achieved below age-appropriate spelling skills.

These findings have implications for teachers and other professionals in the field of oral deaf education. Young hearing children use phonological awareness (or sound-symbol relationships) in order to help them spell. The standard scores and the age equivalent scores show that the subjects of the current study performed, on average, similarly to hearing children in regards to spelling abilities. Therefore, it follows that these children are quite possibly using the speech perception abilities afforded to them by their cochlear implants in order to access sound-symbol relationships (i.e. phonological awareness) and thus assist them in spelling. However, it is important to reiterate that there was considerable variability within the current study's sample. Not all of the deaf subjects performed similarly to their hearing age-mates, even though they used the amplification technology of cochlear implants. Further research is needed to determine spelling success in children who are deaf and use cochlear implants in order to assess the extent to which they are able to access and use phonological information to help them spell accurately.

The second goal of the current study was to address the types of errors that deaf children with cochlear implants make on a specific part of words (i.e. syllable-initial consonant clusters), as well as to address how those errors compare to what the literature has reported on hearing children. According to the results of the current study, children who are deaf made, on average,

similar errors to hearing children when attempting to spell syllable-initial consonant clusters. Of the nine cluster errors, seven were internal consonant omissions, meaning that 78% (or the vast majority) of the cluster errors were second phoneme omissions. None of the errors were external consonant (or first phoneme) omissions. The current results support Treiman's (1991) findings that children treat syllable-initial consonant clusters as a single unit and typically represent only the initial consonant. Similar to the hearing subjects in Treiman's study, the deaf subjects in the current study omitted the second phoneme of a syllable-initial consonant cluster thereby possibly indicating that they possess phonemic awareness skills that are similar to young children. Two of the total errors were categorized as 'other' errors. It is possible that these errors could have been due to the child mishearing or misunderstanding the target word's pronunciation. For example, one child wrote the letter '*T*' when instructed to spell the word '*green*'; both the letter '*t*' and the word '*green*' contain the vowel sound /i/ which could have led to the subject's confusion. Another example of an error that was classified as 'other' was the misspelling of the word '*green*' as '*PEEN*.' It is quite possible that this particular speller merely transposed the letter '*g*' into the letter '*p*' and therefore actually made an internal omission (by omitting the '*r*'). In regards to syllable-initial consonant cluster errors, it is unclear whether or not the children in the current study made these errors because they "lack awareness of the separate phonemes in spoken words" (Treiman, p. 346) or because of their impaired auditory abilities which may result in an inability to detect all of the constituent phonemes in a word. Further research is needed to address this issue. Regardless, a hearing child who makes an interior omission error in a syllable-initial consonant cluster does so because he/she is hesitant to segment the two sounds that comprise the cluster, and he/she at least represents one of the two consonants. The results of the current study (i.e. that the deaf children made mostly interior omission errors) are positive

because they reveal that, in general, the deaf subjects of the current study are making errors that young hearing children make. They are at least representing one of the two *sounds* as opposed to making visual errors (as other studies have found) or using random strings of letters.

Although this study yielded several noteworthy results, there are some limitations. First of all, the sample size (20 participants) was somewhat limited. Additionally, there were many variables that should, if possible, be controlled for such as: age of hearing loss identification, age at amplification/implantation, number of cochlear implants, number of years in an auditory-oral setting, etc. In regards to the test that was used in the current study, it is possible that the sentences that were provided for each spelling word did not actually serve their intended function of clarifying the spelling word but rather confused the child as to what word he/she should be spelling.

Because of the extremely limited research conducted on spelling abilities in deaf children who use cochlear implants, this study is a preliminary one. Because of this, it is difficult to generalize the findings due to the limitations of the study as well as the need for more research. However, the researcher speculates that if deaf children who use cochlear implants perform similarly to the average standard scores as well as the average age equivalent score ratios from the current study, then it would appear that they are able to use phonological information and thus possibly develop spelling skills in a trajectory similar to their hearing age-mates.

Appendix A

Dear Parent(s),

My name is Laura Houston, and I am a second-year graduate student in the Washington University School of Medicine Program in Audiology and Communication Sciences. I will be graduating with a Master of Science degree in Deaf Education in May, 2009. I am conducting a research study in order to fulfill the degree requirements of my program. The title of my research study is "Spelling Errors in Children Who Are Deaf."

The overall purpose of this research is to study the spelling skills of children who are deaf who wear cochlear implants and to compare them with the skills of hearing children. If you choose to allow your child to participate in this study, your child will be asked to complete a standardized spelling test, which will involve your child copying a series of test administrator-made markings (ranging from lines to letters). Your child will then be required to write words dictated by the test administrator. The amount of time required for your child's participation will be approximately 10 to 20 minutes, and your child will receive a small gift, such as a sticker or pencil, for his/her participation. The testing time will be carefully scheduled with your child's teacher so that your child does not miss any important classroom activities.

Thank you in advance for your interest in this research study. If you would like for your child to participate in this study, please sign and return the enclosed consent form to your child's teacher by **Friday, February 13th**. If you have questions or would like further information, please contact me at houstonl@wusm.wustl.edu or (901)489-0030.

_____ _____

Laura Houston *(Project Director)* Lynda Berkowitz, M.S. *(Faculty Advisor)*

Appendix B

Washington University in St. Louis

CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES

Title of Project: Spelling Errors in Children Who Are Deaf

HRPO Approval Number: 09-0057

Research Description

Your child is invited to participate in a research study conducted by Laura Houston, a graduate student in the Program for Audiology and Communication Sciences, and under the direction of faculty member Lynda Berkowitz. The overall purpose of this research is to study the spelling skills of children who are deaf who wear cochlear implants and to compare them with the skills of hearing children. During this study, your child will be asked to complete a standardized spelling test, which will involve your child copying a series of test administrator-made markings (ranging from lines to letters). Your child will then be required to write words dictated by the test administrator. The amount of time required for your child's participation will be approximately 10 to 20 minutes, and your child will receive a small gift, such as a sticker or pencil, for his/her participation.

Risks and Benefits

There are no known risks or benefits associated with the research other than the extra practice in writing that your child will receive, and the knowledge that your child's participation enhances the knowledge of spelling skills in children who are deaf.

Voluntary Participation

Your child's participation is entirely voluntary and you may choose not to participate in this study or withdraw your consent at any time. Your child will not be penalized in any way should you choose not to participate or withdraw. If you do consent to your child participating in this study, your child will be asked to participate and will be given an oral description of the study before testing begins. At that time, s/he will be given the opportunity to decline to participate and will be told s/he may withdraw from the study at any time.

Alternative Therapies

Sometimes there are alternatives to participating in research. Certain studies, such as those that involve a therapy or intervention, are examples of when alternatives might be available. Because this study does not involve an intervention or treatment of any kind, no alternatives are offered.

Privacy and Confidentiality

We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication that may result from this study. Testing will be conducted with teacher permission at your child's school during school hours. All information will be kept in a locked filing cabinet in the office of the research study faculty advisor, Lynda Berkowitz, at Central Institute for the Deaf. In rare instances, a researcher's study must undergo an audit or program evaluation by Washington University or an external oversight agency (such as the Office for Human Research Protection). This may result in the disclosure of your data as well as any other information collected by the researcher

Contact Information

If you have any questions or concerns regarding this study or feel that you have been harmed in any way by your participation in this research, please contact Laura Houston 901-489-0030 and/or Lynda Berkowitz 314-977-0120.

If you wish to talk with someone else or if you have questions about your rights as a research participant, please call Dr. Philip Ludbrook, Executive Chair of Washington University's Human Research Protection Office, at 314-633-7400 or 1-800-438-0445.

I/we have read this consent form and have been given a chance to ask questions. I/we also will be given a signed copy of this form for my/our records. I/we agree to allow my/our child to participate in the research study described above, titled "Spelling Errors in Children Who Are Deaf."

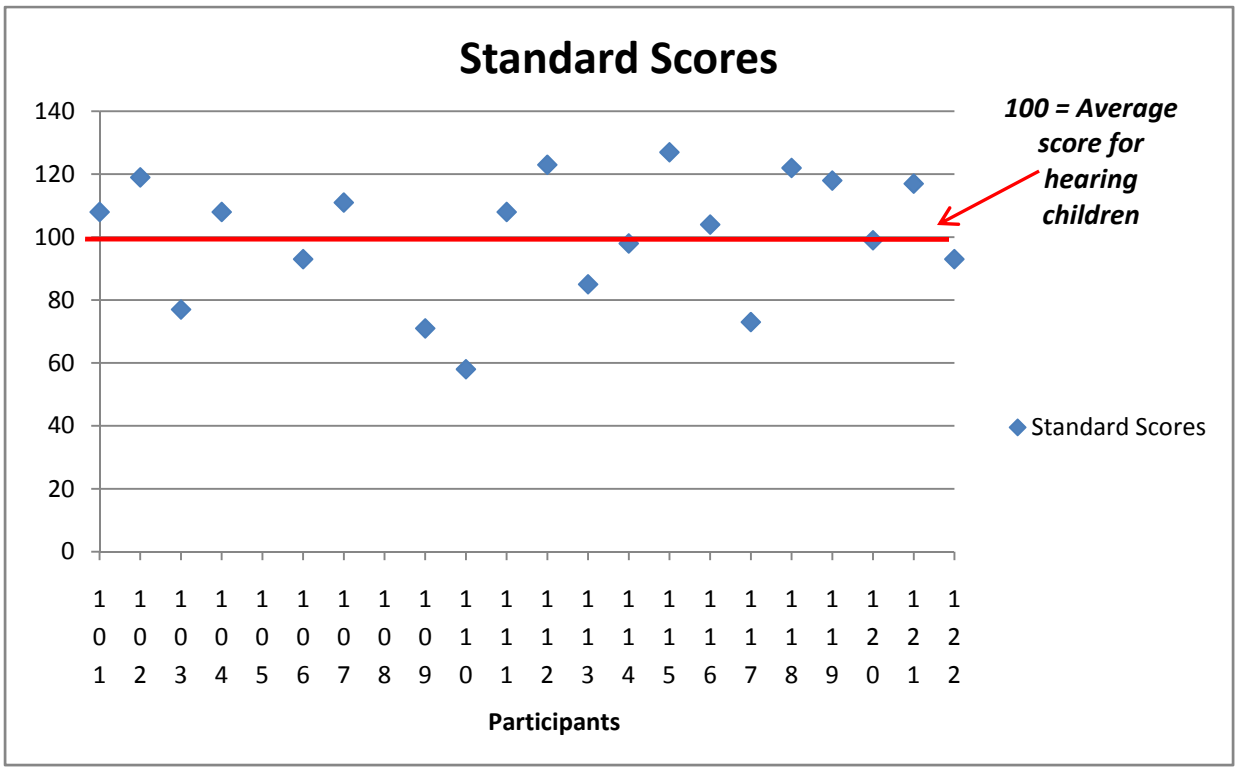
Parents, Guardian, or Legally Authorized Representative's consent on participant's behalf.

Signature	Date
Printed Name	Relationship to research participant
Signature	Date
Printed Name	Relationship to research participant
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

This form is valid only if the Human Research Protection Office's current stamp of approval is shown below.

Washington University
Human Research Protection Office
Protocol Approved 1/23/09
Approval Terminates 1/22/10
Federal Regulations Permit No Grace Period

Appendix C


Standard Scores
140
120
100
80
60
40
20
0
100 = Average score for hearing children
Standard Scores
101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122
Participants

Appendix D

Age Equivalent	Chronological Age	Difference	Ratio	(+/-) 1.0
6.17	5.75	0.42	1.07	+
7.17	6.25	0.92	1.15	+
5.92	7.25	-1.33	0.82	-
6.75	6.33	0.42	1.07	+
5.67	6.08	-0.41	0.93	-
6.75	6.17	0.58	1.09	+
6.33	8.08	-1.75	0.78	-
4.75	7.33	-2.58	0.65	-
7	6.67	0.33	1.05	+
6.75	5.5	1.25	1.23	+
6.92	7.75	-0.83	0.89	-
7	7.17	-0.17	0.98	-
8	6.67	1.33	1.20	+
5.92	5.67	0.25	1.04	+
6.33	7.92	-1.59	0.80	-
7	5.92	1.08	1.18	+
6.75	5.83	0.92	1.16	+
7.83	7.92	-0.09	0.99	-
11.08	8.5	2.58	1.30	+
7.83	8.33	-0.5	0.94	-
	Mean	0.0415	1.02	
		(in real numbers)		
		equivalent to: 0.48 months		
N kids achieved AE at or greater than CA			11	0.55
N kids achieved AE less than CA			9	0.45

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