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# Novel Word Learning of Children with Hearing Impairment and Children with Typical Hearing

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# NOVEL WORD LEARNING OF CHILDREN WITH HEARING IMPAIRMENT AND CHILDREN WITH TYPICAL HEARING

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by

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# ABSTRACT

## NOVEL WORD LEARNING OF CHILDREN WITH HEARING IMPAIRMENT AND CHILDREN WITH TYPICAL HEARING

By Matthew R. Clark

Children with hearing impairment may be at risk for reading difficulty due, in part, to delayed vocabulary development. However, advances in amplification technology, most notably cochlear implant technology, make it possible for children with profound hearing loss to acquire oral language. This study asked if novel word learning differed between children with typical hearing and those with severe to profound hearing loss who either wore hearing aids or had cochlear implants. Children learned nonsense words as names for Beanie Babies during a play scenario and were later asked to identify and name each Beanie Baby using its correct nonsense word name. Results showed no significant difference in novel word learning between children with hearing impairment and those with typical hearing. Additionally, novel word learning strongly correlated to phonological working memory, spontaneous vocabulary measures, age of implantation, and length of speech and language therapy in children with hearing impairment.

## DEDICATION

I am dedicating my work to my family. I want to thank my family for the support they have given me in every decision I have made for my future. Their profound support for my endeavors provided the encouragement to pursue my education and have great expectations of myself in everything I do.

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# Chapter I

## Introduction

Literacy, especially learning to read, has become a focal point of early childhood education. The reason for this is that literacy has been shown to be strongly related to academic success in all areas, including science and math (Burrows & Neyland, 1978; Craig & Gordon, 1988; Duncan et al., 2007; Zimmerman, Rodriguez, Rewey, & Heidemann, 2008). Further, academic success is correlated to economic advancement (Mok, 1996; Weiner 1974). The United States Congress recognized this relationship and the importance of children learning to read at an early age when it passed the *No Child Left Behind Act of 2001 (NCLB)* and through implementation of the *Reading First* Program (U.S. Department of Education [USDE], 2005a; USDE, 2005b). Despite the passage of *NCLB* in 2001, Lusis & Reeves (2008) emphasized the continuing critical need for additional funding for early intervention. To be successful, early intervention must focus on the skills that have been shown to support literacy acquisition.

Researchers have found that the more extensive and varied a child's vocabulary, the more likely the child is to develop strong literacy, especially reading comprehension skills (Chiappe, Chiappe, & Gottardo, 2004; Dickinson & Tabors, 2001; Duncan et al., 2007; McBride-Chang, Wagner, & Chang, 1997; Nation, Clarke, Marshall, & Durand, 2004; Roth, Speece, & Cooper, 2002; Wise, Sevcik, Morris, Lovett, & Wolf, 2007). Vocabulary development occurs rapidly between birth and the age of 3 years. Hulit & Howard (2006) noted that children begin to combine words between 18 months and 2 years and, by the age of 3, have become "conversationalists." However, some groups of children, e.g. children with hearing impairment (HI: Tomblin, Barker, & Hubbs, 2007; Tomblin, Spencer, Flock Tyler, & Gantz, 1999; Uziel et al., 2007) and those with specific language impairment (SLI: Gray, 2003; Nash & Donaldson,

2005) do not develop oral vocabulary as quickly as do their typically developing peers. Research also has shown that these groups of children have poorer literacy (Bishop & Adams, 1990; Catts, Bridges, Little & Tomblin, 2008; Connor & Zwolan, 2004; Geers, Tobey, Moog, & Brenner, 2008; Miller, 2005; Nation et al, 2004; Snowling, Bishop & Stothard, 2000) and overall academic outcomes than do children with typically developing language (Schuele, 2004) and typical hearing (Craig & Gordan, 1988; Davis, Shepard, Stelmachowicz & Gorga, 1981; Geers, 2002). To make sure that these children develop the foundational skills they need for literacy, it is important that we understand the processes that underlie vocabulary acquisition in typically developing children.

Young children begin acquiring vocabulary when they hear strings of sounds/phonemes and are able to distinguish one from another, a process called speech perception (Yeni-Komshian, 1993), at the same time they experience something in the world. When a child processes these novel strings of speech sounds (phonemes), he is said to be engaging in phonological processing (Pence & Justice, 2008). To attach meaning to the string of phonemes, a child must hold the phoneme string in short-term or “working” memory so that it can be analyzed and paired with a simultaneously occurring experience in the world (or a referent) and then transferred to long-term memory. When speech perception and phonological processing occur, researchers say that a child is using phonological working memory (Gathercole, 2006; Gathercole & Baddeley, 1990), which has been correlated with ability to acquire new vocabulary (Gathercole, Willis, Emslie & Baddeley, 1992). When a child is able to accomplish these tasks and use a word meaningfully (both receptively and expressively), after just a few or even a single exposure to the string of phonemes in the presence of a referent, he is said to have engaged in a word learning process called fast mapping (Carey & Bartlett, 1978; Dollaghan, 1985, 1987).

One can conclude that difficulty with speech perception, phonological processing, phonological working memory, or the ability to fast map will place an individual at risk for problems learning new words, resulting in vocabulary deficits (Hansson, Forsberg, Lofqvist, Maki-Torkko & Sahlen, 2004; Nash & Donaldson, 2005). Findings showing a significant relationship between phonological working memory and word learning in typically developing children (Gathercole, Hitch, Service, & Martin, 1997; Gathercole et al., 1992) and in children with SLI (Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Montgomery, 2004; Montgomery & Windsor, 2007) have been robust. However, Hansson et al. found that, not only did children with mild to moderate hearing loss who wore hearing aids learn novel words more easily than did children with SLI, but the phonological short-term memory of the children with HI was unrelated to novel word learning. These findings suggested that the factors underlying novel word learning may differ between children with SLI and children with HI.

One might ask whether children with severe to profound hearing loss learn words in a way similar to children with mild to moderate hearing loss. In recent years, the former group of children, who previously were not able to receive effective amplification through hearing aids, has been receiving surgically inserted cochlear implants (Ertmer, 2002b). These devices provide a measure of hearing by directly stimulating the auditory nerve (Sparrow, 2005). Research has suggested that children with profound hearing loss who have cochlear implants have better speech perception abilities than children with similar levels of hearing loss who wear hearing aids (Mildner, Sindija & Zrinski, 2006). Many children with profound hearing loss who are implanted before 24 months of age achieve oral language abilities that are commensurate with those of their typically developing peers with typical hearing (Geers, Nicholas, & Moog, 2007; Nicholas & Geers, 2004; Svirsky, Teoh, & Neuburger, 2004; Tait, Nikolopoulos, & Lutman, 2007; Tomblin et al, 2005). Taken together, these findings suggest that, provided with appropriate early amplification, children with HI can become oral communicators and achieve good literacy outcomes. However, to be maximally effective, early amplification must be augmented with effective and appropriate strategies to speed word learning in these children.

Although the ability of children with SLI to learn new words through fast mapping has been extensively studied (e.g. Alt & Plante, 2006; Gray, 2006), only a few researchers have investigated this phenomenon in children with HI. One such study was conducted by Houston, Carter, Pisoni, Kirk, & Ying (2005). They found that children with profound hearing loss who used cochlear implants demonstrated poorer recall of names given to beanie babies than did age-matched children with typical hearing, suggesting that the phonological processing skills of the children with HI were not as efficient as were those of the children with typical hearing. However, after a delay of two hours, the children with HI recalled the words they initially identified and named as efficiently as did the children with typical hearing, suggesting that their ability to transfer words processed in working memory to long-term memory might be equivalent to that of children with typical hearing. Because the beanie babies were given names that were real words, with 95% and 60% being familiar to children with typical hearing and HI respectively, Houston et al. evaluated the difference in recall and naming accuracy for children with HI between words that were familiar to them and those that were not. They found that these children showed poorer recall of unfamiliar than familiar beanie baby names after a two-hour delay. The authors were not able to complete this analysis on children with typical hearing because of their high rate of familiarity with the words used. To more nearly replicate what happens during fast mapping, they recommended that follow-up studies using nonwords be conducted.

The purpose of the present study was to extend Houston et al.'s (2005) research. Specifically we wanted to determine if there was a difference in receptive and expressive novel word learning ability between two groups of children, one with HI (who were either aided or implanted) and the other with typical hearing. We also wanted to investigate the relationship between novel word learning and the following variables: child's age, spontaneous language sample measures from a story retelling task (number of different words [*# DW*], number of total words [*# TW*], mean length communication unit [*MLCU*], number of Communication Units [*# CU*]), measures taken from standardized testing (receptive and expressive vocabulary scores), and the child's phonological working memory ability, as measured by the percentage of phonemes produced correctly in response to a nonword repetition task. For children with HI, we wanted to analyze the relationships between novel word learning and the following variables: age at hearing aid fitting or implantation and the length of time child has received speech and language therapy.

# Chapter II

## Review of the Literature

### Importance of Vocabulary for Strong Literacy Outcomes and Academic Success

The more extensive a child's oral vocabulary, the more likely it is that he will be a good reader and achieve academic success (Roth et al., 2002; Schuele, 2004; Snow, Porche, Tabors and Harris, 2007; Snowling et al., 2000). Snow et al. (2007) found that children who experienced difficulty learning to read in first grade were at risk for academic failure. They noted that, the more extensive a child's vocabulary, the more likely he will be to learn to read easily and that, as he begins to read, his vocabulary will continue to grow through that process. In other words, when a child begins to read, the relationship between vocabulary growth and reading attainment becomes a reciprocal one.

Several studies have investigated the relationship between vocabulary and reading ability. Roth et al (2002) found that oral vocabulary and word retrieval were better predictors of literacy than phonological awareness, which is defined as the "ability to segment words into sounds and manipulate sounds in words" (Paul, 2001, p. 389). Stothard, Snowling, Bishop, Chipkase & Kaplan (1998) found that children with delayed language skills, who were unable to acquire vocabulary at a rate comparable to that of their age-matched peers, displayed delayed literacy skills. Snow et al. (2007) found that receptive vocabulary at kindergarten entrance served as a catalyst for improvement in reading comprehension, remaining a significant predictor of literacy attainment throughout elementary school and into the high school years. Thus, a strong vocabulary is critical in enhancing literacy development.

As vocabulary supports literacy, so does literacy supports overall academic achievement. Hansen (2001) found that kindergarten literacy and social skills were predictive of sixth grade academic achievement even when controlling for parental and cultural factors. Paul, Vanderzee, & Rue (1996) investigated the relationship between the Accelerated-Reader program and academic achievement. To do this, they compared two groups of schools, one using the Accelerated-Reader program and the other group not using the program. With socioeconomic status controlled, they found that children in the schools that used the program had significantly better scores in many academic areas than did children who attended schools not using the program.

Finally, Lavin-Loucks (2006) noted that children who do not experience successful academic achievement are likely to experience economic hardships, poor health and possible unemployment. Taken together, these findings suggest that children who experience difficulty learning new vocabulary may develop later reading difficulties, which may lead to academic failure, which in turn may lead to economic hardship. Thus, it is imperative that researchers understand how to assist children in overcoming factors that place them at risk for academic failure.

## An Overview of Vocabulary Acquisition in Typically Developing Children

Vocabulary development begins at birth, as children gain receptive knowledge of words and begin to babble and eventually to produce whole words. According to Shipley & McAfee (2004) children typically acquire their first words receptively and expressively at 7-12 months. Their receptive and expressive vocabularies expand further as they get older and reach approximately 300 words receptively and 100 words expressively by age two. By the time children are ready for preschool, they bring with them receptive vocabularies of approximately 1,200-2,000 words and expressive vocabularies of 800-1,500 words. By the time preschool ends, children typically have receptive vocabularies of over 13,000 words and expressive vocabularies of over 2,000 words. As evidenced by these striking numbers, reasons for delays in word learning need to be understood if intervention is to be successful.

Children acquire vocabulary through a number of interrelated processes, each of which is equally important, considering that there is research relating difficulty in each process to later challenges with spoken language and literacy. The processes involved in developing oral language and vocabulary are speech perception (Pinker, 1994), phonological processing, which includes phonological working memory (Adams & Gathercole, 1995; Gathercole & Baddeley, 1993; Steinbrink & Klatte, 2008), and phonological access to lexical storage (Anthony, Williams, McDonald, & Francis, 2008; Litt, 2003; Wagner & Torgesen, 1987). Finally, children learn new words rapidly through a process called fast mapping (Carey & Bartlett, 1978; Gershkoff-Stowe & Hahn, 2007; Wilkinson, Ross, & Diamond, 2003).

*Phonological Processing: Phonological Working Memory*

McBride-Chang (1995) described word reading in three levels. The first was speech perception ability, which led to phonological processing and later to word reading. What McBride-Chang and other researchers referred to as the representation of sounds in memory was what Baddeley, Gathercole, & Papagno (1998) called the "phonological loop," the means by which children store speech sounds in their memory for retrieval and manipulation when learning new words and learning to read. The phonological loop allows individuals to hold something novel (such as an unfamiliar string of sounds) in memory and rehearse it repeatedly (the *subvocal rehearsal process*) while connecting the sounds to meaning or performing some other function cognitively. These processes are said to occur as part of phonological working memory. Baddeley et al. hypothesized that a specific string of sounds could be moved to long-term memory storage to be recalled at a later time when experienced again by a child.

Researchers have used several methods to test phonological working memory ability in young children. One way has been by having children repeat nonsense words. Baddeley et al. (1998) described nonword repetition as a measure of verbal short-term memory that relies on the phonological loop because it requires children to repeat a novel string of sounds they have just heard. To complete this task, a child must be able to form a phonological representation of a novel word and then rehearse it to keep the novel word in short-term memory so it can be repeated back upon request. Using this methodology, Gathercole & Baddeley (1990) compared the ability of two groups of children to recall an unfamiliar name for a toy. One group had significantly better nonword repetition scores than did the second group. They found that children with better nonword repetition scores, suggesting stronger phonological working memory abilities, were better able to recall unfamiliar names than were children with poorer nonword repetition scores.

Gathercole (2006) suggested that nonword repetition was related to novel word learning because it relied on one's ability to hold phonological information in working memory. Novel word learning involves this same task, albeit to a higher-level degree by requiring not only the holding of sounds in the phonological loop but the mapping of those sounds to some external object for meaning. Coady & Evans (2008) argued that nonword repetition not only taps into phonological working memory, but also speech perception, articulation and motor planning. Thus, they agree with Gathercole that nonword repetition is an excellent tool to assess an individual's phonological working memory.

Another method used to assess phonological working memory is to use digit span tests, where children repeat strings of numbers (Baddeley et al., 1998). As with nonword repetition, digit span tasks require children to hold information in short-term memory until it becomes useful and meaningful. Several researchers have examined the relationship between digit span and word learning (Gathercole, Hitch, Service, & Martin, 1997; Gathercole, Hitch, Service, Adams, & Martin, 1999; Gray, 2006). Gathercole et al. (1997) assessed 5-year-old children's measures of digit span, nonword repetition, vocabulary knowledge and nonverbal ability. They found that nonword repetition and digit span were related to vocabulary knowledge in this group of children, but that nonword repetition had a stronger relationship with vocabulary than did digit span measures. Adams & Gathercole (1995) also found that preschool children's phonological memory abilities, as measured by a combination of nonword repetition and digit span tasks, were related to children's ability to learn new words.

*Phonological Processing: Phonological Access to Lexical Storage*

Phonological access to lexical storage is another aspect of phonological processing and refers to one's ability to process phonemes both visually and auditorally and to retrieve previously stored information from long-term memory (Neuman & Dickinson, 2001; Wagner & Torgesen, 1987). As mentioned before, the phonological component of word learning involves three parts. First, one perceives a string of speech sounds, moves that string to the "phonological loop" while pairing the phoneme string to a unique object or experience in the world (Baddeley et al., 1998). If the child finds that the particular string of sounds is relevant and important, the string of sounds is stored in long-term memory and later accessed from lexical storage when the relevant object is experienced again in different contexts. Therefore, the process that children go through to acquire vocabulary involves using each of these stages of phonological processing.

*Relationship between Phonological Working Memory and Long-Term Memory*

Gathercole, Briscoe, Thorn, & Tiffany (2008) suggested that poor phonological working memory was related to poor long-term memory for new words. Jones, Gobet, & Pine (2007) proposed a model to account for the relationship between phonological working memory and long-term memory, stating that the two are related by the functions they comprise, one of which is successful retrieval of novel information. Gathercole et al. proposed that long-term memory dictates how much new information can be computed in short-term memory and how much information can be transferred to long-term memory at any given time. Hudson, Sheffield, & Deocampo (2006) stated that the more often children are exposed to novel information, the more likely that information is to remain in long-term memory. This might explain why young children learn words such as *mom* and *dad* at such an early age.

In summary, word learning is a process that involves a child first perceiving a novel string of phonemes. He must hold this string of phonemes in short-term memory while he connects them to something meaningful in the world, i.e. processes them through the phonological loop component of phonological working memory. When he attaches meaning to the novel string of phonemes, this representation is transferred to and stored in long-term memory. When the string of phonemes is needed again because the child experiences the meaning attached to the string of phonemes, he accesses them from lexical storage.

*Fast Mapping*

When children are able to accomplish the steps described above following just one or two exposures to the novel string of phonemes, they are said to be engaging in a process called fast mapping (Carey & Bartlett, 1978; Dollaghan, 1985, 1987). Carey and Bartlett investigated children's ability to use fast mapping to make assumptions about new words presented to them. In their study, they used a forced choice task to have children make inferences about novel words. They wanted to look at how children processed new words when presented in meaningful contexts with other words they may have already known. Words used were from the same lexical group (colors) and new words were presented with other common color words (e.g. red, purple, and maroon). They intended to find the type of reference the child would make with the new word. They paired the word *chromium* with the color "olive." Their assumption was that the children, not really knowing the color "olive" would possibly consider it to be *chromium,* since there was not any other meaningful referent for the word. By pairing a new word with a word the children knew, they forced the children to make the assumption that the new word had to be the name of the other object in the pair. Later, some of the children were able to make unique assumptions about the new words that were correct. They did not necessarily have to express the word for the study to find what it sought. Those minor assumptions by the children were enough to suggest that they at least were making beginning assumptions and relationships between the novel word and a referent. Carey & Bartlett also found that size of vocabulary and age had no effect on fast mapping.

## Children at Risk for Difficulty with Word Learning and Academic Success

Perhaps the two groups of children that research has shown to be most at risk for difficulty with word learning, literacy, and academic success are children with HI and those with SLI (Snow, Burns, & Griffin, 1998). Although they pointed out that children with SLI demonstrate problems with language learning in the absence of other issues, such as sensory deprivation, they noted that children with HI are deprived of the sense of hearing, which negatively impacts their ability to learn language. They also said that young children who experience numerous middle ear infections (chronic otitis media) have been shown to be at risk for difficulty with language learning. They speculated this happens because the early years are a critical period for language acquisition (Hulit & Howard, 2006; Paul, 2001). Snow et al. noted that, if children experiencing chronic otitis media or HI do not perceive phonemes in the same way as do children with typical hearing, the processes that support early word learning, i.e. speech perception, phonological processing and fast mapping, are likely to be compromised.

## Word Learning Challenges Faced by Children with Hearing Impairment

### *Specific Challenges for Children Using Hearing Aids*

As noted earlier, children with mild to moderate levels of hearing loss typically use hearing aids to improve auditory acuity. Gilbertson & Kamhi (1995) compared the novel (nonsense) word learning abilities of 20 receptive vocabulary matched children (ranging in age from 7 – 10 years) with mild to moderate hearing loss with a group of 20 typically developing children (ranging in age from 7 – 10 years) with typical hearing. Prior to intervention, the children completed standardized tests that measured nonverbal intelligence, receptive and expressive vocabulary, articulation skills, and overall receptive and expressive language abilities. Preliminary testing was followed by the acquisition phase of the word learning paradigm, which consisted of exposure, comprehension, production and recognition of the nonwords *tam, jaften, shabaffidy,* and *gadakik.* Following the word learning paradigm, participants completed several phonological processing tasks. They first repeated monosyllabic (CVC; e.g. /daf/), then multisyllabic (e.g. /namanu/), and finally three-item sequences of monosyllabic nonwords (e.g. /dap, nuf, kud/). Next, they completed two additional phonological processing tasks, including rapid word naming, during which the children had to name objects as quickly as they could (e.g. scissors, comb) and rapid word learning of letters, number and colors presented in the same way as the objects. The phonological processing tasks were followed by the retention phase of the word learning paradigm.

Results showed that, as a group, the children with HI required more exposure to the novel words to retain them in memory than did the children with typical hearing, with receptive vocabulary being the only significant predictor of novel word learning. However, upon close inspection of the data for the group with HI, Gilbertson and Kamhi (1995) noted a bimodal distribution. Some of the children with HI needed fewer exposures during the acquisition phase of the novel word learning paradigm than did others. In fact, the novel word learning ability of the first half of the group of children with HI was comparable to that of their peers with typical hearing. The other half of the group required extra exposures in the acquisition phase to learn the novel words. Statistical analysis revealed that the subgroup of children with HI was able to learn the novel words as quickly as their peers with typical hearing had higher receptive and expressive language and nonverbal intelligence scores than did the subgroup that learned the novel words more slowly. These findings suggested that nonverbal intelligence or receptive or expressive language may be significant predictors of word learning ability in children with HI. Additionally, the children who were successful with the word learning paradigm, whether they had HI or typical hearing, had superior phonological processing skills than did the children who learned the novel words more slowly, as evidenced by the higher scores on the repetition of multisyllabic words and three item sequences. Based on these findings, Gilbertson and Kamhi concluded that the hearing loss itself did not cause word learning difficulty, and that only some children with HI had problems with phonological encoding, which made it difficult for them to learn novel words and phonological forms.

Lederberg, Prezbindowski, and Spencer (2000) examined novel word learning in 19 preschool aged children with mild to moderate hearing loss, who ranged in age from 3 to 6 years. Their study included exposure, generalization, rapid word learning, and novel word learning sequences. During the exposure sequence children played with familiar and unfamiliar objects. Object names were used for the familiar objects, while the unfamiliar objects were assigned nonword names. Children were not told which name went with which object. During the generalization phase an unfamiliar distracter item was added. Next, the children also completed a rapid word learning task where unfamiliar objects were given nonword names. Unlike the exposure phase, the children were told which nonword went with which object during the rapid word learning phase. Finally the children completed an additional generalization phase to determine which nonwords they had successfully learned and mapped to the appropriate objects.

The children also completed standardized tests of vocabulary, language, and overall development. Results showed that most children chose novel objects appropriately when nonwords were used during the exposure and generalization sequences. In fact, 12 of the 19 children who participated in the study identified enough novel objects correctly to be considered novel word learners. Additionally, children chose the correct nonword 97% of the time during exposure in the rapid word learning sequence and 78% of the time in the generalization sequence of the rapid word learning task. Sixteen children were considered to have passed the rapid word learning task.

The researchers then divided the children into two groups based on their performance during the exposure and generalization phases. Thus, 12 children were placed in the novel mapping group, while other 7 were placed in the slow word learning group. They found a significant difference between the vocabulary scores of the groups, with children in the novel mapping group demonstrating larger vocabularies than children in the slow word learning group. When tested again over an 18 month interval, two of the seven slow word learners reached criterion to move into the novel mapping group. These children also showed a more rapid increase in vocabulary than did the five remaining slow word learners.

Taken together, the results of Gilbertson and Kamhi (1995) and Lederberg et al. (2000) suggest that, for aided children with mild to moderate hearing loss, as well as for children with typical hearing, vocabulary size is significantly related to novel word learning ability. It follows that there exists a relationship between vocabulary acquisition and the ability to process phonemes, as the task of mapping nonwords to novel objects and remembering them later requires sophisticated phonological processing and fast mapping abilities. These studies also show that some children with HI, who use hearing aids, are able to use strategies for successful word learning in much the same way as do children with typical hearing. However, both studies noted considerable variability in novel word learning abilities among children with HI. Given the variability in word learning outcomes among children with mild to moderate hearing loss who use hearing aids, we wondered if the same variability might exist among children with severe to profound hearing loss that use cochlear implants.

*Specific Challenges for Children with Cochlear Implants*

Schorr, Roth, & Fox (2008) compared vocabulary acquisition of two groups of children, one with profound HI who used cochlear implants and another with typical hearing. These researchers found that the cochlear implanted children with HI had age-appropriate vocabulary skills, although their vocabulary scores were significantly lower than those of the group with typical hearing. Specifically, the children with HI had significantly lower scores on measures of receptive and expressive vocabulary and phonological processing than did the children with typical hearing. Schorr et al. also found that that the age of implantation accounted for a significant amount of the variance in receptive vocabulary scores. Analysis of individual performance, however, showed a great deal of variability in the vocabulary and overall language outcomes of the cochlear implanted children with HI. This observed variability agrees with the findings for children with HI who use hearing aids (Gilbertson & Kamhi, 1995; Lederberg et al, 2000) and suggests that factors other than type of amplification used may play a role in these children's success in acquiring oral vocabulary.

Houston et al. (2005) compared the word learning abilities of 24 children with profound hearing loss (aged 2 to 3 years and 4 to 5 years) that used cochlear implants to those of 24 children of similar ages with typical hearing. Stimuli used in their experiment were beanie babies, each given a unique name. Names were chosen for the beanie babies based on their perceptual features. For example, one beanie baby had large teeth and therefore was named "teeth," while another had fur and was given the name "fuzzy." The 48 children who participated in the study were divided into four groups based on age (younger/typical hearing, younger/cochlear implanted, older/typical hearing, older/cochlear implanted), with 12 participants per group.

Houston et al.'s (2005) experiment included two training phases (each using four beanie babies for the younger group and eight for the older group). Each training phase was followed by two testing conditions (receptive and expressive) at two different times (immediately after testing and two hours later). Results showed that, as a group, the children with typical hearing recalled more beanie baby names, both receptively and expressively, immediately after training than did the children with HI. The children with typical hearing also recalled more words receptively and expressively during delayed testing than did children with HI, with the group difference being similar to that during immediate testing. These findings suggested that children with HI who used cochlear implants were not able to make as many word-object associations as were the children with typical hearing. However, the children with HI were able to place new word-object associations they recalled after immediate exposure into long-term memory successfully; they just did not have as many associations to move from short-term memory to long-term memory as did the children with typical hearing.

Interpretation of these results was complicated by the fact that the children with typical hearing had had prior exposure to approximately 95% of the words used as names for the beanie babies, while the implanted children with HI had had exposure to only about 60% of the words. Since past researchers (Pressley & Schneider, 1997, pg. 45) have shown that prior word knowledge assists with memory, Houston et al (2005) performed a follow-up analysis using only the familiar beanie baby names. Results of this analysis were much the same as before; children with typical hearing again recalled and named more beanie baby names both during immediate and delayed testing than did children with HI. Finally, a third analysis found that children with HI recalled and named more beanie babies with familiar than with unfamiliar names correctly, showing that familiarity with the phonological forms of the words assisted them in transferring the phonological information to long-term memory and then retrieving it later from lexical storage. Unfortunately, Houston et al were not able to perform this analysis with children with typical hearing, so were not able to ascertain if there would be a difference between the ability of children with typical hearing and those with HI to fast map novel words (i.e. novel phonological strings) into long-term memory for later retrieval. They suggested a follow-up study using nonwords for this purpose. Finally, Houston et al did not assess the receptive or expressive vocabularies of the participants in either group prior to the study. Therefore, they failed to rule out the possibility that a significant difference between the groups in vocabulary knowledge, rather than the difference in hearing ability, may have accounted for the differences in word learning between the groups.

*Summary of Challenges Faced by Children with Hearing Impairment*

In summary, Gilbertson and Kamhi (1995) and Lederberg et al (2001), both of whom investigated word learning in aided children with mild to moderate hearing loss, showed that vocabulary size and phonological processing ability, not hearing loss, were related to novel word learning in children with HI. In fact, Gilbertson and Kamhi found that children with HI who had vocabulary skills commensurate with those of their typically developing peers with typical hearing learned novel words as easily as did these peers. Although Houston et al. (2005) found that children with severe to profound hearing loss who used cochlear implants learned words more slowly than did their typically developing peers with typical hearing, they did not compare the vocabulary abilities of the two groups, so were not able to determine which factor might be more closely related to word learning; vocabulary skills or hearing loss.

## Impact of Age of Identification and Advances in Amplification Technology on Word Learning Outcomes

*Impact of Newborn Hearing Screening Legislation*

Until recent years, most children with HI were not identified until the age of 2 years (Durieux-Smith, Fitzpatrick, & Whittingham, 2008). With the advent of newborn hearing screening, many of these children are now identified at birth, allowing earlier use of amplification. Spivak, Sokol, Auerbach, & Gershkovich (2008) described conducting hearing screenings within the first month after birth, diagnosing children with HI by three months of age, and fitting them with hearing aids by six months of age. They referred to this process as the 1-3-6 plan. Today, 48 of the 50 states have passed legislation that either requires or encourages newborn hearing screening (American Speech-Language-Hearing Association [ASHA], 2009), with North and South Dakota being the only states with no legislation in this regard.

Perhaps largely due to the widespread use of newborn infant hearing screening, Tharpe, Fino-Szumski, & Bess (2001) found that the audiologists they surveyed reported fitting children even younger than 6 months of age with hearing aids. In fact, they found that nearly 40% of children with HI are aided by 12 months of age, with an additional 40% receiving aids during their second year of life. Verhaert, Willems, Kerschever, & Desloovere (2008) studied a group of children whose HI was identified at birth. They found that, regardless of their level of hearing loss, the earlier the children in their study had received amplification, the more likely they were to be successfully mainstreamed into regular education classes during the school-age years. Geers et al. (2007) showed that children with profound hearing loss who received cochlear implants between one and two years of age later demonstrated receptive vocabulary scores within one standard deviation of their peers with typical hearing. Nicholas and Geers (2004) showed that children with HI who had received cochlear implants before the age of 27 months demonstrated significantly better oral language skills than those implanted between 28 and 36 months of age. They also noted that children who used cochlear implants performed better on measures of oral language than did children with profound hearing loss that used hearing aids. Taken together, these finding suggest that, for children with profound hearing loss, cochlear implants appear to offer a better chance of developing oral language skills commensurate with those of their peers with typical hearing. Additionally, the earlier they receive implants, the better these chances are. Finally, regardless of level of hearing loss, early amplification results in better language outcomes for children with HI.

*Impact of Advances in Amplification Technology*

Another factor to consider is that the technology underlying cochlear implants and hearing aids is continuously improving. Although not able to exactly replicate a human cochlea, cochlear implants are increasingly using more electrodes, leading to better speech processing (Loizou, 1998). Current types of cochlear implants include the Ineraid, which uses six electrodes, the Clarion, which uses eight electrodes, and the Nucleus-22, which uses 22 electrodes (Cochlear Americas, 2009). One of the more recent implants to be utilized is the Nucleus 24, which uses customized settings depending on the listening environment in which the cochlear implant user is participating (Cochlear Americas). This technology was given the name *SmartSound* and is suggested to improve hearing ability by allowing the user to focus their hearing on desired objects, such as a person standing in front of them when in a large crowded area.

Hearing aid technology also has improved over the years. Metselaar et al. (2007) found that following the NAL-RP formula, which National Acoustic Laboratories describes as a formula for “prescribing the gain-frequency response in linear hearing aids with the aim of maximizing speech intelligibility” (National Acoustics Laboratories, 2009), for hearing aid selection allowed for better speech intelligibility in noise. Van Tasell (1993) noted that appropriate frequency response, syllabic compression, maximizing audibility in noise, and lowering the amount of masking were all factors in maximizing hearing aid users’ ability to understand the speech of others. Therefore, the NAL-RP formula will likely improve spoken language development in children with HI.

## Aims of Current Study

Past research has shown word learning outcomes among children with HI vary widely, with some children acquiring new words at a rate commensurate with that of their typically developing peers with typical hearing (Gilbertson & Kamhi, 1995). Studies also have shown that current vocabulary is a good predictor of novel word learning in both children with HI and in those with typical hearing (Gilbertson & Kamhi; Lederberg et al., 2000). Although Houston et al. (2005) showed that children with HI who used cochlear implants learned words more slowly than did their typically developing peers with typical hearing, they did not assess the vocabulary or phonological processing ability of their participants, leaving open the question as to which factor or factors had the most significant relationship to word learning; vocabulary knowledge, phonological processing ability, or hearing acuity. Houston et al. also noted that the children with HI in their study transferred the words they did map onto meaningful objects from short-term to long-term memory as efficiently as did children with typical hearing and that the children with HI fast mapped words with which they were familiar more quickly than they did words with which they were not familiar. Since the children with typical hearing in their study were familiar with most of the words, they were not able to perform this analysis with that group. Therefore the question as to whether children with HI would have performed more poorly than those with typical hearing if they were engaging in an authentic fast mapping task, i.e. using nonwords, remained unanswered. To answer this question and to further investigate the factors that may influence novel word learning in children, this study sought to answer the following questions:

1. Is there a difference between the fast mapping abilities of children with hearing-impairment (HI) and a similarly aged group of children with typical hearing? Fast mapping abilities were measured by the number of novel words (nonwords), which children had previously learned as the names of four beanie babies, children identified and named correctly immediately after intervention, and again after delays of two hours and one week.

2. Are the following variables significantly correlated with the number of nonword names children with typical hearing and with HI correctly identify and name immediately after intervention and again after delays of two hours and one week?
    - Mean length of communication unit (*MLCU*) obtained from a story retelling task.
    - Number of different words (*# DW*) obtained from a story retelling task.
    - Number of total words (*# TW*) obtained from a story retelling task.
    - Number of communication units (*# CU*) obtained from a story retelling task.
    - Receptive vocabulary scores on the *Peabody Picture Vocabulary Test-Third Edition (PPVT-III;* Dunn & Dunn, 1997).
    - Expressive vocabulary scores on the *Expressive Vocabulary Test (EVT;* Williams, 1997).
    - Phonological Working Memory ability, as measured by the percentage of phonemes repeated correctly on the *Nonword Repetition Task (NRT;* Dollaghan & Campbell, 1998).
    - Nonverbal cognitive functioning as measured by the nonverbal tests of the *Wide Range Intelligence Test (WRIT;* Glutting, Adams, & Sheslow, 1998).
    - Articulation ability as measured by the *Goldman Fristoe Test of Articulation – Second Edition (GFTA-2;* Goldman & Fristoe, 2000).
    - Child's age
3. Are there correlations between word learning and the following variables in children with HI?
    - Age at amplification
    - Age at which child received CI (if implanted)

- Length of time child has received speech and language therapy

# Chapter III

## Method

### Participants

Participants were 17 children, 12 (7 male, 5 female) who were typically developing and had typical hearing and 5 (3 male, 2 female) who had hearing impairment (HI). Participants in the group with typical hearing ranged in age from 39 to 104 months ($M$ = 63.8, $SD$ = 22.9), while participants in the group with HI ranged in age from 56 to 80 months ($M$ = 66.8, $SD$ = 12.2). An independent samples $t$- test showed no significant age difference between groups, $t(15) = -.271$, $p = .790$. A Chi-Square Analysis showed that group and child sex were independent of each other, $X^2(1, N = 17) = .004$, $p = .949$. Participants consisted of children recruited from Cincinnati, OH, local schools near Huntington, WV, and children from the Luke Lee Listening, Language, Learning Lab at Marshall, a program that supports oral deaf education for young hearing impaired children with hearing aids or cochlear implants. Each child's parents completed a questionnaire indicating the age at first amplification and at implantation (if child had cochlear implant), number of electrodes for children with cochlear implants, and the length of time each child had received speech and language therapy. Four of the children with HI, all of whom had profound hearing loss, used cochlear implants and the fifth child with HI, who had severe/profound hearing loss, wore bi-lateral hearing aids. The length of time they reported having received speech and language therapy ranged from 41 to 72 months ($M$ = 56, $SD$ = 13.19). All reported receiving oral-only therapy. Information for each child with HI can be seen in Table 3.1.

Table 3.1 Demographic information for children with HI (M = Male; F = Female; P = Profound, S/P = Severe/Profound; CI = Cochlear Implant; HA = Hearing Aid; U = Unilateral; B = Bilateral).

| Participant | Age (months) | Sex | Level of Hearing Loss | Age of first amplification (months) | Age when implanted | Type of Aid currently used | # of electrodes for CI | Type of CI | Length of speech/language therapy (months) | Therapy type |
|---|---|---|---|---|---|---|---|---|---|---|
| *1 HI* | 56 | M | P | 3 | 27 | CI/HA | 22 | U | 51 | Oral |
| *2 HI* | 61 | M | P | 9 | 24 | CI/HA | 22 | U | 52 | Oral |
| *3 HI* | 80 | M | S/P | 5 | N/A | HA | N/A | N/A | 72 | Oral |
| *4 HI* | 57 | F | P | 5 | 16 | CI | 22 | U | 41 | Oral |
| *5 HI* | 80 | F | P | 5 | 13 | CI | 24 | B | 60 | Oral |

To make sure that the 12 children in the group with typical hearing qualified for group membership, the researcher screened their hearing using a Grason-Stadler GSI Clinical Audiometer. All children in this group passed the screening, which was conducted for frequencies 500, 1000, 2000, and 4000 Hz at a 20 dB hearing level. All participants were treated in an ethical manner (American Psychological Association, 2001).

## Research Design

To answer the first research question, we used a one-between, two-within mixed model repeated measures design. Group (children with typical hearing and those with HI) served as the between subject factor, while time of testing (immediate, two hour delay, one week delay) and type of test (expressive and receptive) were the within subject factors. The dependent variable was the number of nonwords identified and named correctly during each testing condition. To answer the second two research questions, we used nonexperimental correlational analyses.

## Setting, Materials, and Procedures

### *Pre-Intervention Measures*

Prior to participating in the experimental sessions, each child completed a series of pre-intervention tests for the purpose of evaluating receptive and expressive vocabulary, articulation ability, nonverbal intelligence, phonological working memory, lexical diversity, verbosity, and linguistic complexity. These measures were obtained during one to three sessions. Each session lasted approximately 30-60 minutes, depending on each participant's attention to task and willingness to continue. If participants expressed that they were tired, testing was finished for the day and resumed in subsequent sessions. Typically, pre-intervention testing was completed over two sessions.

During the first pre-intervention session, children completed the *PPVT-III* to assess receptive vocabulary and the *EVT* to assess expressive vocabulary. The *PPVT-III* was chosen as the receptive vocabulary measure because its norming sample included the age range of children in this study. The norming group also mirrored the United States population on the following variables: mothers' educational level, ethnic group membership. Furthermore, criterion-related validity was established by correlating scores on the *PPVT-III* with scores on the *Wechsler Intelligence Scale for Children*-Revised.

The *EVT* was given to assess expressive vocabulary because it has been shown to be valid and reliable. Criterion related validity was established by showing strong correlations between the *EVT* and other tests of oral vocabulary. Its norming sample included participants with speech and language problems and other disabilities. Next, each child with typical hearing completed the hearing screening described earlier.

During the second session, children completed the *GFTA-2* to assess articulation ability. Speech-language pathologists routinely use this test to assess articulation ability. Its standardization sample included 2,350 individuals, aged 2:00 through 21:11, at more than 300 representing the Northeast, North Central, South, and Western regions of the United States, including several sites in West Virginia. Percentages of participants mirrored the U. S. population in the following categories: sex, level of mother's education, race or ethnic group, and special education status. Internal consistency reliability coefficients were .92 or greater for each age group.

In the present study, each child's production of the words from the *GFTA-2* was recorded onto audiocassettes and a digital voice recorder (Olympus, WS-210S) for later scoring and interrater reliability checks. This test was given to control for articulation errors when later scoring the *NRT*, which children completed immediately following the *GFTA-2,* and to observe any articulation errors that could affect correct production of phonemes in the nonword names given to the beanie babies in this study.

Next, each child was told that he or she would hear 16 nonsense words from the *NRT* (See Appendix A). We chose to complete a test of nonword repetition because research has shown that phonological working memory is related to word learning in typically developing children (Gathercole et al, 1997; Gathercole et al., 1992), and in children with SLI (Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Montgomery, 2004; Montgomery & Windsor, 2007), although its relationship to word learning in children with HI remains unclear (Hansson et al., 2004). The nonwords ranged in length from one to four syllables, with four nonwords at each length. These nonwords were recorded onto a compact disk using the voice of the thesis advisor. Recording was accomplished using a Sennheiser 421 studio microphone (Sennheiser electronic GmbH & Co.). The auditory signal was digitized into a Pentium 4 Computer using Sound Forge 6 software (Sony Creative Software Inc). These audio segments were burned onto a compact disk (CD) using a 52x burner and Nero software (Nero Inc.). To complete the *NRT*, the nonwords were presented to each child in the following manner: The CDs were placed in a Sony CD player (Sony Corporation of America). Older children heard the nonwords through the CD player speakers and then repeated each nonword. Younger children followed the sequence with an additional step; the experimenter produced the nonword after it was played on the CD player and the child repeated the nonword after the experimenter had said it. This step was added because research has shown that younger children respond more accurately following a live voice than a recorded voice (Madell & Flexor, 2008). Both stimulus nonwords and each child's repetitions were recorded onto audiocassettes and the digital voice recorder for later scoring. To determine *NRT* scores, the number of syllables produced correctly by each child (out of a possible 40) was recorded. Any substitution or omission of a phoneme in a syllable was counted as an error. Distortions and additions were not counted as errors. The first author scored each audiotape of the *GFTA-2* and *NRT*. An independent rater scored 29% of audiotapes chosen randomly. Using a unit-by-unit ratio, interrater reliability was 92% for the *NRT* and 95% for the *GFTA-2*. Disagreements between the two raters were resolved by the thesis advisor after re-listening to the tapes.

Next, children who were four years of age or older completed the nonverbal portions of the *WRIT*, which consisted of Matrices and Diamonds. This test was chosen because research has shown nonverbal intelligence to be related to word learning in children with HI (Gilbertson

& Kamhi, 1995). This test was chosen because it is able to be given by speech-language pathologists and the test authors showed that children's scores on this test were correlated with their scores on the *WISC-III.* The Diamonds portion assessed each participant's ability to form pictures using diamonds that matched a picture shown to them in a picture book and the Visual Matrices portion of the *WRIT* assessed children's ability to examine an array of pictures and make a choice as to an additional picture that was related to the rest of the presented visual collection.

Finally, each child told a story in response to a wordless picture book, *One Frog Too Many* (Mercer & Meyer, 1975). The researcher read the story to each child using a script he developed (See Appendix B). Following this, children were told flip through the book and tell the story. They were told, though, that they could make up their own words and character names for the story. In other words, originality in story retelling was encouraged. Each child's story retelling was recorded onto an audiocassette and the digital voice recorder for later scoring and interrater reliability checks. The examiner transcribed each story retelling, dividing the child's utterances into C-Units according to the protocol described by Hughes, McGillivray, and Schmidek (1997). The software program, *Systematic Analysis of language Transcripts: Windows Clinical Version 9 (SALT-9;* Miller & Iglesias, 2006) was used to determine each child's *# DW, # TW, MLCU,* and *# CU.*

*Experimental (Intervention) Sessions*

During experimental sessions, which were conducted individually, the child and the experimenter sat on the floor. The experimenter first introduced each beanie baby and the beanie baby's nonword name. The number of nonwords utilized in the intervention was kept at four. The reason for this was twofold. Houston et al. (2005) had used only four beanie baby names per session with children under the age of 4 years, and they used real words as beanie baby names in their study. Although only three of our participants were under the age of four, we used nonword names and initial pilot testing suggested that introducing more than four nonword names per session might create a floor effect. Names used for each beanie baby are shown in Table 3.2.

Table 3.2 Beanie Babies and their nonword names.

| Beanie Baby | Nonword Name |
|---|---|
| *Snake* | h^p |
| *Kangaroo* | moId |
| *Duck* | beIp |
| *Iguana* | Touf |

The names utilized in the intervention were adapted from Storkel (2001). Some modifications were made to ensure that each phoneme appeared only once across the nonwords. Additionally, all phonemes are mastered by typically developing children by the age of three years (Goldman & Fristoe, 2000).

The intervention procedures followed a specific format each time a new beanie baby was presented for a total of four times, one for each of the four beanie babies used in the study. The order of presentation of the beanie babies was counterbalanced so that specific beanie babies were not remembered more just because they were presented first or last in order. Counterbalancing was accomplished utilizing a randomized counterbalancing technique. Gould (2001) suggested the use of this counterbalancing technique when the number of participants in a study does not allow for equal presentation of every order of an independent variable (order of presentation of beanie babies and nonword names). Considering there were 24 possible different orders of presentations and only 17 participants, this form of counterbalancing was utilized. Each possible order of presentation was placed into an excel sheet utilizing Microsoft Excel Software and given a number from 1-24. Then a random number generator was utilized to choose a specific number from 1 through 24. Whichever number was chosen for each participant determined which order they would receive the stimulus words and beanie babies. The format for presentation of the beanie babies followed a particular script (Appendix C).

A variety of objects were used within the interaction scenario to allow the children to have play exposure with each beanie baby. The protocol used was similar to the one used by Houston et al. (2005). As in the Houston et al. study, the number of times the researcher and the participating child repeated each beanie baby's nonword name was held constant. Specifically, the researcher said each nonword name seven times and the child was given the opportunity to name each one three times during each play scenario. This gave each child auditory exposure to the nonword name and a chance to speak the word. Immediately following each play session, the experimenter asked the child to name each beanie baby. The experimenter asked "What's his name again?" after the participants had said "goodbye" to each beanie baby. This was done to give each child one more opportunity to learn the nonword name of each beanie baby.

To provide the children with a richer exposure to the nonword names and beanie babies, the experimenter gave the participants additional experiences that had not been utilized in the Houston et al. (2005) study. To do this, he created four sentences that described the appearance of the beanie baby while the participants held the beanie baby in their hands. For example, the beanie baby duck required use of the sentence "/beip/ likes to swim in the pond. He has a long beak." These additional experiences were completed after the presentation of all four beanie babies before moving towards the immediate measures of recall. The four sentences utilized for this purpose are presented in Table 3.3.

Table 3.3 Sentences to help children connect beanie babies with their nonword names.

| Beanie Baby | Sentence |
|---|---|
| *Snake* | h^p has a long tongue. He can make it slither. |
| *Kangaroo* | moId has a baby and can hop all over the place. |
| *Duck* | beIp likes to swim in the pond. He has a long beak. |
| *Iguana* | touf likes to climb in trees. He has a long tail. |

The play scenarios for each beanie baby were recorded onto audiocassettes and onto on an Olympus WS-210S Digital Voice Recorder (Olympus Imaging American Inc.). These recordings allowed the researcher to later review each participant's nonword name production, so that when the later measures of long-term memory of the names were obtained, they could be matched with the initial productions made by each participant for phonological similarity.

*Measures of Immediate and Delayed Recall*

We followed Houston et al. (2005)'s protocol to measure the children's immediate and delayed recall of beanie baby nonword names. To assess nonword name recognition, each participant was instructed to sit on the floor with the researcher. Each of the four beanie babies used in the study was placed in front of the child in a row. The child was instructed to put a particular beanie baby in the bus that had been used during the earlier play scenarios as the researcher named it (e.g. "Can you put /moid/ on the bus?"). Each time the child had placed a beanie baby in the bus it was taken out and replaced in the row so that there was always a choice among four beanie babies during the receptive task. Then the researcher asked the child to put a different beanie baby in the bus. The researcher recorded correct and incorrect identification for each child during this activity.

Following this task, Houston et al.'s protocol to test children's expressive recall of beanie baby names was used. To determine how many beanie babies each child could name, the researcher said that the beanie babies had "gone on a field trip and were coming back." The bus was placed in front of the child. The researcher and child proceeded to play a "knock-knock" game similar to the one used by Houston et al. The child knocked on the door of the bus while saying "knock knock." The researcher then opened the door, allowing the beanie babies to come into view, and asked, "Who's there?" The participant was instructed to pull one beanie baby out of the bus and the researcher asked "Who was on the bus?" The child was then told to tell the experimenter the nonword name associated with whichever beanie baby he or she had pulled from the bus. This play scenario was also digitally recorded so that the researcher could review the productions of the nonword names for interrater reliability as well as analysis of the productions made by each participant. This scenario was repeated four times, once for each beanie baby. In cases where the child did not produce the name on first presentation, the researcher again asked, "Who's there"? The researcher allowed for three presentations of the question to elicit production of a nonword name from the participant before moving on and counting the specific name used as missed for that particular beanie baby. Following immediate testing, these protocols were repeated after delays of two hours and one week.

# Chapter Four

## Results

### Preliminary Analysis

Before running our main analyses, we noted that there were some missing data points. Two participants with typical hearing declined to complete the story retelling task and so were missing data for *# DW*, *# TW*, *MLCU*, and *# CU*. Three children with typical hearing were under the age of 4 years at the time of testing and, therefore, did not complete the *WRIT*. Due to our small sample size and the wide age range of the children in the study, we determined that replacement strategies suggested by Tabachnick & Fidell (2001) were not appropriate for this data set. Therefore, when conducting correlational analyses, our *n* was 14 (5 for children with HI and 9 for children with typical hearing) for *WRIT* data, 15 task (5 for children with HI and 10 for children with typical hearing) for all measures from the story retelling, and 17 (5 for children with HI and 12 for children with typical hearing) for all other variables.

Next, we inspected each distribution for normality. To do this, we calculated the *z*-statistic (by group) for each continuous variable by dividing its skewness and kurtosis by their standard errors (Tabachnick & Fidell, 2001). Using an alpha level of .001, skewness and kurtosis were not significant for any variable (i.e. all distributions met the assumption of normality). Data are shown in Tables 4.1 and 4.2.

Table 4.1 Means, Standard Deviations, Skewness, Kurtosis, and *z* statistics for each continuous variable for children with typical hearing (*IR = immediate receptive; IE = immediate expressive; 2-HR-R =2hour delayed receptive; 2-HR-E = 2 hour delayed expressive; 1-WK-R = 1 week delayed receptive; 1-WK-E = 1 week delayed receptive; MR = mean receptive score across conditions; ME = mean expressive score across conditions).*

| Variable | *N* | *M* | *SD* | *Skew* | *SE Skew* | *z* | *Kurtosis* | *SE Kurtosis* | *z* |
|---|---|---|---|---|---|---|---|---|---|
| *Age* | 12 | 63.83 | 22.89 | .694 | .637 | 1.09 | -1.148 | 1.232 | -0.93 |
| *PPVT* | 12 | 113.92 | 9.53 | -.152 | .637 | -0.24 | .313 | 1.232 | 0.25 |
| *EVT* | 12 | 106.33 | 10.33 | .657 | .637 | 1.03 | 1.31 | 1.232 | 1.06 |
| *GFTA-2* | 12 | 105.90 | 6.13 | .709 | .637 | 1.12 | .342 | 1.232 | 0.28 |
| *Nonverb IQ* | 9 | 119.56 | 8.81 | 1.40 | .717 | 1.95 | 1.291 | 1.4 | 0.92 |
| *NRT* | 12 | 31.42 | 7.00 | -1.341 | .637 | -2.11 | 2.686 | 1.232 | 2.18 |
| *# DW* | 10 | 65.6 | 31.93 | .075 | .687 | 0.11 | -1.44 | 1.334 | -1.08 |
| *# TW* | 10 | 152.4 | 82.03 | -.307 | .687 | -0.45 | -1.63 | 1.334 | -1.22 |
| *MLCU* | 10 | 6.01 | 2.2 | .433 | .687 | 0.63 | -1.582 | 1.334 | -1.19 |
| *CU* | 10 | 27.2 | 10.52 | -.227 | .687 | -0.33 | -.309 | 1.334 | -0.23 |
| *IR* | 12 | 3.33 | .958 | -.812 | .637 | -1.28 | -1.650 | 1.232 | -1.34 |
| *IE* | 12 | 1.17 | .937 | .412 | .637 | 0.65 | -.298 | 1.234 | -0.24 |
| *2-HR-R* | 12 | 2.75 | 1.42 | -.611 | .637 | -0.96 | -.857 | 1.234 | -0.69 |
| *2- HR-E* | 12 | 1.67 | 1.78 | .373 | .637 | 0.59 | -1.904 | 1.234 | -1.54 |
| *1-WK-R* | 12 | 2.83 | 1.40 | -.833 | .637 | -1.31 | -.447 | 1.234 | -0.36 |
| *1-WK-E* | 12 | 1.5 | 1.45 | .649 | .637 | 1.02 | -.474 | 1.234 | -0.38 |
| *MR* | 12 | 2.97 | 1.2 | -.715 | .637 | -1.12 | -.769 | 1.234 | -0.62 |
| *ME* | 12 | 1.44 | 1.25 | .423 | .637 | 0.66 | -1.166 | 1.234 | -0.95 |

Table 4.2 Means, Standard Deviations, Skewness, Kurtosis, and *z* statistics for each continuous variable for children with HI.

| Variable | *N* | *M* | *SD* | *Skew* | *SE Skew* | *z* | *Kurtosis* | *SE Kurtosis* | *z* |
|---|---|---|---|---|---|---|---|---|---|
| *Age* | 5 | 66.8 | 12.19 | .506 | .913 | 0.55 | -3.213 | 2.0 | -1.61 |
| *PPVT* | 5 | 94.2 | 24.47 | .829 | .913 | 0.91 | .260 | 2.0 | 0.13 |
| *EVT* | 5 | 103.4 | 15.18 | .465 | .913 | 0.51 | -2.782 | 2.0 | -1.39 |
| *GFTA-2* | 5 | 94 | 10.93 | -.419 | .913 | -0.46 | 1.129 | 2.0 | 0.57 |
| *Nonverb IQ* | 5 | 104.6 | 10.83 | .166 | .913 | 0.18 | 1.256 | 2.0 | 0.63 |
| *NRT* | 5 | 27.4 | 4.23 | -.831 | .913 | -0.91 | .581 | 2.0 | 0.29 |
| *# DW* | 5 | 57.2 | 18.2 | -.77 | .913 | -0.84 | -1.9 | 2.0 | -0.95 |
| *# TW* | 5 | 145 | 64.26 | -.205 | .913 | -0.23 | -1.46 | 2.0 | -0.73 |
| *MLCU* | 5 | 6.15 | 1.47 | .259 | .913 | 0.28 | -.339 | 2.0 | -0.17 |
| *CU* | 5 | 26.0 | 9.14 | .60 | .913 | 0.66 | -.739 | 2.0 | -0.37 |
| *IR* | 5 | 2.8 | 1.64 | -.609 | .913 | -0.67 | -3.33 | 2.0 | -1.67 |
| *IE* | 5 | 1.8 | 1.48 | .552 | .913 | 0.61 | .868 | 2.0 | 0.43 |
| *2-HR-R* | 5 | 2.6 | 1.52 | -.315 | .913 | -0.35 | -3.081 | 2.0 | -1.54 |
| *2- HR-E* | 5 | 1.4 | 1.67 | 1.09 | .913 | 1.19 | .536 | 2.0 | 0.27 |
| *1-WK-R* | 5 | 2.6 | 1.67 | -1.09 | .913 | -1.19 | .536 | 2.0 | 0.27 |
| *1-WK-E* | 5 | 2.0 | 1.58 | .000 | .913 | 0.00 | -1.2 | 2.0 | -0.60 |
| *MR* | 5 | 2.67 | 1.27 | -.273 | .913 | -0.3 | -2.95 | 2.0 | -1.48 |
| *ME* | 5 | 1.73 | 1.55 | .605 | .913 | 0.66 | -.065 | 2.0 | 0.33 |
| *Age CI* | 4 | 20.0 | 6.58 | .000 | 1.014 | 0.00 | -4.067 | 2.619 | -1.55 |
| *Length SLT* | 5 | 57.2 | 9.12 | 1.433 | .913 | 1.57 | 1.424 | 2.0 | 0.71 |
| *Age amplif* | 5 | 5.4 | 2.19 | 1.29 | .913 | 1.41 | 2.917 | 2.0 | 1.46 |

Next, we ran a series of independent samples *t*-tests to see if children with typical hearing and those with HI differed significantly on pre-intervention variables. Results showed that these groups differed significantly only on the *GFTA-2*, $t$ (15) = 2.905, $p$ = .011 and the *WRIT*, $t$ (12) = 2.814, $p$ = .016. We also noted that means for standardized measures of vocabulary, as well as for articulation and nonverbal intelligence, were within the average range for children with HI. *T*-test results can be seen in Table 4.3 and descriptive statistics in Table 4.4.

Table 4.3 Independent samples *t*-test results for pre-intervention variables.

| | ***Levene's*** | | ***t*-test** | | |
|---|---|---|---|---|---|
| | *F* | *p* | *t* | *df* | *p* |
| Age | 3.30 | .089 | -.271 | 15 | .790 |
| *PPVT* | 6.7 | .021 | 1.747 | 4.515 | .147 |
| *EVT* | 2.68 | .122 | .466 | 15 | .648 |
| *GFTA-2* | 1.30 | .272 | 2.905 | 15 | .011* |
| *Nonverb IQ* | .03 | .872 | 2.814 | 12 | .016* |
| *NRT* | .731 | .406 | 1.183 | 15 | .255 |
| *# DW* | 2.44 | .142 | .540 | 13 | .599 |
| *# TW* | 1.21 | .291 | .175 | 13 | .863 |
| *MLCU* | 3.44 | .087 | -.127 | 13 | .901 |
| *CU* | .01 | .946 | .217 | 13 | .832 |

* $p < .05$; ** $p < .01$

Table 4.4 Comparison of means and standard deviations for pre-intervention variables for children with TH and those with HI.

| | TH | | | HI | | |
|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *n* | *M* | *SD* |
| Age | 12 | 63.83 | 22.89 | 5 | 66.80 | 12.19 |
| *PPVT* | 12 | 113.92 | 9.53 | 5 | 94.2 | 24.47 |
| *EVT* | 12 | 106.33 | 10.33 | 5 | 103.4 | 15.18 |
| *GFTA-2* | 12 | 105.90 | 6.13 | 5 | 94.0 | 10.93 |
| *Nonverb IQ* | 9 | 119.56 | 8.81 | 5 | 104.6 | 10.83 |
| *NRT* | 12 | 31.42 | 7.00 | 5 | 27.40 | 4.22 |
| *# DW* | 10 | 65.6 | 31.93 | 5 | 57.2 | 18.2 |
| *# TW* | 10 | 152.4 | 82.03 | 5 | 145 | 64.26 |
| *MLCU* | 10 | 6.01 | 2.2 | 5 | 6.15 | 1.47 |
| *CU* | 10 | 27.2 | 10.52 | 5 | 26.0 | 9.14 |

## Main or Principal Analyses

*Experimental Analysis*

To answer the first research question, “Is there a difference in the fast mapping abilities of similarly aged children with hearing impairment (HI) and those with typical hearing?” we used a 2 x 3 x 2 analysis of variance (ANOVA), with repeated measures on the two within-subject factors. Results revealed no significant main effects for time, $F(2, 14) = .227$, $p = .80$, indicating that participants’ ability to map nonword names to the correct beanie babies was not significantly different across the immediate and delayed conditions. A significant main effect was found for test, $F(1, 15) = 37.135$, $p < .001$, indicating that participants recalled more nonword beanie baby names receptively than they did expressively. The main effect for group did not reach significance, $F(1, 15) < .001$, $p = .990$, indicating that children with HI mapped nonwords onto beanie babies as effectively as did children with typical language. There were no significant interactions. Also, linear trends for time, $F(1, 15) = .041$, $p = .842$, and for time x test, $F(1, 15) = 4.268$, $p = .057$, were not significant, indicating that children did not identify or name significantly more or fewer words over time. ANOVA statistics are listed in Table 4.5 and group means for the word learning factors are listed in Table 4.6.

Table 4.5 Results of Mixed Model Repeated Measures ANOVA.

| Source | *df* | *F* | $\eta^2$ | *p* |
|---|---|---|---|---|
| *Time* | 2, 14 | .227 | .031 | .800 |
| *Time X Group* | 2, 14 | .303 | .042 | .743 |
| *Test* | 1, 15 | 37.135 | .712 | .000 *** |
| *Test X Group* | 1, 15 | 2.166 | .126 | .162 |
| *Time X Test* | 2, 14 | 2.938 | .296 | .086 |
| *Time X Test X Group* | 2, 14 | 2.150 | .235 | .153 |
| *Group* | 1, 15 | < .001 | < .001 | .990 |

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4.6 Descriptive statistics for the dependent variable between groups and across testing conditions.

| | TH | | | HI | | |
|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *n* | *M* | *SD* |
| *IR* | 12 | 3.33 | .985 | 5 | 2.8 | 1.64 |
| *IE* | 12 | 1.17 | .937 | 5 | 1.8 | 1.48 |
| *2-HR-R* | 12 | 2.75 | 1.42 | 5 | 2.6 | 1.52 |
| *2-HR-E* | 9 | 1.67 | 1.78 | 5 | 1.4 | 1.67 |
| *1-WK-R* | 12 | 2.83 | 1.4 | 5 | 2.6 | 1.67 |
| *1-WK-E* | 10 | 1.5 | 1.45 | 5 | 2.0 | 1.58 |

*Correlations*

*Relationships between Pre-Intervention Variables and Measures of Novel Word Learning*

Although there had not been a significant difference in novel word learning between children with typical hearing and those with HI, children with typical hearing had a much wider age range (39 to 104 months) than did the children with HI (56 to 80 months). Therefore, we were curious as to whether or not there might be group differences in the strengths of the correlations between pre-intervention variables and novel word learning. We realized that, due to our small *n*, especially in the group of children with HI, our results would remain speculative. Also, rather than comparing correlations of pre-intervention variables with novel word learning over time, we investigated the relationship between these variables and children's mean receptive and expressive word learning (collapsed across time). As can be seen from the data in Table 4.7, age was significantly correlated to novel word learning for children with typical hearing but not for children with HI. Other than age for children with typical hearing, measures taken from the story retelling task had the strongest correlations with novel word learning in both groups, with *NRT* also showing a strong correlation to novel word learning for children with HI.

Table 4.7 Comparison of correlations between children with typical hearing and those with HI.

| | *NH* | | *HI* | |
|---|---|---|---|---|
| | *MR* | *ME* | *MR* | *ME* |
| *Age* | .700 * | .813 ** | .042 | .385 |
| *PPVT-3* | .157 | .179 | .352 | .132 |
| *EVT* | .074 | -.226 | .628 | .349 |
| *GFWTA-2* | -.328 | -.139 | .655 | .457 |
| *WRIT* | .044 | -.233 | .199 | .474 |
| *NRT* | .261 | .475 | .902* | .808 |
| *# DW* | .696* | .500 | .916 * | .846 |
| *# TW* | .722 * | .595 | .968 * | .975 * |
| *MLCU* | .659 * | .657 * | .830 | .919 * |
| *# CU* | .575 | .412 | .870 | .757 |

*$p < .05$; ** $p < .01$

<u>*Relationships among Pre-Intervention Variables*</u>

Next, we compared the intercorrelations among pre-intervention variables between children with typical hearing and those with HI. As can be seen in tables 4.8 and 4.9, results showed significant intercorrelations among measures taken from the story retelling task for both groups. However, age correlated significantly with story retelling measures only for children with typical hearing. *NRT* showed non-significant moderate correlations with story retelling measures for both groups.

Table 4.8 Intercorrelations among pre-intervention variables for children with typical hearing.

| | *1* | 2 | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
|---|---|---|---|---|---|---|---|---|---|---|
| *1 Age* | | .330 | -.170 | -.151 | .015 | .605* | .613 | .707 * | .839 ** | .295 |
| *2 PPVT-III* | | - | .301 | .218 | .075 | .024 | .742 * | .759* | .751* | .438 |
| *3 EVT* | | | - | .022 | -.078 | .049 | .438 | .409 | .199 | .369 |
| *4 GFTA-2* | | | | - | .521 | -.270 | .092 | .214 | .173 | .107 |
| *5 WRIT* | | | | | - | -.237 | .383 | .390 | .064 | .386 |
| *6 NRT* | | | | | | - | .470 | .527 | .449 | .472 |
| *7 # DW* | | | | | | | - | .947** | .699* | .809** |
| *8 # TW* | | | | | | | | - | .852** | .759* |
| *9 MLCU* | | | | | | | | | - | .334 |
| *10 CU* | | | | | | | | | | - |

**p* < .05; ** *p* < .01

Table 4.9 Intercorrelations among pre-intervention variables for children with HI.

| | *1* | 2 | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
|---|---|---|---|---|---|---|---|---|---|---|
| *1 Age* | | -.148 | -.433 | -.407 | .713 | -.183 | .137 | .280 | .475 | -.047 |
| *2 PPVT-III* | | - | .903* | .585 | -.185 | .115 | .637 | .313 | .334 | .303 |
| *3 EVT* | | | - | .744 | -.289 | .473 | .762 | .526 | .410 | .597 |
| *4 GFTA-2* | | | | - | .179 | .737 | .706 | .508 | .563 | .328 |
| *5 WRIT* | | | | | - | .201 | .280 | .320 | .661 | -.212 |
| *6 NRT* | | | | | | - | .715 | .797 | .669 | .700 |
| *7 # DW* | | | | | | | - | .921* | .895* | .737 |
| *8 # TW* | | | | | | | | - | .899* | .849 |
| *9 MLCU* | | | | | | | | | - | .537 |
| *10 CU* | | | | | | | | | | - |

*$p < .05$; ** $p < .01$

<u>Summary</u>

Results of separate correlations for each group showed significant intercorrelations among story retelling measures and non-significant moderate correlations between *NRT* and story retelling measures for both groups. However, age correlated significantly with story retelling measures only for children with typical hearing. Age also correlated significantly with novel word learning for children with typical hearing, but not for children with HI, with story retelling measures correlating significantly with novel word learning for both groups. Finally, *NRT* showed non-significant moderate correlations to novel word learning for children with HI only.

*<u>Relationships between Pre-Intervention Variables and Measures of Novel Word Learning, Controlling for Age</u>*

Although chronological age had not related significantly to novel word learning in children with HI, it had in children with typical hearing. Therefore, we conducted partial correlations between pre-intervention measures and novel word learning for each group. Results revealed that no pre-intervention variable other than age significantly correlated with receptive or expressive novel word learning in children with typical hearing, although *# CU* showed a moderate correlation with receptive novel word learning. However, for children with HI, there were strong positive correlations between *NRT* and receptive and expressive novel word learning, and between all measures taken from the story retelling task and both receptive and expressive novel word learning. These results can be seen in Table 4.10.

Table 4.10 Comparison of partial correlations between children with typical hearing and those with HI with age controlled.

| | *TH* | | HI | |
|---|---|---|---|---|
| | *MR* | *ME* | *MR* | *ME* |
| *NRT* | -.286 | -.037 | .927 | .968* |
| *# DW* | .433 | -.016 | .920* | .868 |
| *# TW* | .367 | .028 | .997 * | .979 * |
| *MLCU* | -.041 | -.116 | .921 | .906 |
| *# CU* | .593 | .313 | .874 | .841 |

**p* <.05; ***p* < .01p

<u>*Relationships among Pre-Intervention Variables, Controlling for Age*</u>

Next, with age controlled, we compared the relationships among pre-intervention variables for children with typical hearing and for those with HI. The relationship between *NRT* and standardized language measures showed the most dramatic difference between groups, with children with typical hearing showing negative correlations between the variables and children with HI showing moderate positive correlations between *NRT* and all standardized measures except the *PPVT-III*. Correlations between measures taken from the story retelling task and standardized measures of receptive and expressive vocabulary were similar between groups, showing moderate to strong positive correlations. Correlations between story retelling measures and the *GFTA-2* were stronger for children with HI than they were for children with typical hearing. Results can be seen for children with typical hearing in Table 4.11 and for children with HI in Table 4.12.

Table 4.11 Partial correlations among pre-intervention variables for children with typical hearing, controlling for age.

| | *NRT* | *PPVT-III* | *EVT* | *GFWA-2* | *WRIT* |
|---|---|---|---|---|---|
| *1 NRT* | - | -.370 | .127 | -.245 | -.294 |
| *2 # DW* | .140 | .667* | .738* | .218 | .437 |
| *3 # TW* | .154 | .707* | .812** | .434 | .505 |
| *4 MLCU* | -.177 | .786* | .713* | .519 | .248 |
| *5 # CU* | .385 | .360 | .464 | .153 | .373 |

**p* <.05; ***p* < .01p

Table 4.12 Partial correlations among pre-intervention variables for children with HI, controlling for age.

| | *NRT* | *PPVT-III* | *EVT* | *GFTA-2* | *WRIT* |
|---|---|---|---|---|---|
| *NRT* | - | .073 | .445 | .738 | .481 |
| *# DW* | .760 | .699 | .919 | .842 | .262 |
| *# TW* | .898 | .411 | .748 | .710 | .178 |
| *MLCU* | .873 | .529 | .776 | .941 | .523 |
| *# CU* | .705 | .301 | .640 | .338 | -.255 |

<u>*Summary*</u>

Novel word learning appeared to be explained primarily by age for children with typical hearing. However, for children with HI, novel word learning was explained by *NRT* scores and by spontaneous language measures taken from the story retelling task. There were moderate to strong positive correlations among measures from the story retelling task and standardized measures of vocabulary for both groups.

<u>*Analysis of Variables Specific to Children with HI*</u>

In an attempt to further explain the relationship between variables specific to children with HI (age at first amplification, age at first implantation, and length of speech and language therapy) and novel word learning, as well as the relationships between HI specific variables and pre-intervention variables, we conducted another series of partial correlations, controlling for child's age. Due to the small number of children in our study with HI (5) and the even smaller number using cochlear implants (4), the correlations were not statistically significant. However, there were strong negative correlations between age of implant and mean receptive and expressive novel word learning and strong positive correlations between the length of speech and language therapy and receptive and expressive novel word learning respectively. These analyses also showed strong negative correlations between age of implant and the following pre-intervention variables: *NRT*, *# TW*, and *# CU*, with strong positive correlations between length of speech-language therapy and the same variables. Results further showed a moderate negative correlation between age of implantation and # DW, with a moderate positive correlation between length of speech-language therapy and the same variable. These results can be seen in Tables 4.13 and 4.14.

Table 4.13 Partial correlations (controlling for age) among some pre-intervention variables for children with HI.

| | *NRT* | *# DW* | *# TW* | *MLCU* | *# CU* |
|---|---|---|---|---|---|
| 1 Age of first aid | .410 | .696 | .378 | .606 | .149 |
| 2 Age of implantation | -.980 | -.508 | -.851 | -.333 | -.975 |
| 3 Length of SLT | .966 | .458 | .819 | .300 | .961 |

Table 4.14 Partial correlations (controlling for age) among some pre-intervention and intervention variables for children with HI.

| | *MR* | *ME* |
|---|---|---|
| 1 Age of first aid | .361 | .262 |
| 2 Age of implantation | -.851 | -.913 |
| 3 Length of SLT | .819 | .888 |

Inspection of individual data for children with HI (refer back to Table 3.1) showed that participant # 5 was the only child who had bilateral cochlear implants and the only participant in the study to achieve perfect scores on the novel word learning task. This child also received the first cochlear implant at the age of 13 months (the earliest of all participants) and was aided at 5 months.

## General Summary

Results showed no novel word learning difference between children with typical hearing and those with HI. This lack of difference was most pronounced in the expressive task. All children recalled significantly more words at both immediate and delayed conditions receptively than they did expressively.

Partial correlations showed that novel word learning was primarily related to age in children with typical hearing, but not in children with HI. For the latter group, novel word learning was related to spontaneous language measures taken from the story retelling task and to their performance on the *NRT*. There also were moderate to strong positive correlations between measures from the story retelling task and standardized measures of vocabulary for both groups.

With age controlled, age of implantation and length of speech and language therapy showed strong correlations (negative and positive respectively) with receptive and expressive novel word learning, as well as with *NRT* and with several measures taken from the story retelling task. We also noted that all children with HI had received early amplification and auditory-verbal therapy. The only child in the study to use bilateral cochlear implants had the best performance of all participants in the study on expressive novel word learning.

Finally, there were no statistically significant differences between children with typical hearing and those with HI on measures of vocabulary from the story retelling task or on standardized measures of vocabulary. Additionally, all standardized measures, including vocabulary, articulation, and nonverbal intelligence, fell within the average range for children with HI.

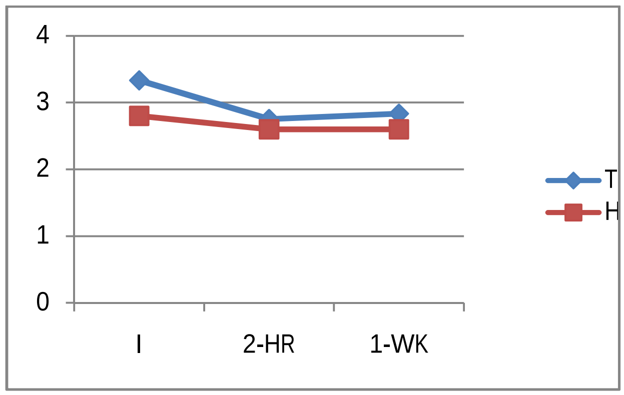
# Chapter Five

## Discussion

### Experimental Findings

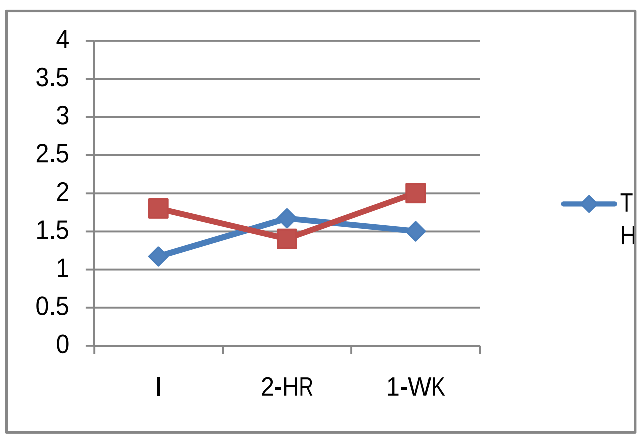
Perhaps the most significant finding of this study was that children with HI were able to fast map novel words names onto beanie babies as effectively as were children with typical hearing. Additionally, the ability to transfer novel words to long-term memory and then to recall them two hours and one week later did not differ between groups. As can be seen in Figure 5.1, the ability of children with typical hearing and those with HI to match the correct beanie baby with its nonword name receptively mirrored each other over time.

Figure 5.1 Mean receptive performance of children with typical hearing (TH) and those with HI in the immediate and delayed conditions.



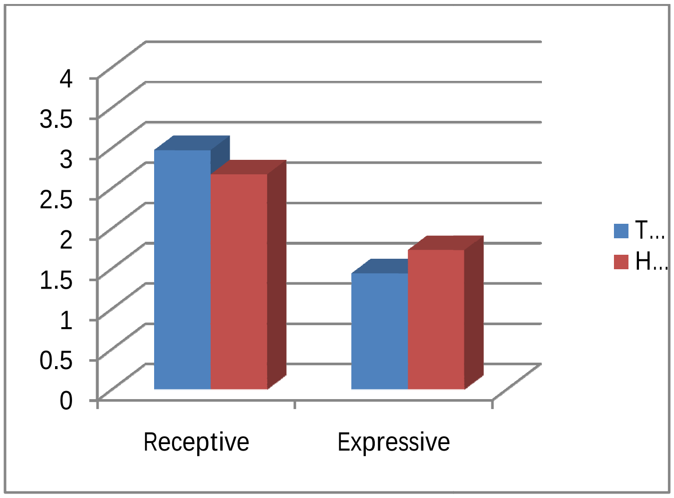

As can be seen in Figure 5.2, children with HI verbally identified more beanie babies correctly than did children with typical hearing in the immediate expressive condition, fewer in the two-hour delayed condition, and then again more in the 1- week delayed condition. Figure 5.3 shows that, when comparing group mean receptive and expressive performance across immediate and delayed conditions, it appears that, while the children with typical hearing had a slightly higher mean receptive performance than did children with HI, the

Figure 5.2 Mean expressive performance of children with typical hearing (TH) and those with HI in the immediate and delayed conditions.



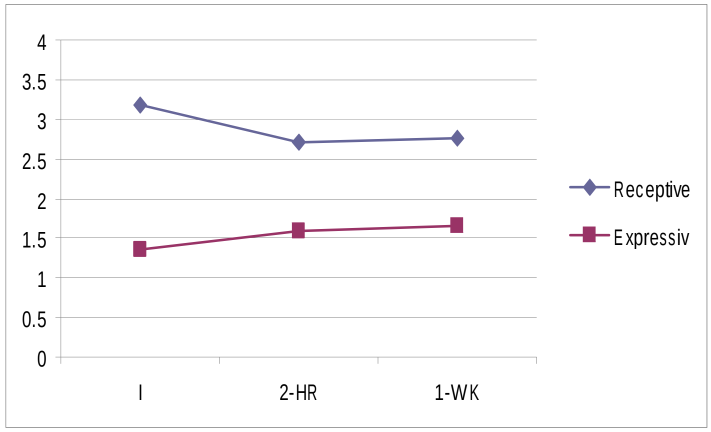
reverse was true for mean expressive performance. This is an interesting finding, although the difference was not statistically significant.

Figure 5.3 Comparison of overall performance of children with typical hearing and with HI on the receptive and expressive novel word learning tasks.




These findings differed from those of Houston et al. (2005), who found that children with profound HI who used cochlear implants learned fewer names for beanie babies than did their peers with typical hearing. We speculate that several factors may have accounted for the studies' different outcomes. First, Houston et al. did not report their participants' language or phonological working memory abilities. Therefore, it is possible that the children with HI in their study may have had language or phonological working memory abilities that were significantly poorer than those of their participants with typical hearing. If this was the case, differences in word learning outcomes between their groups of participants might have been explained by differences in language and phonological working memory abilities, rather than in differences in unaided hearing acuity. Also, Houston et al. used real words to name beanie babies and found that their participants with typical hearing had prior knowledge of many more target words than did their participants with HI. Although they still found that children with typical hearing outperformed children with HI when only words with which both groups were familiar were used, they were not able to do the same analysis using words with which both groups were unfamiliar. They had speculated that such an analysis might give children with typical hearing an even greater advantage over children with HI because studies (e.g. Carey & Bartlett, 1978) have shown fast mapping to be well developed in children with TH. The results of the present study suggest, however, that children with HI are able to fast map novel words onto referents as effectively as do children with typical hearing. As in the Houston et al. study, our study also showed that children performed better with the receptive than with the expressive novel word learning task, as can be seen in Figure 5.4.

Figure 5.4 Comparison of receptive and expressive novel word identification and naming means across time.



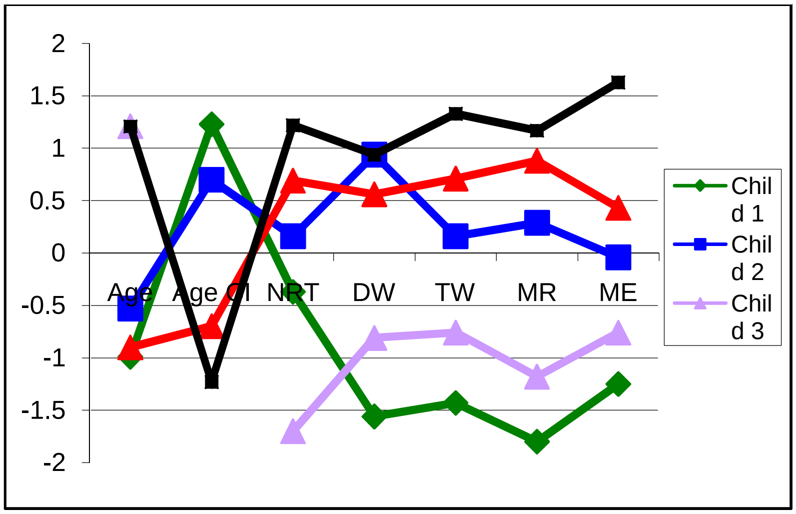

In their study, Houston et al. used eight beanie babies during each play scenario with children aged 4 years and older, whereas we used only four. The decision was made to use four names because we had some children younger than 4 years of age in our study, and since we used nonsense words rather than real words to name the beanie babies, we speculated that this would add an extra challenge in mapping the novel names to beanie babies. However, we noted that seven of our participants (six of whom had typical hearing and one HI) performed at ceiling level on the receptive task. This suggests that, given additional nonword names to learn, these children might have achieved higher scores. If this were the case, it is probable that children with typical hearing might have outperformed children with HI. On the other hand, only one participant performed at ceiling on the expressive task and this was a child with HI. Since children with HI outperformed children with typical hearing on this task, it is unlikely that additional nonword names would have changed these results. However, further study, using an increased number of nonword names and more closely matching chronological age between groups, is needed to answer these questions.

<u>Correlations</u>

Results further showed that the factors most strongly related to novel word learning were participants' age and language measures taken during the story retelling task. The children in our study represented a wide age range (39 – 104 months) and, as would be assumed for typically developing children, their linguistic complexity and the size of their productive vocabularies increased with age. However, the participants' age range differed between children with typical hearing (39 – 104 months) and those with HI (56 – 80 months). Indeed, separate correlations for each group showed that age was significantly related to novel word learning for children with typical hearing, but not for children with HI. We assume that the fact that children with typical hearing represented such a wide age range made it difficult to determine the influence of factors other than age on their novel word learning ability.

However, as seen in figure 5.5, children with HI showed strong positive correlations between *#DW*, *#TW*, *NRT* and novel word learning which, despite the small number of children with HI, reached statistical significance. Indeed, these measures were more strongly related to these children's novel word learning ability than were standardized measures of vocabulary. Researchers have suggested that authentic language measures taken from spontaneous language samples are good indicators of children's language ability (Dunn, Flax, Sliwinski, & Aram, 1996; Pickert & Chase, 1978; Soundy & Gallagher,

Figure 5.5. Comparison of age of cochlear implantation and spontaneous vocabulary measures in children with HI. All measures are converted to *z* scores for comparison.



1993). For example, (Dunn et al, 1996) argued that these measures reliably could be used to differentiate children with typically developing language from those with language impairment in non-mainstream populations. Additionally, research has shown that having children engage in narrative activities such as story retellings produce richer language samples with more complex language than do other types of language sample elicitation techniques (Sutter, & Johnson, 1995). The fact that these measures correlated strongly with children's ability to learn novel words agrees with findings by (Staehr, 2008) which have found that the stronger one's vocabulary, the more easily one learns new words.

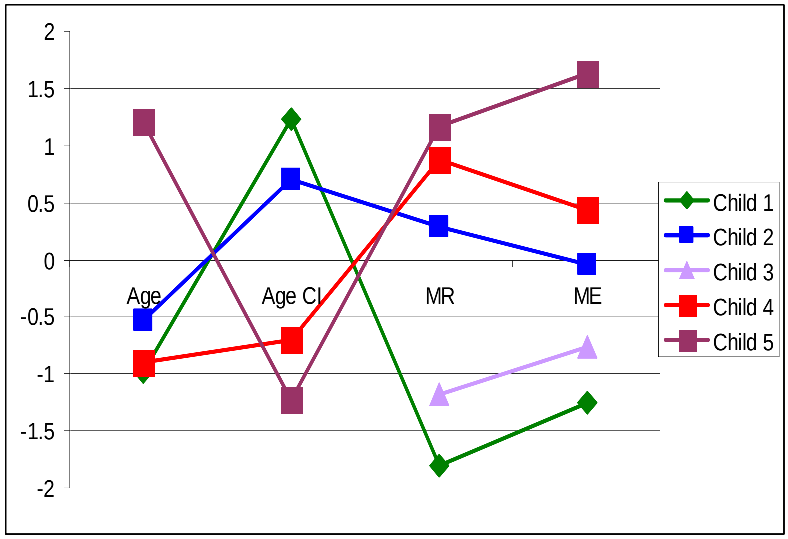
In addition to spontaneous language measures, *NRT*, which measured phonological working memory, significantly correlated with expressive novel word learning (as also seen in figure 5.5) in children with HI and showed a strong positive correlation to receptive novel word learning as well. Past research (e.g. Baddeley et al., 1998, Gathercole et al., 1992) has suggested that phonological working memory is strongly related to word learning ability in young children. Gathercole et al. showed that, between the ages of 4 and 5, phonological working memory appeared to enhance the development of vocabulary in young children, but that after the age of 5, vocabulary began to enhance phonological working memory. Therefore, phonological working memory and vocabulary development appear to have a reciprocal relationship, with one supporting the other. We also noted that all children demonstrated moderate to strong correlations between *NRT* and measures taken from the story retelling task, although these disappeared for children with typical language when age had been controlled. These findings provide further evidence of a relationship between phonological working memory and word learning. Our findings for children with HI do not agree with the findings of Hansson et al. (2004), who had suggested that children with HI might use mechanisms other than phonological working memory to support word learning. Although caution must be used in interpreting the results of the present study, our findings suggest phonological working memory relates to word learning in children with HI in much the same way as previous researchers have found that it relates to word learning in children with typical hearing. We speculate that we did not have a similar finding for the children with typical hearing in our study because of the relationship of age to their performance.

As might be expected, we found that, with age controlled, standardized measures of vocabulary correlated significantly with spontaneous measures from the story retelling task for children with typical hearing and, although they did not reach statistical significance, showed moderate to strong correlations for children with HI. These findings suggest that, for both groups of children authentic measures of language and standardized measures were closely related. It is interesting to note, however, that novel word learning related more strongly to children's ability to use words productively in a story retelling task than to standardized measures of language. At first we speculated this was because of the effect of age (which was controlled for standardized measures) and, although this may have been true for children with typical hearing, these relationships remained for children with HI after age had been controlled.

## Factors Specific to Children wih HI

As has been found by other researchers, we found that age of cochlear implantation (Geers et al., 2007; Nicholas & Geers, 2004; Svirsky et al., 2004; Tait et al., 2007; Tomblin et al., 2005) showed a strong negative correlation with novel word learning (as displayed in Figure 5.6) and phonological working memory and authentic vocabulary measures in children with HI. In other words, the earlier the child had received a cochlear implant, the better his or her outcomes. Length of communication therapy also correlated strongly (in this case in a positive

Figure 5.6 Relationship between chronological age, age of implantation and mean receptive and expressive novel word learning in children with HI. Scores converted to *z* scores for comparison.




direction) with word learning in children with HI and showed moderate to strong correlations with these children's phonological working memory ability and with their vocabulary measures from the story retelling task. This was true even though all of our participants had received cochlear implants by the age of 27 months. Although other factors, such as number of electrodes in the cochlear implant, type of cochlear implant (unilateral or bilateral) were not able to be statistically analyzed due to the homogenetiy of this sample, several speculations can be made. First, the child with the strongest performance on the novel word learning task (indeed the only child to reach ceiling on both the receptive and expressive task) was a child with HI who had received her first cochlear implant at the age of 13 months. This was three months earlier than the next participant, who had received an implant at 16 months. In addition to receiving a cochlear implant at 13 months, this child has since received another and was the only child in the study to use bilateral implants. This child also had the strongest measures from the story retelling task and the best nonword repetition and nonverbal intelligence scores of the children with HI, but did not have the strongest standardized vocabulary scores. Finally, this child was one of the two older children with HI (aged 80 months). So, although it is possible that age had some effect on outcome, the other 80-month-old child with HI, who wore hearing aids rather than a cochlear implant, did not perform as well on any measure except receptive vocabulary, despite receiving initial amplification at the same age (5 months) and reporting having had 12 additional months of speech and language therapy.

Additional speculation can be made with regard to the child with HI who received a cochlear implant after the 24 month timeframe Geers (2002) suggested as being related to enhanced outcomes. This child had the poorest novel word learning scores among the participants with HI, even when compared to a similarly aged child who received a cochlear implant much earlier. The child who received the later implant also had the lowest standardized vocabulary measures among the children with HI. This child showed poor novel word learning abilities despite having nonverbal intelligence within the average range. Although previous findings have suggested that nonverbal intelligence is related to novel word learning in children with HI (Gilbertson & Kamhi, 1995), our results did not show this relationship, but suggested that spontaneous language, phonological working memory, and age of implantation were more closely realted to novel word learning in these children.

Finally, all children in this study have been enrolled in auditory-verbal therapy. Research has suggested that, in conjunction with early cochlear implantation, auditory-verbal therapy is an effective method to help children with profound hearing loss develop oral language skills that allow them to communicate effectively within the hearing community (Ertmer, 2002a). The findings of the present study support this conclusion.

## Limitations

This study had several limitations. Due to time constraints, a small number of children with HI in the local area, and limited access to similarly aged children with typical hearing, this study had a smaller than desired number of participants. Also, although the mean age did not differ significantly between the children with HI and those with typical hearing, the age range of the children with typical hearing was such that the relationship between age and novel word learning superceded the latter's relationships with measures of language and phonological working memory. Despite these limitations, however, we feel that this study provides data that suggests that, with early implantation and auditory-verbal therapy, children with profound HI can achieve language skills within the average range of their typically developing peers with typical hearing.

## Summary and Conclusions

1. Children with HI learned novel words as effectively as did children with typical hearing. Although, due to the small *N* in this study, these results must be interpreted with caution, they suggest that, with early amplification and therapy, children with HI can learn words orally as effectively as can children with typical hearing. These findings also sugggest that children with HI do not have delayed memory strategies and word learning ability. Therefore, they should become achieve reading milestones at a typical rate. In doing so, their expectations for academic achievement can clearly be met through the use of technology (hearing aids or cochlear implants) and their educational experience will likely be more engaging and meaningful.
2. Although spontaneous language measures correlated significantly with novel word learning in children with typical hearing, these relationships disappeared with age controlled. This suggests that, for children with typical hearing, age was primarily related to novel word learning. We suggest, however, that this was primarily due to the wide age range represented in this group.
3. Spontaneous vocabulary measures, taken from the story retelling task, and measures of phonologial working memory showed moderate to strong correlations to novel word

learning in children with HI, with several reaching statistical significance. These results suggest that the same abilities that support word learning in children with typical hearing support word learning in children with HI.

4. Spontaneous vocabulary measures, taken from the story retelling task, showed moderate to strong correlations with measures of phological working memory for all children, although these relationships disappeared for children with typical hearing after age had been controlled.
5. For children with HI, age of cochlear implantation and length of speech and language therapy showed strong correlations to novel word learning, spontaneous language measures and phonological working memory skills.
6. Mean standardized language and nonverbal intelligence score for children with HI in our study were within the average range. Indeed all children with HI demonstrated standardized expressive vocabulary and nonverbal intelligence scores within the average range.

## Implications for Future Research

In light of the present study's findings, we suggest that further research be conducted to replicate this study using a larger number of participants. Additionally, efforts should be made to match children for age and to restrict the age range of participants. Finally, we suggest adding additional beanie babies to control for ceiling effects.

Although the results of this study suggest that children with profound HI, who receive cochlear implants and auditory-verbal therapy at a young age, are able to fast map novel words onto referents after just a few exposures, Ouelette (2006) suggested that vocabulary depth was a better predictor of literacy skills than was vocabulary breadth. Ouelette described breadth of vocabulary as the number of words a child may be able to use at any one time in development without having a full grasp of their meaning. On the other hand, he said that vocabulary depth refers to the number of words to which a child can apply meaning. Roth et al. (2002) found that children's ability to define words was predictive of reading comprehension. Studies of the ability of school-aged children with profound hearing loss, who had received cochlear implants before the age of 24 months, to define words would provide further evidence of the effectiveness of early implantation and auditory-verbal therapy in helping these children develop the prerequisite language skills they need to successfully transition to literate language.

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# Appendixes

## Appendix A

*Stimulus words for Nonword Repetition Test*

| | | | |
|---|---|---|---|
| /naib/ | /tei vak/ | /tfi noi taub/ | /vei ta tfai doip/ |
| /voup/ | /tfou vaeg/ | /nai tfou veib/ | /dae vou noi tfig/ |
| /taudz/ | /vae tfaip/ | /doi tau vaeb/ | /nai tfoi tau vub/ |
| /doif/ | /noi tauf/ | /tei voi tfaig/ | /tei va tfi naig/ |

# Appendix B

*Story Re-telling Script (One Frog Too Many – Mercer & Meyer, 1975)*

One day Michael found a gift with his name on it.

He opened it and was excited at what was inside.

Inside the box were two frogs!

He thought they should be friends, but one frog bit the other frog's leg and it made Michael mad.

Michael told the frog "that's not nice! We don't hurt our friends!"

They all decided to go to the forest to sail in the water.

The mean frog thought it would be funny and he kicked the other frog off of the turtle's back.

Michael told the frog, "Stop being mean. You don't get to go for a ride on the boat."

They set sail across the water, but the mean frog decided to jump on board when no one was looking.

He kicked off the other frog, who fell in the water.

Michael noticed and became very worried.

Nobody could find the other frog anywhere!

Michael and his friends went sad and worried.

They sat in Michael's room not knowing what to do when suddenly they heard a noise from outside.

The frog had come back!

He jumped through the window and landed on top of the mean frog's head.

Both frogs became friends after the mean frog apologized and everyone was happy.

# Appendix C

*Script for Presentation of Beanie Babies*

This is *Name*.

Can you say hi to him?

Say "Hi *Name*." {child then says "Hi *Name*."}

*Name* likes to climb in the bus.

Can you put him in the bus? {child interacts with beanie baby}

Look -- *Name* is in the bus.

Tell him to get out.

Say "Get out *Name*" {child says, "Get out *Name"*}

Good. Now, *Name* has to go bye bye.

Say, bye bye *Name*. {Child repeats "Bye bye *Name"*}

**Name* referred to the specific name of the beanie baby utilized in the scenario

-adapted from Houston et al. (2005)

Appendix D

*Parent Questionnaire*

WORD LEARNING IN CHILDREN WITH HEARING IMPAIRMENT AND TYPICAL HEARING

CHILD'S NAME________________________________________________________

---

YOUR CHILD WILL BE ASSIGNED A STUDY NUMBER______________________ WHEN THIS INFORMATION IS RECEIVED. AT THAT TIME, HIS OR HER NAME WILL BE REMOVED FROM THIS INFORMATION SHEET AND DESTROYED SO THAT THE INFORMATION PROVIDED BELOW WILL NOT IDENTIFY HIM OR HER IN ANY WAY.

CHILD'S GENDER______________________________

NUMBER OF SIBLINGS__________________ AGES OF SIBLINGS______________

NUMBER OF EAR INFECTIONS CHILD HAS HAD?__________________________

HOW WERE EAR INFECTIONS TREATED?_________________________________

FATHER'S AGE______________________ MOTHER'S AGE___________________

CHILD LIVES WITH: MOTHER___ FATHER____BOTH___OTHER_____________

FATHER'S OCCUPATION_______________________________________________

MOTHER'S OCCUPATION_______________________________________________

HIGHEST GRADE COMPLETED BY FATHER________________________________

HIGHEST GRADE COMPLETED BY MOTHER_______________________________

CHILD'S DEMOGRAPHIC INFORMATION:

_______AFRICAN-AMERICAN ______________HISPANIC _________ASIAN

_______NATIVE AMERICAN ______________WHITE _____________OTHER

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DOES CHILD USE A COCHLEAR IMPLANT, HEARING AID, OR BOTH?

________________________________________________________________________

AGE OF IMPLANTATION OR HEARING AID FITTING?_______________________

IF IMPLANTED, DID CHILD USE HEARING AIDS PREVIOUSLY AND FOR HOW LONG?_______________

HOW LONG HAS CHILD USED COCHLEAR IMPLANT OR HEARING AID?
___________________________________________________________

WHAT IS THE CHILD'S PREFERRED MODE OF COMMUNICATION (ORAL OR SIGN)?____________________________________________________________________

WHAT TYPE OF COMMUNICATION INTERVENTION HAS THE CHILD RECEIVED (ORAL, TOTAL COMMUNICATION, SIGN)?___________________________________

HOW LONG DID YOUR CHILD EXPERIENCE DEAFNESS BEFORE HAVING COCHLEAR IMPLANT OR BEING FITTED WITH HEARING AIDS?______________

IF IMPLANTED, WHAT IS THE NUMBER OF ELECTRODES USED WITH COCHLEAR IMPLANT?______________________________________________________

*Thesis Invitation*

Dear Parents:

My name is Matthew Clark. I am a graduate student in the Department of Communication Disorders at Marshall University. In my time here at Marshall I have become interested in learning how children with typical hearing and those with hearing impairment learn new words. I am requesting an opportunity to include your child in the research study. The nature of the study is explained on the attached consent form. Please consider allowing your child to be in the study. Your child will have an enjoyable experience and what we learn will help other children to improve their word learning and reading skills.

Thank you.

Sincerely,

Matthew Clark, Graduate Student
Communication Disorders

P.S. If you allow your students to participate in the research study, please initial each page of the consent form, sign the appropriate space on the last page, and have a witness sign the form as well.

**WORD LEARNING IN CHILDREN WITH HEARING IMPAIRMENT AND CHILDREN WITH TYPICAL HEARING**

Mary E. Reynolds, Ph.D., Principal Investigator
Matthew Clark, Co-Investigator

## *Introduction*

We would like to conduct a research study at (Name of school, preschool, or head start). The findings from this study may help us learn about how children with hearing impairment (whether using a cochlear implant or hearing aid) learn new words and remember them for later use.

## *Why Is This Study Being Done?*

This study is being done because few studies have been done that have compared word learning in children with hearing impairment to that of children with typical hearing. We feel that it is important to study this because children with strong vocabularies have been shown to be good readers.

## *What Is Involved In This Research Study?*

If your children participate in the study, they will first complete speech, language, reasoning, and (if reported to have typical hearing), hearing tests.

Following these tests, children will participate in one intervention session. During this session, children will learn new names for beanie babies. Following the intervention session, children will be asked to choose the beanie baby named by the experimenter and then to name each beanie baby the experimenter shows him or her. These procedures will be repeated again after two hours and after one week later.

## *What About Confidentiality?*

We will do our best to be sure children's information is kept confidential. Each child will be assigned a study number, with every test or material used in the study being given this number to identify the child. Neither the children's name nor other identifying information will be recorded on any test forms. If we publish the research obtained in this study, children will not be identified by name or in any other way. However, we cannot guarantee absolute confidentiality. Federal law says we must keep your study records private. Nevertheless, under unforeseen and rare circumstances, we may be required by law to allow certain agencies to view records. Those agencies would include the Marshall University Institutional Review Board (IRB), Office of Research Integrity (ORI) and the federal Office of Human Research Protection (OHRP). This is to make sure we are protecting your rights and your safety.

## *What Are The Costs Of Taking Part In This Study?*

There are no costs to (school) for allowing your students to take part in this study. All the study costs, including any study tests, supplies and procedures related directly to the study, will be paid for by the study.

## *Whom Do I Call If I Have Questions Or Problems?*

If you have questions about the study, contact the study investigator, Mary E. Reynolds, (304) 696-2987 or reynoldm@marshall.edu.

For questions about the rights of research participants, contact the Marshall University IRB#2 Chairman Stephen Cooper.

You will be given a copy of this consent form.

***SIGNATURES***

I certify that I have read this consent form and understand the purpose of the study and the procedures to be used. I agree to allow the study to be conducted at (Name of school).

________________________________________

Name of School Administrator (Printed)

________________________________________ ________________

Signature of School Administrator Date

________________________________________ ________________

Principal Investigator Date

________________________________________ ________________

Witness Date

# Curriculum Vitae

## Matthew Clark

**Current Address:** 2107 Buffington Avenue
Apt. #114B
Huntington, WV 25703

**Permanent Address:** 1643 Atson Lane
Cincinnati, Ohio 45205

**Telephone:** (513) 673-9224
**E-mail:** clark248@marshall.edu
**Date of Birth:** April 15, 1984
**Place of Birth:** Cincinnati, Ohio
**Citizenship:** United States of America

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### Education

M.S.: Communication Disorders – Speech-Language Pathology, Marshall University, May 2009
B.A.: GPA: 3.4, Psychology, University of Cincinnati, June 2006
H.S. Diploma: Elder High School, Cincinnati, Ohio, June 2002

### Honors and Awards

Dean's List, University of Cincinnati
Golden Key National Honor Society
National Dean's List
Sister's of Charity Scholarship
Mortar Board Honor Society
National Honor Society
Honors, University of Cincinnati

### Experience

**Clinical Experience**
Marshall University Speech and Hearing Center June 2007 – present

Responsibilities:

-evaluated and treated both children and adults with a variety of speech and language disorders including articulation/phonological impairments, cognitive communication disorders, voice disorders, aphasia, motor speech disorders, autism, and expressive and receptive language disorders. I gained experience with the following child evaluation tools: Goldman-Fristoe Test of Articulation-2, Expressive Vocabulary Test, Peabody Picture Vocabulary Test-III, Wide Range Intelligence Test, Comprehensive Assessment of Spoken Language and the Clinical Evaluation of Language Fundamentals-4.

-I received additional experience with the Scales of Cognitive Ability for Traumatic Brain Injury and Boston Diagnostic Aphasia Examination for adult evaluation of language.

Lawrence Co. Early Learning Center — January 2008 – May 2008
Lawrence Co. Elementary, Louisa KY

Responsibilities:

-evaluated and treated children with a variety of speech/language impairment. I gained additional experience in evaluating children with the following tools: Receptive One Word Picture Vocabulary Test, Receptive One Word Picture Vocabulary Test, Clinical Evaluation of Language Fundamentals-Preschool and The *Fluharty* Preschool Speech and Language Screening Test.

-I also gained experience in conducting group therapy within a school setting for articulation/phonological disorders and for pragmatic group experiences.

Pleasant Valley Hospital, Pt. Pleasant WV — June 2008 – August 2008

Responsibilities:

-evaluated and treated adults and children with a variety of speech and language disorders ranging from dysphagia with adults to articulation/phonological disorders and autism with children. Additional evaluation tools I gained experience in include: Ross Information Processing Assessment and the Preschool Language Scale-4.

-I also gained additional experience in performing bedside dysphagia and cognitive communication evaluations with adults.

St. Mary's Medical Center, Huntington WV — January 2009 – present

Responsibilities:

-evaluated and treated adults with acute care needs related to dysphagia management as well as cognitive communication impairments and various voice disorders.

-gained further experience with Fiberoptic Endoscopic Evaluation of Swallowing and Modified Barium Swallowing Studies.

**Teaching Assistant** — September 2005 – December 2005
University of Cincinnati, Introductory Psychology 102
3 hrs/ week — Supervisor: Catherine Strathern, Ph.D.

Responsibilities:
- Graded homework assignments
- Assisted students with quarter projects
- Graded quarter projects
- Held reviews with students for upcoming tests

**Research Assistant** December 2004 – June 2006
Psychology Department, University of Cincinnati
3 hrs/ week Supervisor: Peter Chiu, Ph.D.

Responsibilities: Collected brain imaging and behavioral data for adults/children in project examining how brain processes sound in someone who has hearing impairment.

**Research Assistant** March 2005 – June 2005
Psychology Department, University of Cincinnati
3 hrs/ week Supervisor: Marina Klein, M.A.

Responsibilities: Collecting data and running participants for study investigating learning of motor-tasks in an endoscopic surgery simulator.

**Research Assistant** August 2006 – August 2008
Department of Communication Disorders, Marshall University
10 hrs/week Supervisor: Mary Reynolds, PhD., CCC-SLP

Responsibilities: Typing transcripts and analyzing measures/data collection for a study investigating Appalachian dialect in children and a study investigating predictors of middle childhood language ability in rural Appalachian children.

**Master's Thesis** January 2008 – April 2009
Department of Communication Disorders, Marshall University
Thesis Mentor: Mary Reynolds, PhD., CCC-SLP

Responsibilities: Research completed as part of graduate program. Data collection and statistical analysis of measures for a study investigating the word learning/fast mapping abilities of children with hearing impairment (both with cochlear implants and hearing aids) and children with typical hearing.

**Volunteer Experience** March 2005 – Summer 2005
Big Brother/ Big Sisters, Dayton Teen Center, Dayton, KY
2 hrs/ week Supervisor: Eric Wilson

Responsibilities:
-Mentored student in an after-school program at teen center