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Language Associations with Literacy Achievement in Children with Cochlear Implants

Trisha Christine Noble
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To the Graduate Council:

I am submitting herewith a thesis written by Trisha Christine Noble entitled "Language Associations with Literacy Achievement in Children with Cochlear Implants." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Speech Pathology.

Ilsa Schwarz, Major Professor

We have read this thesis and recommend its acceptance:

Peter Flipsen, Mark Hedrick

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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LANGUAGE ASSOCIATIONS WITH LITERACY ACHIEVEMENT IN CHILDREN WITH COCHLEAR IMPLANTS

A Thesis
Presented for the
Master of Arts
Degree
University of Tennessee, Knoxville

Trisha Christine Noble
May 2007

ABSTRACT

In order to succeed in normal academic environments, reading is a critical skill for children to develop (Catts, Fey, Proctor-Williams, 2000; Musselman, 2000). Unfortunately, literacy development is often delayed in children with hearing impairment (Harris & Beech, 1998). The purpose of this research was to advance the understanding of language and speech variables that predict literacy acquisition in children with cochlear implants. Participants in this study included children with severe or profound hearing impairments, ages 6;4-8;11 who received their cochlear implant before 3 years and 6 months of age. A battery of language, cognitive, reading, spelling and speech reading tests was administered at the University of Tennessee's Child Hearing Services. Results, although limited by a small sample size (n=5) found elision (eliminating a syllable or phoneme in a word) to be associated with basic reading skills, as measured by the *Woodcock Reading Mastery Test-Revised* (Woodcock, 1998). Further research is necessary to expand this pilot study. Skills that were not associated with basic reading ability included vocabulary development, rapid naming, speech reading and spelling.

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CHAPTER ONE: INTRODUCTION

Hearing Impairment

It is estimated that congenital hearing loss occurs in approximately 1-3 of every 1000 live births, resulting in an estimated 28 million people in the United States having a hearing impairment (Centers for Disease Control and Prevention [CDC], 2003). Congenital hearing loss can be an inherited genetic trait, or it can be a result of numerous prenatal, perinatal and postnatal factors, including malformations of the outer and inner ear, trauma during birth, and infections can result in congenital hearing loss (Bradford & Hardy, 1979).

Hearing loss is described as being mild, moderate, severe and profound, based on the degree of hearing loss. A mild loss describes a loss of 15-40 dB HL, a moderate loss in within 40-60 dB HL, a severe loss ranges from 60-90 dB HL and profound refers to a hearing loss of 90 dB HL and greater. Most speech occurs in the 0-65 db HL range (Spivak & Sokol, 2005).

Universal newborn screenings have helped identify children with hearing impairments at earlier ages (Jerger, Roeser & Tobey, 2001). Early identification of a hearing loss by 6 months, with appropriate intervention, often results in the child developing language abilities comparable to their peers with normally developing hearing (Yoshinaga-Itano, Sedey, Coulter & Mehl, 1998). Hearing loss can also be progressive, resulting in late identification of a hearing loss. Once a hearing loss has been diagnosed, it is important to quickly begin the habilitation process. Approximately 90% of children with hearing impairment are born to parents with normal hearing (Mitchell & Karchmer, 2004), and the majority of these parents will seek out aural/oral habilitation to help their children develop speech and language (Spivak & Sokol, 2005).

Educators must be aware of the language deficits associated with hearing loss, which can affect a child's academic performance and development. One problem often associated with hearing loss is the inability of these children to benefit from incidental learning. They have trouble "overhearing" speech that is not directed specifically towards them.

A hearing loss can also fluctuate, which results in the same word sounding dissimilar at different times to the listener with a hearing loss. The distance between the speaker and the listener also affects how clearly and accurately the child with the hearing loss will hear and understand the intended message. In a classroom, the teacher may walk around the classroom, and background noise can interfere with the teaching. These issues can negatively affect the language development of a child with a hearing loss.

Hearing Aids

Hearing aids are amplification devices used to make sounds audible to a child with a hearing loss. They amplify the sound before the sound travels to the cochlea via the middle ear. Hearing aids are suggested for use in children with mild (15-40 dB HL), moderate (40-60 dB HL) and severe (60-90 dB HL) hearing losses. Digital hearing aids are becoming the preferred choice of hearing aids, due to advancements in technology. Digital hearing aids allow for reprogramming to occur, so that the amplification best fits the potentially changing needs of a child, and gains are automatically adjusted in relation to the environment (Spivak & Sokol, 2005).

Cochlear Implants

Cochlear implants are surgically implanted internal devices that directly stimulate the auditory nerve. Cochlear implants are suggested for use in children with a severe-to-profound and profound hearing loss (90 dB HL and above) (Spivak & Sokol, 2005). A cochlear implant picks up the sound, and converts the acoustic information into a digital format. The external device transmits the digital information to the internal device via a transcutaneous link. The internal device then converts the digital information into an electrical signal. The electrical signal travels through the electrodes to stimulate the auditory nerve. Recently in 2000, the U.S. Food and Drug Administration approved cochlear implantation in children with a profound hearing loss as young as 12 months of age (Food and Drug Administration [FDA], 2001).

Literacy

In order to succeed in typical educational environments, children must develop the ability to read (Catts, Fey & Proctor-Williams, 2000; Musselman, 2000). Reading, or literacy, is a common term that most people understand, but few can clearly define. It is a process that is likely made up of several components that work together to produce an integrated outcome (Adams, 1990). Several models have attempted to break reading down into its components (Adams, 1990; Chall, 1979; Gough & Tunmer, 1986), and these models detail the necessary skills a child must develop to become literate. Literacy skills are often heavily targeted during the first and second grade, and preliteracy skills are addressed during the earlier preschool age (van Kleek, 1998).

Research has shown that letter knowledge, print conventions, syllable segmentation, rhyming and phoneme segmentation are all important literacy skills for children to acquire (van Kleek, 1998). However, knowing how to rhyme or segment syllables and phonemes does not ensure a child will learn to read without any difficulties. A stronger preliteracy skill base prior to reading may result in a better outcome of a child learning to read (van Kleek, 1998). The integrative component of preliteracy and literacy skills makes it difficult to determine the necessary skills for a child to develop into a fluent reader.

Models of Reading

Gough and Tunmer: A simple view of reading

One model that has been proposed to describe the components that make up the foundations of literacy is the simple view of reading (Gough & Tunmer, 1986). This model of reading development has broken reading into the primary components of decoding and language comprehension. The model stresses the interactive qualities of both components, resulting in an outcome of reading [See Figure 1].

Decoding, the first main component of the simple view of reading model is divided into cipher and lexical knowledge. Cipher knowledge refers to the ability to recognize the relationship between letters and sounds. Children learn that the letters "a," "b," and "c" all have specific corresponding sounds that they represent. "b" always makes the /b/ sound when it is found in a word. This allows a person to recognize words never read, although the meaning is comprehended from an earlier auditory exposure.

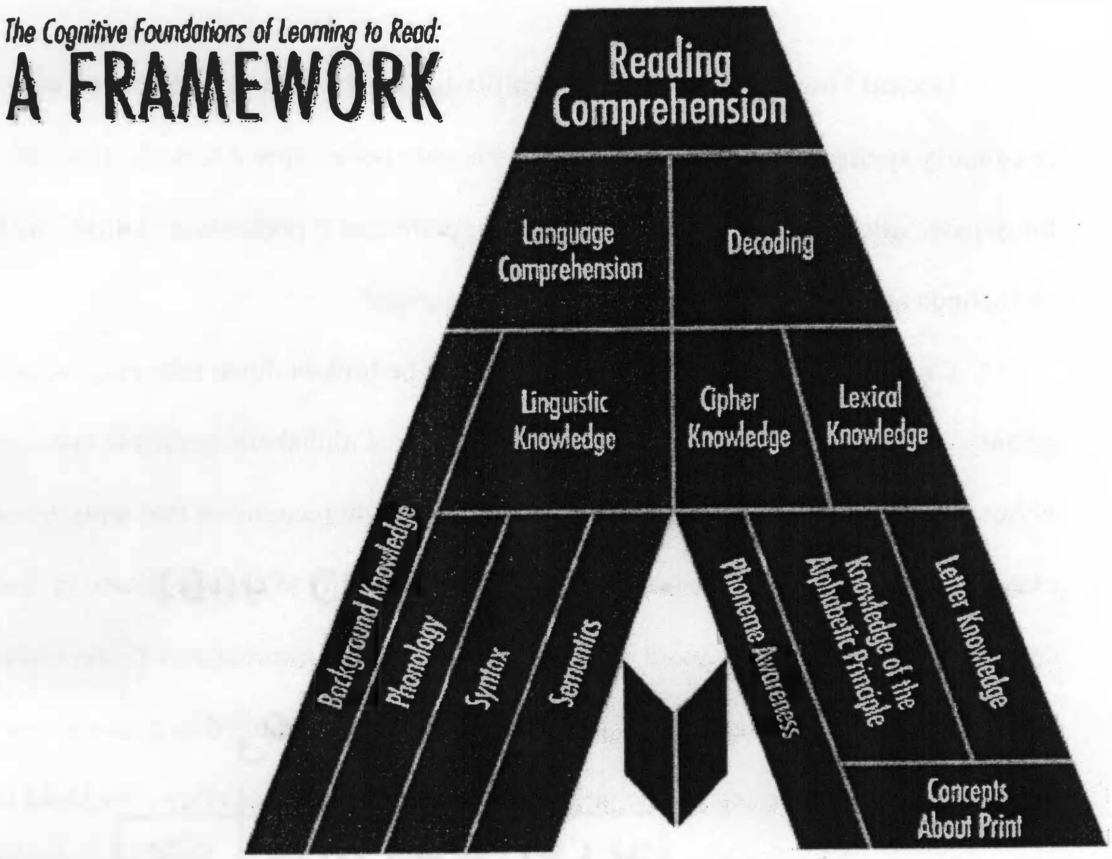

Figure 1: The Simple View of Reading

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Lexical knowledge refers to the ability to link the meaning of a word with an irregularly spelled word. The word "lotion" is not spelled how it sounds. Lexical knowledge allows the child to recognize this spelling as representing "lotion," although the sounds and letters used are irregularly represented.

Cipher and lexical knowledge can further be broken down into categories of phonemic awareness, letter knowledge, knowledge of alphabetic principle and concepts about print. Phonemic awareness occurs when the child recognizes that word meanings change by changing specific sounds in a word. The ability to change the /b/ in "bat" to /m/ to create "mat," a new word, demonstrates phonemic awareness. Children often have to be explicitly taught that letters can be taken away or rearranged to create a new word. Words may be memorized as one unit, but phonemic awareness allows the child to manipulate the letters and sounds to break up the word unit (Hoover & Gough, 2006).

Letter knowledge includes recognition of the letters in the alphabet. Children learn the name for each symbol represented in the alphabet. Knowledge of the alphabetic principle is necessary for word decoding. Knowledge of the alphabetic principle develops as a child discovers that there is a relationship between the spoken and written word. Specific letters combined to form a word require a specific sequence of phonemes. "Kite" is always spoken aloud as /kaIt/.

Finally, concepts about print refer to the understood relationship between written and spoken words. This is an important concept to understand in order to transform written letters on a page into a symbolic language used to communicate (Catts, Adlof, & Ellis-Weismer, 2006). Spatial concepts about print are also important to understand where words are placed on a page, and how letter and word order are important to convey meaning (Hoover & Gough, 2006). Children learn to read from left to right, and they learn to place letters sequentially from left to right to create a word. Children also learn that words can be segmented into syllables (i.e. "base-ball", as opposed to "ba-seball") to retain meaning.

The second main component of the simple view of reading is language comprehension, which is divided into background and linguistic knowledge. Language comprehension is important in order for the reader to derive a message from the printed words (Catts et al., 2006). Background knowledge includes the content, or substance, of what is being communicated, as learned during the acquisition of spoken language. It is the message being conveyed. Linguistic knowledge refers to the process of using language to communicate. It is *how* the message is being conveyed.

Linguistic knowledge is then subdivided into phonology, semantics and syntax. Phonology refers to the sound structure of words, which can be manipulated to change meaning. Children beginning to read must learn the phonological rules that govern the way sounds and letters are combined to create words. Specific sounds often follow one another, and others never appear together. Syntax refers to the grammatical rules that govern sentence structure. Grammatical structure, such as what order words follow in a sentence, is included in syntax. Children must learn the relationships between nouns, verbs, adjectives, adverbs, direct objects, and many other categories of words in order to effectively communicate and decipher texts.

Semantics refers to the meanings of words. The child's lexicon is described through semantics. The words a child comprehends and uses makes up the child's lexicon.

According to Catts et al. (2006), the simple view of reading is a framework that may be used to identify a child's area of deficit that affects their overall reading ability. Once the area is identified, intervention can target this area to remedy the deficit. Catts et al. also propose that this model may allow for the early identification of language comprehension and decoding deficits. Early identification allows for early intervention before any reading deficits negatively affect the child's language and literacy acquisition.

Adams

Adams (1990) has presented a related model of reading development. This model attempts to describe the preliteracy process that lays the foundation for future reading abilities. The Adams model consists of four components, including an orthographic processor, a phonological processor, a meaning processor and a context processor. These components are considered integrated in the "fluent reader" (van Kleek, 1998, p. 34), but they develop in a loosely independent method, with reading fluency improving as the components become more integrative in function.

The orthographic processor is responsible for recognizing printed letters and the phonological processor is responsible for recognizing phonemes, or the sounds that make up words. Adams describes how the phonological processor "provides an alphabetic backup system" (p. 159) for word recognition and it allows for the deciphering of unfamiliar words. The orthographic processor develops as letters become familiar to the child, and the child begins to learn that the letters represent a meaning. The meaning processor is responsible for identifying the semantic information about a word, including the definition. The context processor is responsible for evaluating the comprehensive background in which to comprehend the meaning (Adams, 1990). The context processor uses information gathered from experiences and world knowledge. As the child develops, his experiences provide new opportunities for language development.

Van Kleek (1998) describes how the four components of Adam's model become more integrative. Initially, reading is introduced in meaningful contexts. The meaning processor and orthographic processor develop as word awareness increases along with print conventions. Children learn with repeated exposure that the auditory knowledge of letters and words are associated with printed letters and words. The phonological processor becomes integrated with the meaning and orthographic processors in the process as children learn how to manipulate sounds and letters to create new words. As children develop, their experiences contribute to their exponentially increasing knowledge through incidental and independent learning. The context processor becomes integrated with the other processors as a child's experiences increases and becomes associated with vocabulary, words and meaning.

Chall

A final model of reading development is one presented by Chall (1979). Chall described six stages (stages 0 through 5) of reading, with the first being a pre-reading stage. Chall describes how children progress through these stages as they develop into literate communicators. Chall's (1979) model of reading stages allows one to descriptively describe the level of maturity in reading a child has acquired. The term "reading" is very general, and Chall describes how her stages allow a more detailed analysis of a child's reading skills. The stages provide an outline of the components of reading (decoding, fluency, comprehension, synthesis of ideas) for one to categorize a child's reading.

In stage 0, the child is exposed to the alphabet through multiple sources in their environment. Books, signs, newspapers, and numerous other resources provide examples of letters and words. Visual and auditory perceptual skills are being developed during this pre-reading stage.

In stage 1, the child relies on their specific world knowledge as they are learning the organization of the language's syntax and semantics. A letter and sound relationship is discovered by realizing that specific letters represent certain sounds. Chall described this decoding stage as being a "guessing and memory game" (p. 39).

In stage 2, the reader progresses from developing decoding skills to improving fluency. This is demonstrated when children read a familiar text, and they can concentrate on specific word structures and meaning, since they already know the story.

During stage 3, the reader is beginning to "read to learn (Chall, 1979, p. 40)," as they learn to derive "meaning from print (Chall, p. 40)" and "print from meaning (Chall, p. 40)". This is evidenced as the reader understands that printed words convey meaning, as well as being able to translate ideas into printed words to convey an intended message. During this stage, the reader learns how to find information in the text.

During stage 4, the reader learns to synthesize information from multiple viewpoints. The reader adds additional information about topics previously learned. In the fifth and final stage, abstract ideas are analyzed and comprehended from text. The reader is able to determine what they need to read in order to gain the necessary knowledge they are seeking through reading. The reader can skim through a text, reading the key passages that are necessary for a comprehensive understanding of the subject.

Reading abilities in children with hearing impairment

The models of reading acquistion developed by Gough and Tunmer (1986), Adams (1990) and Chall (1979) attempt to explain how reading develops in children with normal hearing. They do not explicitly address hearing in their models, but appear to assume that hearing is intact for typical reading to develop. Questions arise when determining what impacts reading development when the auditory system is impaired. It is well documented that children with hearing impairment are at risk for developing reading deficits (Conrad, 1979; Harris & Beech, 1998; Connor & Zwolan, 2004; Harris & Moreno, 2006). They may graduate high school with reading skills equivalent to students in elementary school (Allen, 1986; Holt, 1994).

Research has shown there are several factors that influence the ability to read for a child with a hearing impairment, including the severity of hearing loss and the type of amplification (Connor & Zwolan, 2004). Research has also shown that a relationship exists between language development, literacy and writing abilities (Catts, et al., 2000). This relationship reinforces the importance of each skill, since a deficit in one area will affect the other areas. Vocabulary, syntax, discourse, phonological processing skills and memory all have been suggested as factors that may influence reading abilities in children with hearing impairment (Harris & Beech, 1998).

Spencer, Barker and Tomblin (2003) describe how readers who do not advance to the stage of "reading to learn" (stage 3 in Chall's (1979) model) are unable to develop the higher-level comprehension and analytical skills necessary to be able to synthesize information from several different viewpoints. Because of the integrative nature of all of the skills necessary for reading, and due to individual variables, it is often difficult to determine what factors significantly hinder children with a hearing impairment from developing reading skills that are similar to those of children with typical hearing.

The reading development for children with a hearing impairment is often contrasted with that of children with typical hearing. Researchers attempt to determine what components hearing impaired children are lacking, so that intervention can target these deficit areas. There is debate whether children with hearing impairment learn to read using the same literacy and preliteracy components as children with typical hearing, or if they employ alternative strategies to develop literacy skills (Musselman, 2000).

CHAPTER TWO: LITERATURE REVIEW

Hearing impairment and literacy

A number of studies have been reported that attempt to describe the relationship between hearing impairment and early literacy (Andrews & Mason, 1991; Connor & Zwolan, 2004; Geers, 2002; Harris & Beech, 1998; Harris & Moreno, 2006; Musselman, 2000; Spencer, Barker & Tomblin, 2003; Sterne & Goswami, 2000). According to Musselman (2000), educators hold opposing viewpoints about how children with a hearing impairment learn to read. Some believe that children with hearing impairments learn to read using the same decoding and comprehension strategies as do children with typical hearing. However, others have argued that children with a hearing impairment develop and use different strategies to acquire literacy skills.

Alternative strategies possibly used to develop literacy skills include using an orthographic code (visual processing) or a speech perception code (speech reading) (Harris & Moreno, 2006). Phonological awareness, context and semantics are also important skills that are necessary for children with a hearing impairment to develop in order to acquire typical reading skills, as compared to children with typical hearing.

Speech reading

Arnold and Kopsel (1996) administered a test battery looking at reading, speech reading, visual memory and rhythm to: 1.) a group of children with typical hearing, 2.) a group of children with hearing impairment educated orally and 3.) a group of children with hearing impairment educated using total communication. Both the group with typical hearing and the group with a hearing impairment educated orally scored similarly on the speech-reading task. Speech reading did correlate with reading in the group with a hearing impairment educated orally, although no correlation was found for the group with typical hearing. These results suggest a relationship between speech reading and phonological coding may exist for children with a hearing impairment, stemming from a possible relationship between reading, speech and speech reading.

Alegria and Lechat (2005) completed a study looking at speech reading in children with hearing impairment who use cued speech. They wanted to observe how the visual and auditory information would be processed together. All of their participants were prelingually and profoundly deaf, and they all wore binaural hearing aids. The results indicated that speech is multimodal and that speech reading added to other visual cues (cued speech) to assist the participants to develop a phonological code. Alegria and Lechat concluded that speech reading adds a visual component that can assist in clarifying an unclear auditory message.The results were generalized to defend the position that children with a hearing impairment are able to develop phonological awareness from speech reading.

Harris and Moreno (2006) attempted to identify language skills that were found in good readers who were deaf. The participants in this research project used total communication, with a variable amount of signing used. Amplification devices used was neither recorded nor controlled for, resulting in a mixed group of hearing aid and cochlear implant users (Harris & Moreno, 2004). This group heterogeneity makes it difficult to generalize the results because of questions concerning the similarities of children with hearing impairments. Different degrees of hearing loss, with different types of amplification for variable amounts of time all affect the child's development (Connor & Zwolan, 2004; Geers, 2002).

The children were divided into "good" and "poor" readers based on a single-word reading test from the revised *British Ability Scales II* (Elliott, Smith & McCulloch, 1996). The "good" readers were defined as reading within 10 months of their chronological age. The authors looked at spelling, orthographic awareness, speech intelligibility, and speech reading. Results showed a difference in phonetic errors and syllabic representation (spelling), orthographic awareness and speech reading between the good and poor readers. Speech reading was close to being significantly correlated with spelling variables and orthographic awareness. They propose that their results supported the claim that speech reading is important for deaf children to develop phonological representation, although they did indicate that strong speech reading skills alone did not necessarily result in proficient reading.

In a study related to that of Harris and Moreno (2006), Kyle and Harris (2006) assessed twenty-nine children with a hearing impairment (7-8 years old) and thirty-one reading-age matched peers with typical hearing. Participants with a hearing impairment were included if they 1.) were prelingually deaf (before 2 years old); 2.) had a hearing loss of greater than 71 dB; 3.) received a composite score of at least 85 for nonverbal intelligence; and 4.) had no other cognitive, social or behavioral problems. All of the children with a hearing impairment wore hearing aids; seven children also had a cochlear implant. The children were a mixed group in the type of communication mode they used. Eighteen children used sign language, four used total communication and seven relied on spoken language.

The children were assessed in reading, spelling, productive vocabulary, phonological awareness, short-term memory and speech reading. The research concluded that reading predictors and correlations with language tasks are different for children with typical hearing and children with a hearing impairment. It was determined that the degree of hearing loss, speech reading and expressive vocabulary were predictors of reading ability for children with hearing impairment.

As would be expected, the hearing-impaired group in Kyle and Harris' study (2006) did perform more poorly on phonological tasks than the children with typical hearing. However, the children with a hearing impairment performed better than the children with typical hearing in the speech-reading task. These results support the idea that speech reading may be associated with reading single words. Expressive vocabulary was found to be the language variable most predictive of sentence comprehension. Nation and Snowling (1998) described how a child's developed semantic base assists the child in comprehending the text being read. A strong word knowledge allows a child to bridge any gaps in their comprehension.

Context and semantics

Andrews and Mason (1991) examined reading strategies 5 children with a hearing impairment (aged 17-20) used when reading a text. All of the participants with a hearing impairment used American Sign Language to communicate. A group of 5 children with typical hearing and a group of 5 reading ability matched children were also observed to compare the results of the children with a hearing impairment They found that the teacher had to explicitly explain definitions of words and metaphors. The authors decided they would explain any unknown words to the children if assistance was asked. The children with a hearing impairment asked for more direct help from the teachers than the children in the other two groups. The students with hearing impairment required individual attention in order to understand the passages being read. The authors concluded that children with hearing impairment are less likely to use context to determine the meaning of new words when compared to children with typical hearing.

Phonological awareness

Miller (1997) discussed how phonemic awareness (the child's ability to segment words into their phonological components of sounds, blends, and rhymes) may be different for children with a hearing impairment when compared to children with typical hearing. The Hebrew language was used in this study, since the same phoneme can be represented by different symbols. Using Hebrew would allow Miller to observe the processing strategies used by the children, in that they had to use a phonological code to match words that sounded the same.

Miller describes how phonemic awareness stems from the auditory memory of sounds, and children with a sustained hearing loss do not have the chance to develop an auditory memory of phonemes. In order to overcome the lack of adequate auditory information, Miller (1997) suggests that the phonological representation of words may be learned in a more orthographic and visual nature that relies on memory of written words. This difference in processing phonological information may affect the development of literacy in children with a hearing impairment. In Miller's study (1997), the type of amplification and length of using amplification was not reported. The children with a hearing impairment were grouped according to method of communication, either oral or sign. Fourth to ninth graders were used in the study.

Harris and Beech (1998) assessed phonological awareness in both children with typical hearing and children with hearing impairment, while also describing individual skills in readers who are deaf. Harris and Beech examined whether implicit phonological awareness would predict reading outcomes. Implicit phonological awareness refers to a child being able to segment words into syllable and sub syllabic (onsets and rhymes) parts. An onset is the beginning of a word, while the rhyme includes the vowel and ending consonants. The onset of "spy" would be [sp], and the onset of "cat" would be [k]. The rhyme would include [aI] for "spy" and [at] in "cat" (van Kleek, 1998).

According to Harris and Beech (1998), implicit phonological awareness is different from explicit phonological awareness. Explicit phonological awareness develops as reading develops. Children demonstrate explicit phonological awareness as they learn to manipulate the phonemes in a word. In other words, explicit phonological awareness develops as the child learns that different arrangements of the letters and corresponding sounds results in words with different meanings.

The test battery used by Harris and Beech (1998) included tests of single word reading, letter orientation, implicit phonological awareness, finger spelling, signing, articulation and language comprehension in both children with hearing impairment and children with typical hearing. The children with a hearing impairment recognized only half as many words as their hearing peers after 3 months of reading instruction. The better readers with a hearing impairment did obtain similar reading scores when compared with the better readers with typical hearing after 1 year. The children with typical hearing also scored better on implicit phonological awareness. Results indicated implicit phonological awareness was positively correlated with reading vocabulary for both groups.

Articulation skill and language comprehension also positively correlated with reading for the children with a hearing impairment. Strong language comprehension allows the reader to "make an intelligent guess" (Harris & Beech, p. 214) of what a word may be. Once again, degree of hearing impairment, onset of hearing loss, and method of communication were uncontrolled. The type of amplification the participants used, if any, was not listed.

Design confounds

In order to make the studies described above more useful, different degrees of hearing loss and different types of amplification need to be controlled. The type of amplification used is one factor that influences the mode of communication for the child with hearing impairment. The mode of communication (oral, sign, total communication, etc.) influences how the child codes language, whether it be phonologically or orthographically (Miller, 1997). The development or neglect of specific abilities influence the overall development of language skills (as described in the models of reading acquisition), which also affects the development of literacy skills.

The heterogeneous population of children with hearing impairment often used in the above studies limits the usefulness of the results for predictive purposes. Kyle and Harris (2006) attempted to compare the results of children wearing cochlear implants children with children wearing hearing aids. A reliable comparison could not be made, since the children had received their cochlear implants at relatively older ages (3-6 years old). Results of children implanted at different ages may not be able to be compared when looking at their language abilities. Children implanted at younger ages have more time to develop early language skills. Geers (2002) stated how children who receive cochlear implants before the age of 5 years old are able to develop speech and language during a "crucial time" (p. 181). Children who receive early implantation often are observed to develop speech skills that surpass those of children with a profound hearing impairment who wear hearing aids (Geers, 2002).

Harris and Moreno (2004) noted discrepancies in age of participants and measures of phonological awareness in previous research. It is important to know details about the participants in a study, so that results can be accurately replicated and compared with other studies. The current study will attempt to control for different variables (age of implantation, type of amplification) that could possibly result in inconclusive results.

With the technological advances available today, children with a "hearing impairment" are not necessarily the same. Despite similar types of hearing loss, the type of amplification used and the length of use can influence the development of the child. Children without amplification are exposed to language differently from those who receive a hearing aid or a cochlear implant. It is not adequate to group all children with "hearing impairment" together if specific and accurate results are to be found.

Purpose

The purpose of the current study was to determine whether there are specific language, cognitive, or speech perception variables that predict the development of literacy skills in children with cochlear implants who are implanted at a relatively early age. Specifically, this study proposed to investigate phonological processing, language comprehension, expressive language, speech reading, and spelling as predictors of reading abilities in children implanted before the age of 3 years and 6 months. This pilot study should help to determine which language variables may be important to target for improving reading skills in children with cochlear implants. Results should also help clinicians determine if children with cochlear implants share a similar pattern of literacy development with children with typical hearing. The specific questions asked in this study are as follows:

1. Do children implanted with cochlear implants before the age of 3;6 develop literacy skills similar to the process described in studies of children with typical hearing?
2. What variables best predict literacy acquisition for children implanted before the age of 3;6?

CHAPTER THREE: METHODS

Participants

Participants were recruited as potential subjects through notification of speech language pathologists and audiologists at the University of Tennessee Child Hearing Services.

Five children (two girls and three boys) were selected for this study from the population of 6;00 to 10;00 year old children with cochlear implants residing in the Knoxville, Tennessee regional area [See Table 1]. Other than hearing impairment, the participants were not known at the time of testing to have any sensory, physical, or neurological problems, as determined from observation, previous assessments and parental report. The participants' hearing loss ranged from severe-to-profound to profound. All participants were implanted by the age of 3;6. Three participants were in kindergarten and two participants were in the third grade.

Participant 1 (P1) presented with a severe-profound bilateral hearing loss with a diagnosis of auditory neuropathy. He was a kindergartener who attended a mainstream private school. He was 6 years and 10 months old, and he received his implant at 3 years and 6 months. He wore an Advanced Bionics Clarion Auria BTE on his right ear, and used Hi-RES processing strategy. He used an FM system at school.

Participant 2 (P2) presented with a severe-profound bilateral sensorineural hearing loss with an unknown etiology. P2 was a female kindergartener who was 6 years and 4 months old. She attended a mainstream school. She received her implant at 2 years of age. She wore a Cochlear Nucleus Freedom at her right ear, and used ACE processing strategy. She used an FM system at school. Although not reported at the time of testing, a visual processing deficit recently has been suspected due to school performance and parental report.

Participant 3 (P3) was a 6 year, 4 month old female who presented with a profound bilateral sensorineural hearing loss. Etiology included cytomegalovirus and a family history of hearing loss. P3 attended a mainstream kindergarten. She received her implant at 2 years and 8 months of age. She wore a Cochlear Nucleus Freedom at her right ear, and she used ACE processing strategy. She used an FM system at school.

Participant 4 (P4) is an 8 year, 9 month old male who presented with a profound bilateral sensorineural hearing loss. The etiology of his hearing loss was unknown, and he received his implant when he was 2 years and 4 months old. He attended a mainstream elementary school, where he was in the third grade. He wore an Advanced Bionics PSP BTE at his left ear, and he utilized SAS processing strategy. He used an FM system at school.

Patient 5 (P5) was an 8 year, 11 month old male who presented with a profound bilateral sensorineural hearing loss. The etiology of his hearing loss was unknown, and he received his cochlear implant at 1 year and 9 months of age.

Table 1: Participant Demographics

	P1	P2	P3	P4	P5
Grade	Kindergarten	Kindergarten	Kindergarten	3rd	3rd
Age	6;10	6;4	6;4	8;9	8;11
Age at implant	3;6	2;0	2;8	2;4	1;9
Implant Device	Advanced Bionics Auria BTE	Nucleus Freedom	Nucleus Sprint	Advanced Bionics PSP BTE	Nucleus Sprint
Processor	Hi-RES	ACE	ACE	SAS	ACE

He wore a Nucleus Sprint device at his right ear, and he utilized an ACE processing strategy. He received a second cochlear implant at age 8 years and 6 months. Testing was completed with only his right cochlear implant. He attended a mainstream elementary school, where he was in the third grade. He used an FM system at school.

Materials

The assessment battery included commonly used standardized tests for expressive and receptive language assessment, speech-reading assessment, spelling, and reading assessment.

Language

The *Test for Auditory Comprehension of Language-3* (TACL-3) (Carrow-Woolfolk, 1999) was administered to assess receptive language comprehension, including vocabulary, grammatical morphemes and elaborated phrases and sentences. The test was administered following the instructions in the test manual.

The *Comprehensive Test of Phonological Processing* (CTOPP) (Wagner, Torgeson & Rashotte, 1999) assesses phonological awareness, phonological memory and rapid naming, which have been related to literacy development. There are two forms of the CTOPP, and choice of the form used is made based on the participants' age. One form is for ages 5-6 years old, and the other form is for ages 7-24 years old. All of the core subtests are administered for each age category. The older participants also complete the rapid digit naming and rapid letter naming subtests, which make up the rapid naming composite. The rapid naming composite for children ages 5-6 years old is made up of rapid color naming and rapid object naming subtests.

Modifications for blending words, memory for digits, non-word repetition and blending non-words were made to present the test in an undistorted manner. These subtests normally require the participant to listen to words on an audio tape player. Modifications for the current study involved the principal investigator listening to the audiocassette tape via headphones, and then immediately repeating the instructions and models for all participants.

The *Expressive Vocabulary Test*-2 (EVT-2) (Williams, 2007) was administered to assess expressive standard American English vocabulary and word retrieval. Each participant was administered Form A of the test.

Spelling

The pictures for the spelling task were taken from the list including 39 words used in Harris and Moreno's (2004) research. Harris and Moreno selected words to produce a large number of spelling errors, including monosyllabic regular and irregular words, along with multisyllabic words. The 10 words used in this study were a random selection of these words (cake, door, key, mouse, clown, envelope, sock, comb, square, and owl). Only 10 words were selected in an attempt to minimize any frustration felt by the participants. A group of 10 black and white line drawing pictures was shown to each participant, along with one verbal production of the object depicted for the child to spell. The child was instructed to write the name of the picture. The spelling errors were analyzed by determining 1.) the number of words spelled correctly, 2.) the number of initial phonemes correct and 3.) the number of final phonemes correct.

Speech reading

The speech-reading task was drawn from a research article by Kyle and Harris (2006). A speech-language pathology graduate student created a video of a female saying words and sentences about pictures and objects. Each participant was told they would watch the woman on the video without sound, and they must determine which object she named by reading her lips. Five boards of pictures were created to give the participants visuals of the words produced. The children were instructed to point to the word they thought the woman said. The sixth board had a picture of a teddy bear, and the children were instructed to follow the woman's directions. The directions were in sentence form and instructed the participants to point to different parts on the teddy bear. The final section included props, which were labeled for the children. They then had to follow the directions of the woman on the video to manipulate the props.

Reading

The *Woodcock Reading Mastery Test* (WRMT) (Woodcock, 1998) was administered to assess reading components, including letter and word identification, word attack of non-real words, word comprehension (with synonyms and opposites) and passage comprehension. According to the test developers, letter identification represents reading readiness, word identification and word attack represents a basic skills cluster, and word and passage comprehension represent a reading comprehension cluster. All participants completed the letter identification, word identification and word attack subtests. The third graders also completed the word and passage comprehension subtests. All participants were administered Form G.

Nonverbal intelligence

The *Leiter International Performance Scale-Revised* (Roid & Miller, 1997), was used to screen nonverbal intelligence of the participants. The brief IQ screening was used, which is comprised of figure ground, form completion, sequential order and repeated patterns subtests. This composite is appropriate to use for all ages.

Procedure

All of the tests were administered during regularly scheduled therapy sessions. The assessment battery lasted approximately three hours over two to five sessions, depending on the attention and motivation of the participant. All assessments were conducted by the principal investigator under the supervision of a speech-language pathologist (SLP), certified by the American Speech Language Hearing Association.

After consent was obtained from parents, the principal investigator administered the assessment battery in the same order for every child. The test order followed: TACL-3, CTOPP, spelling screening, speech reading assessment, EVT-2, WRMT, and the *Leiter*. A clinical supervisor and/or graduate student clinician assisted in keeping the participants focused on the tasks if necessary. Short breaks were taken in between tests if necessary.

Interrater reliability

Interrater reliability was determined by having 1 or 2 graduate students score each test (not including the EVT-2 and the spelling assessment) once as it was administered by the author. Test scores were then compared for any differences in recording answers. Interrater reliability for the entire assessment was found to be 98%.

CHAPTER FOUR: RESULTS

Purpose

The purpose of the analysis was to determine if any relationship existed between the independent language variables and the dependent reading abilities. The standard scores of the tests administered during the assessment comprised the language variables, and the basic skills cluster standard score from the WRMT (Woodcock, 1998) represented the reading abilities. The *Leiter* (Roid & Miller, 1997) brief IQ screen scores for all of the participants were above 70. Although the data were limited by a small N (N=5), the following analyses could be performed.

Variables

All of the subtest standard scores were analyzed for variance, and 8 variables were selected with the largest variance in the reported scores. These 8 variables included: total quotient (TACL), elision (CTOPP), nonword repetition (CTOPP), blending nonwords (CTOPP), phonological memory composite (CTOPP), number of correct initial phonemes (spelling), number of total words correct (speech reading) and number of total possible words and sentences correct (speech reading) Standard scores for each subtest for each participant are reported in Tables 2, 3 and 4.

Analyses

Scatter plots were created comparing the dependent variable with the independent variables [See Figures 3 and 4]. Pearson correlation coefficients were then performed on the best-fitting lines, which included elision (0.820) and blending nonwords (0.291). The elision standard score, using a 1-tailed test, significantly correlated with the basic skills standard score on the WRMT (p=0.0445).

Table 2: Standard Scores of the WRMT

	S1	S2	S3	S4	S5
WOODCOCK					
Letter id	86	96	98	92	122
Word id	101	99	106	95	108
Word attack	102	94	107	96	117
Basic Skills cluster	100	98	107	94	116
Word comprehension				85	100
Passage comprehension				79	100
Reading Comp Cluster				81	100
Total Reading Cluster				89	107

Table 3: Standard Scores of the CTOPP

CTOPP	S1	S2	S3	S4	S5
Elision	4	5	5	1	7
Rapid color naming	9	10	9	9	9
Blending words	4	5	5	8	8
Sound matching	7	6	4		
Rapid object naming	11	13	10	9	10
Memory for digits	9	3	6	6	6
Nonword repetition	7	6	6	5	1
Blending nonwords supplemental	9	7	11	6	7
Phonological awareness composite	68	70	66	67	85
Phonological Memory composite	88	67	76	73	51
Rapid name composite	100	109	97	94	97

Table 4: Standard Scores

	S1	S2	S3	S4	S5
SPELLING					
Correct intial sound	2	2	8	9	10
Correct final sound	1	1	1	8	10
Correct words	1	0	0	6	8
SPEECH READING					
Board 1	5/8	3/10	3/8	8/9	10/10
Board 2	5/9	1/4	3/10	7/8	9/9
Board 3	2/9	1/8	2/9	5/9	8/10
Board 4	5/9	4/9	3/5	2/3	5/10
Board 5	2/3	1/2	2/5	7/10	6/10
Board 6	0/5	0/5	1/5	0/5	2/5
Board 7	0/7	0/7	2/7	6/7	3/6
Total words	52%	33%	38%	73%	78%
Total sentences	0%	0%	25%	50%	45%
Words and sentences	41%	26%	36%	68%	72%
EVT-2					
Standard score	61	96	91	67	99
TACL-3					
Vocabulary	2	6	6	5	6
Grammatical morphemes	6	7	4	3	3
Elaborated phrases/sentences	8	8	4	5	7
Total Quotient	57	81	66	64	70

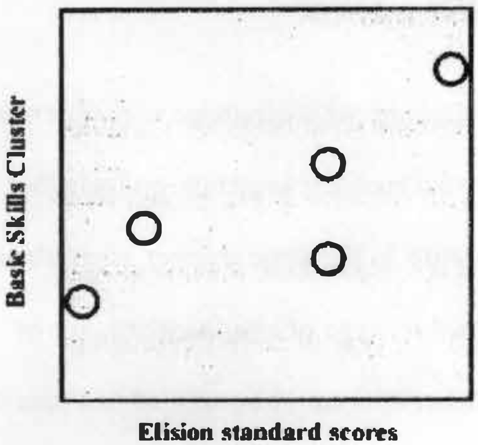

Figure 2: Elision Scatter Plot

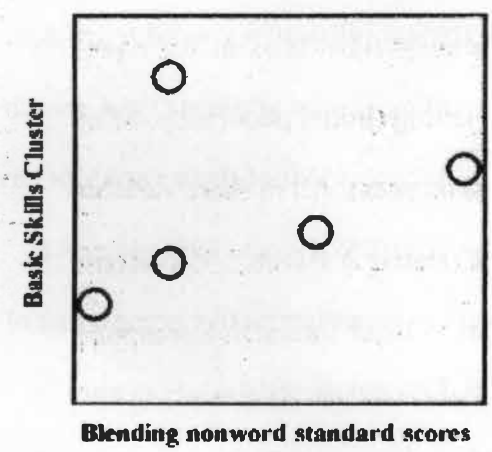

Figure 3: Blending Nonword Scatter Plot

CHAPTER FIVE: DISCUSSION

Purpose

The present research was completed to determine what language variables might be associated with reading outcomes in children with cochlear implants, and whether children with cochlear implants develop literacy skills in the same manner as children with typical hearing. The study attempted to control for type of amplification, age of implantation, and degree of hearing loss so that the results could be applied to a specific group.

Variables

The independent factors with the most variance were components of receptive language (TACL total quotient), phonological awareness (elision, nonword repetition, blending nonwords, and phonological memory), spelling (initial phoneme) and speech reading (total words and total possible words and sentences). All of these variables have been shown to be important for literacy acquisition (Harris & Beech, 1998; Harris & Moreno, 2006; Kyle & Harris, 2006). There appears to be an interactive component of these variables, in that being proficient in one skill does not directly relate to age-appropriate reading abilities (van Kleek, 1998). Musselman (2000) also recognizes how different children may have different skills. Reading instruction may need to focus on the individual needs of the child, resulting in targeting different combinations of literacy skills for each child.

Participant Characteristics

The results of the previously mentioned studies cannot often be generalized to children with cochlear implants, since the participant groups are mixed with hearing aid users, children who sign and cochlear implant users. The age of cochlear implantation is also important to record, as earlier implantation allows language to develop earlier. It can be difficult to find enough subjects when participant requirements are very specific, but a body of research for children with cochlear implants and their literacy development needs to be developed to best serve this population. It is important to understand what language variables are associated with literacy development in children with cochlear implants, since "children with stronger language skills tend to have stronger reading skills" (Connor & Zwolan, 2004).

Findings

Of the language variables assessed, elision was the most closely associated factor with the reading basic skills cluster. Elision refers to a child breaking a word down into its parts of either syllables or phonemes. An example of elision is: "Say airplane. Now say airplane without 'air.'" Elision of phonemes is demonstrated by completing the task of: "Say bee. Now say bee without /b/." Elision is important for a child to understand the relationship of sounds and letters of printed words (Wagner, et al., 1999).

Results from this research showed that a relationship existed between elision and the basic skills cluster of the WRMT. The basic skills cluster was comprised of subtests including word identification and word attack. In word identification, each participant had to read the word printed on the page. In work attack, each participant had to read nonwords. The basic skills cluster is a "broad measure of basic reading skills" (Woodcock, 1998, p.8).

Elision fits into Gough and Tunmer's (1986) simple view of reading in the phonology section, within the main language comprehension section. Elision also requires children to have phonemic awareness in order to remove a phoneme from a word. Phonemic awareness is under the decoding section in the model. This one skill of elision represents both components of the simple view of reading.

Adams' (1990) states that phonemic awareness is important for beginning readers. Elision fits into Adam's model in the phonological processor category, since elision is a phonological skill. Elision would also fit into reading stages 1 and 2 by Chall (1979). Stage 1 is when phonological awareness is developing, as children work to recognize that different letter combinations spell different words. In stage 2, children become more fluent, and elision may become easier to perform, since words are more familiar.

The segmenting of words and sounds is important for children as they are learning to decipher unfamiliar words. The corresponding relationship of sounds and letters is important for children to learn as they begin to read. This knowledge will help them understand that changing a familiar sequence of letters ("cat") by one letter ("hat") will result in changing the sounds produced. This change affects the speech production and meaning of the word.

The answers to the questions in this study are general in nature, due to the small number of participants included. Question 1 asked if children who received a cochlear implant by the age of 3 years and 6 months develop literacy skills in a similar process as do children with typical hearing. Question 2 asked what variables best predict literacy acquisition for children with early implantation of a cochlear implant. Children with early cochlear implantation do show better reading abilities with early intervention, although they still are at risk for having reading deficits. With early and appropriate intervention, children with cochlear implants are able to develop similar reading skills to children with typical hearing, although it may take more time for these skills to develop (Harris & Beech, 1998; Yoshinaga-Itano et al., 1998). The children in this study all were within 1 standard deviation of the average for basic reading skills, and the third grade participants were within 1 standard deviation for total reading cluster. The beginning readers (kindergarteners) and the early readers (third graders) all were within a normal range for the literacy skills they have acquired.

The language variable associated with reading abilities in the current study is elision. These results agree with the literature that phonological awareness is important for literacy development for children with a hearing impairment. Speech reading, another skill the literature has found associated with literacy in children with hearing impairment, was not found in this study to be significantly associated with literacy development. Speech reading may be a skill that develops along with other skills associated with literacy components, including vocabulary development. The method of communication used also may influence the development of speech reading skills.

Associations between speech reading and literacy development may have an attention component, as children with a hearing impairment may need to focus on watching mouths to better understand speech. A visual focus on the mouth may be associated with visually focusing on text to develop literacy skills.

The results should be cautiously interpreted, since this is a pilot study with a small number of participants. Generalization of the results to the larger population of all children with cochlear implants who received their implant by age 3 years and 6 months cannot be currently predicted. More testing with a larger participant group would be warranted to observe if the results of this study remain stable. Research has shown that phonological awareness is important for reading to develop (Catts, et. al., 2000). The current research suggests that elision, a specific type of phonological awareness, may be associated with literacy development.

Questions about literacy development are still being asked and research continues to search for answers. Although there is extensive literature on literacy development, there is a limited amount of research that specifically looks at reading abilities in children who received a cochlear implant at an early age. This is due in part to the fact that the age of implantation has not always been so young. Implantation for children aged 12 months old has only been allowed for the past 7 years (FDA, 2001). As more children are implanted at younger ages, researchers will have a larger number of participants to observe and assess.

Conclusion

To conclude, the research presented showed that phonological awareness, specifically elision, was the most strongly associated skill with reading abilities. An association between speech reading, vocabulary development, rapid naming and spelling with reading outcomes was not observed. As technology for cochlear implants has improved, it is important to look at children with cochlear implants separately from children who sign and use hearing aids. The age at which a child receives a cochlear implant will influence their language development, and it is difficult to generalize results if the details of amplification and communication mode are not recorded. Children with a hearing impairment are at a risk for developing deficits in reading abilities, although this may not always occur. Early intervention and individual assessment and treatment protocols are appropriate services to provide while researchers continue to determine what the key components are necessary to ensure literacy success.

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