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The Effects of Cochlear Implantation and Educational Audiology Services on Language Skills: A Case Study

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THE EFFECTS OF COCHLEAR IMPLANTATION AND EDUCATIONAL AUDIOLOGY SERVICES ON LANGUAGE SKILLS: A CASE STUDY

By
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A thesis submitted to the faculty of The University of Mississippi in partial fulfillment of the requirements of the Sally McDonnell Barksdale Honors College.

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ABSTRACT
MADISON E. JOSEY: The Effects of Cochlear Implantation and Educational Audiology Services on Language Skills: A Case Study
(Under the direction of Dr. Ying Hao)

Purpose

Hearing loss can affect many aspects of a child's life, particularly their language abilities and academic performance. Literature shows that children with hearing loss are more likely to have language deficits compared to their hearing peers (Tomblin et al., 2015). The degree to which language skills are affected has been shown to correlate with various factors, such as age of identification, hearing levels, and amount of speech and language intervention (Delage & Tuller, 2020; Shojaei et al., 2016). The aim of this research study was to assess how cochlear implantation and speech-language intervention affects the language skills and academic grades of one child with hearing loss.

Method

A case study method was utilized in order to gather detailed information on the language development of the child as treatment measures were implemented. Using a pre-and post-test research design, researchers gathered data on the child's narrative skills and classroom grades before and after her cochlear implantation and continuous modifications and accommodations at school. Language abilities were determined using the story re-tell method in both language samples. The participant's narrative was transcribed and analyzed using microstructure and macrostructure analysis. Results between the pre- and post-test language samples and the child's grades in language arts, reading, and mathematics were compared and interpreted.

Results

Regarding microstructure, the child displayed reduction in five out of six microstructural errors and improvement in lexical and morphosyntactic diversity. In regards to macrostructure, the child improved in four out of seven elements, maintained status in two elements, and decreased in one element. The child's grades increased in language arts from the pre- to post-test period, however decreased in reading and mathematics.

Conclusion

The results of the research show that the child's language skills improved with cochlear implantation and educational audiology services. Overall, the participant showed improvement in both micro- and macrostructural language abilities as the treatment measures were implemented. While the participant's grades in reading and mathematics decreased, academic growth was seen by both clinicians and researchers.

PREFACE

This thesis seeks to address the effects of intervention and a unilateral cochlear implant on one child's language skills. It was written to fulfill the graduation requirements for the Sally McDonnell Barksdale Honors College and to continue tracking the progress of the child's development following the pilot study the year prior. The pilot study occurred from August to March of 2019-2020. The research conducted for this thesis took place from June to March of 2020-2021.

This research project was conducted under Dr. Ying Hao and Dr. Rebecca Lowe. This thesis magnifies a component of a larger research project aimed at assessing the effects of educational audiology services on ten students with hearing loss. As with this study, the research seeks to apply a wholistic view of children with hearing loss, focusing not just on their hearing abilities, but their quality of life and daily functioning levels. Researchers were interested in including all members of a child's support system including teachers and clinicians to encourage a team approach and address the barriers that exist with service provision.

Researchers assessed the language development of the child through regular assessment, however it was the work of her family, teachers, and speech language pathologist that contributed most to her language growth over the past year. Their willingness to implement recommendations and support her academically, socially, and emotionally led to immense progress that cannot be properly quantified by data. It has inspired me to watch such dedicated professionals advocate for a child to reach her fullest potential.

Over the entire course of this research project, the COVID-19 pandemic brought unprecedented circumstances and caused us to constantly adapt. We learned how to be flexible and patient, as school closings, quarantine orders, and illnesses shifted our original plans. Thankfully, technology allowed us to continue assessments and intervention remotely.

It has been an honor to work alongside the researchers and professionals that have made this project possible, their willingness to advise me and guide me in this process is greatly appreciated. It has also been an honor to work with such a bright, young girl. Getting to watch her progress so rapidly has been a privilege and I am excited to see what the future has in store for her.

Writing this thesis has taught me a lot about perseverance, but I have thoroughly enjoyed this process. I hope you enjoy this culmination of hours spent reading, writing, and sitting in zoom meetings.

Sincerely,
Madison Josey

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LIST OF ABBREVIATIONS

ASHA……AMERICAN SPEECH-LANGUAGE-HEARING ASSOCIATION

WHO……..…….……WORLD HEALTH ORGANIZATION

CDC……..…CENTER FOR DISEASE CONTROL AND PREVENTION

EHDI……..EARLY HEARING DETECTION AND INTERVENTION

IDEA…….INDIVIDUALS WITH DISABILITIES EDUCATION ACT

HAT……..…..HEARING ASSISTIVE TECHNOLOGY

AAA…….....AMERICAN ACADEMY OF AUDIOLOGY

SLP……...…….SPEECH LANGUAGE PATHOLOGISTS

EAA……..EDUCATIONAL AUDIOLOGY ASSOCIATION

SNR…….……SIGNAL TO NOISE RATIO

IRB……...……INSTITUTIONAL REVIEW BOARD

dB……...…….DECIBELS

SALT…….SYSTEMATIC ANALYSIS OF LANGUAGE TRANSCRIPTION

IEP…….INDIVIDUALIZED EDUCATION PLAN

MLU……...……MEAN LENGTH OF UTTERANCE

NDW……...……..NUMBER OF DIFFERENT WORDS

NTW…….…….NUMBER OF TOTAL WORDS

INTRODUCTION

Hearing is vital to the speech and language development of children. Children with hearing loss may miss speech sounds, and therefore experience developmental delays (American-Speech-Language-Hearing Association [ASHA], 2015). ASHA (2015) identifies four different ways hearing loss can impact a child's development including delayed expressive and receptive language, learning difficulties, communication difficulties and social isolation, and vocational choices. Prevention and early identification are vital to ensure optimal language development. While hearing loss in children is often due to genetic factors, approximately 60% of cases of hearing loss in children could have been prevented (World Health Organization [WHO], 2020). Preventable causes may include ototoxic medications after birth or during pregnancy, birth complications, and infections (WHO, 2020). Early identification is vital when a hearing loss does become present. Newborn hearing screenings are performed on approximately 98% of infants (Center for Disease Control [CDC], 2018), however late-onset hearing loss in children may lead to unidentified hearing loss and developmental delays. The prevalence of late-onset hearing loss is not widely known, but the amount of children with hearing loss increases with age, highlighting a need for continued screening and intervention (Eiten). The Early Hearing Detection and Intervention (EHDI) program is an agency in every state that seeks to provide testing services and intervention for children with hearing loss. The EHDI guidelines are to screen babies by 1 month, diagnose any potential hearing loss by 3 months, and begin intervention by 6 months (American Academy of Pediatrics [AAP], 2021). Early intervention usually occurs in the first three years of a child's life and is crucial for the speech, language, and social development of children with hearing loss (CDC, 2020).

Children with hearing loss require a team of people to support their academic, social, and personal development. The Individuals with Disabilities Education Improvement Act (IDEA, 2004) provides services for children with disabilities from birth to 3 years, which enables all children with hearing loss to receive early intervention. Professionals such as speech language pathologists (SLPs), audiologists, pediatricians, and school faculty work with the child and their families on how to best support their individual communication needs. A number of different intervention methods may be implemented to lessen the gap between children with hearing loss and their typical hearing peers. Special education plans, parent and teacher training, support groups, and hearing assistive technology (HAT) are all intervention measures aimed at advocating and supporting children with hearing loss. For children with more severe cases of hearing loss, cochlear implant surgery may be the most effective course of intervention. These small electronic devices are used to stimulate the cochlear nerve and give individuals with hearing loss greater access and clarity to sounds (John Hopkins Medicine). Children who receive cochlear implants show positive outcomes academically and compare well in academic achievement as compared to their hearing peers (Spencer, Gantz, & Knutson, 2009). While the outcome is dependent on many factors such as age of implantation, severity of loss, environment, and education level, cochlear implants may help children with hearing loss develop adequate language, social, and academic skills (Weerdenburg et al., 2019).

Audiologists' scope of practice includes the prevention, identification, assessment, diagnosis, and treatment of hearing loss (American Academy of Audiology [AAA], 2004). Educational audiologists provide these services in school settings while working alongside teachers , nurses, SLPs, parents, and other professionals to ensure all children have appropriate access to auditory information in the classroom (Educational Audiology Association [EAA],

2019). Educational audiologists are able to make recommendations to teachers based on students' individuals communication needs in the classroom. Recommendations may include but are not limited to: implementing appropriate accommodations for each classroom, modifying assignments, and using visual clues in the classroom. The purpose of this study is to explore the effects of cochlear implants and educational audiology services on one child's language skills and academic performance. This study utilized remote intervention methods and assessments to deliver services that were effective and efficient for the client and clinicians.

Chapter 1

LITERATURE REVIEW

Effects of hearing loss on language skills

Children with hearing loss are at a greater risk of experiencing language delays and academic difficulties due to the lessened auditory input as compared to children with normal hearing. Hearing is fundamental in the language development of a child, therefore it is vital that hearing loss is identified and intervention takes place as early as possible so that children receive access to all speech sounds. A study conducted by Tomblin et al. (2015) assessed the language skills of 290 preschool children with hearing loss through language samples, standardized testing, and parent reports. A group of 112 children with normal hearing of matched age and socioeconomic status were also assessed and the results of the two groups were compared. Overall, the group of children with hearing loss performed significantly lower than the group of hearing children, particularly in morphosyntax abilities, such as word and sentence formation. Researchers did find, however, that language skills were better in children who used hearing aids regularly and were fitted at any early age. Results show that with early identification and intervention, the language gap between children with hearing loss and children with normal hearing may be lessened. These results are consistent with Shojaei et al.'s (2016) study, which compared the language skills of children who received early intervention for hearing loss (3-6 months) with children who received intervention after the first year of life. The authors found that the children who received earlier intervention had significantly higher language skills than

those who received intervention later. This data indicates that intervention is most vital in the early stages of language development.

A study conducted by Walker et al. (2020) analyzed whether these language gaps were still present later in the school years. A group of fourth grade children with hearing loss were assessed on vocabulary, morphological awareness, listening comprehension, and reading skills and their scores were compared to a similar group of hearing children. The group of children with normal hearing performed better than the group of children with hearing loss on these tasks, and had significantly higher scores in morphological awareness and listening comprehension. These results are expected, as children with hearing loss have difficulty hearing quiet morphemes such as the /s/ and /t/ sounds. Listening comprehension is particularly difficult for a child with hearing loss because a great deal of energy is spent straining to hear speech sounds, with little energy available to comprehend the auditory information being received (Lewis et al. 2015). Walker's study also supported the claim that increased hearing aid usage results in better listening comprehension and language skills.

While early intervention shows promising outcomes in the language skills of children with hearing loss, intervention must continue beyond the first developmental years. Research shows that the language gap seen between children with normal hearing and children with hearing loss does not lessen by the adolescent years. Delage and Tuller (2020) assessed the oral and written language skills of 19 students with mild to moderate sensorineural hearing loss, ages 11-15 years and compared the results to scores from students with normal hearing. Language disorders and difficulties with phonology and grammar were found in the group of students with hearing loss and the extent of language impairment was correlated with the degree of hearing loss. Further, due to these language gaps that exist into adolescent years, children with hearing

loss often have delayed psychological and social development as well and may display behavioral issues if language delays are left unaddressed. Dalton (2013) interviewed three high school students regarding how their hearing loss affected their experiences in school. These students expressed feelings of social isolation, inadequate communication with teachers, and lack of comprehension in the classroom. The experiences of these adolescents highlights the need for continued intervention beyond early childhood years.

Language Sample Analysis

Language samples provide useful insight into a child's language abilities in real-world situations (Ebert & Scott, 2014). While conversational language samples rely on context and the interaction between two or more speakers, narrative language samples allow one speaker to display expressive language skills and develop a structured context solely through the use of language (Petersen, 2010). In contrast to many norm-referenced language assessments that are dependent on the child to behave or perform a specific way, such as sitting for prolonged amounts of time, narrative language samples are a flexible and valid form of language assessment (Ebert & Scott, 2014). A child's macrostructural and microstructural language skills can be measured through the use of these narrative language samples. Macrostructural language skills include story-grammar such as presence of an introduction, character development, conflict resolution, character emotional states, referencing and listener awareness, and story cohesion (Orizaba et al., 2020). Microstructural language skills include more specific linguistic features on the word and sentence level, such as mean length of utterance (MLU), total number of words (TNW), and number of different words (NDW).

MLU is a reliable indicator of a speaker's morphosyntactic development (Chamberlain, 2016). Morphemes are the smallest unit of language with meaning. Each word is comprised of

one or more morphemes, for example the word “run” is one morpheme. Adding a unit of language that cannot be divided further increases the morphemes, therefore “running” would consist of two morphemes. Greater morpheme usage indicates higher level language. MLU is calculated by dividing the total number of morphemes by the total number of utterances. A higher MLU score is indicative of greater use of more complex syntax and morphology. NTW is simply the total number of words in a given language sample and is a measurement of lexical productivity. It has low reliability concerning language level, therefore the measure is not usually interpreted alone (Pezold et al., 2020). NDW is an indicator of lexical diversity in samples of 50-100 utterances (Hewitt et al., 2005). Higher NDW scores are representative of a diverse vocabulary and higher expressive language skills.

In a study by Hewitt et al. (2005), the measures derived from narrative language analysis are sound predictors in identifying children with language development. Measures such as MLU and NDW were analyzed in the transcribed language samples of 27 children with specific language impairment (SLI) and 27 age-matched, normally developing children. It was found that the MLU and NDW scores were lower in the group with diagnosed specific language impairment, as compared to the typically developing children. The findings indicate that microstructural language skills measured in language sample analysis are valid measurements of language abilities and deficits. Further, narrative language sample analysis results seem to be consistent with the results of many norm-referenced tests such as the Clinical Evaluation of Language Fundamentals (CELF) and Peabody Picture Vocabulary Test (PPVT). A study by Ebert and Scott (2004) explored the relationship between norm-referenced tests and narrative language samples. Researchers retrospectively evaluated performance on both modes of assessment with 73 children, ranging from 6-12.8 years of age. To compare the children’s

performance on different targeted language skills, measurements from the norm-referenced assessments and narrative language samples were categorized into groups such as word-level, sentence-level, and discourse-level. Contingency analysis showed that correlations were especially strong for younger children between the two types of language assessments. The resulting language levels for each child were found to have moderate overlap, suggesting that narrative language samples provide similar findings as norm-referenced language assessments, while also allowing for flexibility with children and utilizing real-world settings.

Cochlear Implants with early intervention

For children with severe to profound hearing loss, cochlear implants may help increase auditory input. Cochlear implants are associated with greater speech perception and spoken language outcomes for deaf children, but these outcomes are highly dependent on many factors. The age of implantation, whether it is unilateral or bilateral, ability to read lips, environment, and education level can determine the effectiveness of cochlear implants (Weerdenburg et al. 2019). It is suggested that deaf children should receive a cochlear implant before the age of five for optimal language development by 12 months after implantation (Robinson, 1998). The results of research conducted by Nicholas and Geers (2007) is consistent with the claim that earlier implantation yields better outcomes. Researchers obtained two language samples from 76 children with hearing loss, once at age 3.5 and again at age 4.5. All children were implanted before they were 3 years old. The results of language analysis showed that children who had longer duration of cochlear implant use and were implanted at an earlier age scored higher in overall language abilities. Additionally, children who were implanted at the youngest ages scored on similar levels on the PLS as their peers, while children who were implanted after 24 months did not perform on the same level as their hearing peers.

There are mixed results in literature regarding the language outcomes of children with cochlear implants, but a study conducted by Weerdenburg et al. compared the development of spoken language, speech decoding, and verbal memory among profoundly deaf children with cochlear implants, hard of hearing children, and children with specific language impairment. The children were assigned to either a young-age group (median age of 6.2 years) or an old-age group (median age of 9.0) and completed 11 tests over a three year time period. The results of the study found that children with cochlear implants are able to develop language similarly to hard-of-hearing children and children with specific language impairment, even if on a lower level due to reduced auditory input prior to the implantation. These findings show that the gap between profoundly deaf children and their peers may be lessened with the use of cochlear implants. Results were also consistent with other studies that showed better outcomes with earlier implantation. Since cochlear implants are most effective early in a child's life, the decision on whether to implant is left up to the parents' judgement. While implantation is risky and highly invasive, cochlear implants can provide accessibility to language and auditory input that a deaf child would otherwise not receive.

Hearing assistive technology (HAT)

There are many additional hearing assistive devices available for people with hearing loss. The device used depends on the individual's environment, severity of hearing loss, age, and personal preference. Sound-field systems or personal FM systems have shown to be effective at improving the signal to noise (SNR) ratio and speech perception in noise in educational settings for children with hearing loss (Nelson et al., 2013). These two systems amplify sound in large and small areas through the use of microphones. Sound fields use either FM transmission or infrared technology to transmit sounds to loudspeakers, while personal FM systems deliver

sound from the microphone directly to a child's hearing aid or cochlear implant. Sound field use can improve listening environments for everyone in a classroom and have been shown to improve speech perception and academic performance for both children with normal hearing and children with hearing loss (Mendel et al., 2003).

A study by Nelson et al. (2013) surveyed preschool teachers who utilized FM systems in their classrooms. Respondents claimed that FM systems had many advantages such as improvements in attention, speech and language development, academic performance, and behavior. The results are consistent with the findings from Anderson and Goldstein's (2004) study. Children 9-12 years of age with hearing loss and who used hearing aids were required to verbally repeat sentences from the Hearing in Noise Test. An alternating treatments design was used to compare which of three amplification devices yielded the best performance on the sentence repeating task. The three amplification devices consisted of a ceiling sound field system, a personal desktop sound field, and FM systems linked to hearing aids. The results showed that the desktop sound system and FM system demonstrated significant improvements from the participants baseline scores of hearing aids alone. With training from an educational audiologist, HAT can improve listening conditions for all children in the classroom and improve academic performance, behavior, and attention in students.

Teacher Training

Teachers are primarily responsible for ensuring that their students with hearing loss can hear and understand classroom instruction, however many teachers lack the knowledge needed to provide this support and often feel unequipped to teach their students with hearing loss (Furness et al. 2019). In Furness' research, ten classroom teachers and two school employees were interviewed via telephone and asked three questions to explain how they felt about supporting

their students with hearing loss. Common themes from the teacher responses included lack of professional training, limited resources, time constraints, and an overall lack of awareness of how to best support their students with hearing loss. Through teacher training, teacher confidence levels have been shown to increase, making them more effective educators (Autry 2020). In a pilot study by Autry (2020), an educational audiologist provided teachers with training on how to most effectively support their students with hearing loss after classroom observations and needs assessments were completed by the researchers. The confidence levels of the teachers and the students' academic grades were monitored. Results from a teacher self-assessment found that after teacher training was completed via videoconferencing technology, confidence levels of both students and teachers increased. Additionally, four out of five responding teachers noted an increase in academic performance from their students with hearing loss.

Training teachers on how to most effectively communicate with their students with hearing loss is important to ensure needs are being met. A study conducted by Rekkedal (2015) surveyed 137 students with hearing loss and 167 teachers on the perception abilities of students with hearing loss. The results showed that students reported much lower levels of teacher perception, with students claiming they could not accurately understand their teachers 30% of the time. Teachers estimated that their students with hearing loss had difficulty understanding instruction 10% of the time, revealing discrepancies in the effectiveness of teaching strategies and highlighting a need for teacher training. Teachers may feel as if they are speaking at adequate levels or utilizing amplification devices properly, however they often do not address their performance with the students in need of the services.

Tele practice

Innovation in technology has led to changes in the way clients and healthcare professionals can interact. Individuals now have the option of receiving services through secure video conferencing technology. Due to COVID-19 pandemic, telehealth services are being expanded as many clinicians turn to distance technology for outpatient appointments (Kwan et al., 2020). The convenience, cost effectiveness, and accuracy of telehealth services makes remote care an attractive option for many who do not have easy access to in person clinics. Additionally, areas with insufficient amounts of health care professionals in a particular field may have access to specialized professionals across the country.

ASHA defines tele practice as the use of telecommunication technology to deliver speech pathology and audiology services to clients from a distance (ASHA, 2012). In remote or rural areas, access to speech and language services may be limited. Tele practice provides these hard to reach populations with high quality SLPs and audiologists at reduced costs and greater ease. Research shows it is both a feasible and effective service delivery method, as it has been proven to be just accurate as face-to-face intervention (Sutherland et al. 2017). In Sutherland's (2017) research, three SLPs assessed the language skills of 23 children using the Clinical Evaluation of Language Fundamentals- Fourth Edition (CELF-4) language assessment both in person and through a digitized model for tele practice. One SLP administered and scored a digitized version of the CELF-4 language assessment through a telehealth program. Another SLP was on-site with the child and simultaneously scored the language assessment. The severity scores reached agreement between the tele practice session and the in-person session on 22 out of the 23 children.

There are many barriers tele practice may help address in educational audiology service provision, such as lack of funding and educational audiologists. Services provided by audiologists via tele practice may be more cost effective for school districts and reduce the strain placed on the few educational audiologists in the state. Research shows that hearing assessments conducted via tele practice are shown to be both feasible and as effective as in-person services (Crowell, 2011).

Educational audiology scope of practice

As the number of deaf or hard of hearing children entering school systems is increasing due to greater identification, there is a pronounced need for educational audiologists. Educational audiologists work in academic settings to provide access to communication and classroom instruction to students with hearing loss. The EAA (2019) includes identification, assessment, counseling and support services, and hearing technology management in an educational audiologist's scope of practice. Educational audiologists are a part of a multidisciplinary team of professionals focused on a student's academic success. Along with teachers, nurses, SLPs, and specialized instructors, educational audiologists help address the needs of students with hearing loss in classrooms. They advocate on behalf of students with hearing loss and may also train teachers, family members, and peers on how to create environments that will foster growth in the classroom for the student.

Part of educational audiologists' job is to ensure classroom environments are suitable for students with hearing loss. Being able to hear in the classroom is vital to the academic success of children. Due to high noise levels in classrooms, children with hearing loss often have difficulty perceiving spoken language. ASHA sets a standard for optimal acoustic hearing environments in the classroom. They recommend noise levels lower than 35 decibels (dB) and reverberation

times no more 0.6 seconds (Lewis et al. 2015). Many classrooms do not meet this standard, as proven by Knecht, Nelson, and Whitelaw (2002) when they tested the noise levels of 32 unoccupied classrooms and found that only four had noise levels under 35 dB.

ASHA highlights the need for educational audiologists in all educational settings, as their expertise adds unique insight to address the needs of students with hearing loss in the classroom (ASHA, 2002). Students, from birth to 21 years of age, are entitled to the services educational audiologists provide according to the Individuals with Disabilities Education Act (2004). The implementation of educational audiology services must be supported by school personnel, proper technology and equipment, and qualified clinicians. However, many school districts in rural or lower socioeconomic areas do not have the resources to support educational audiology services, leaving many students in need of intervention without proper support.

Risks

Several measures were implemented to ensure the protection of researchers and participants. All electronic data was gathered using HIPPA-compliant software and stored in secure locations with passwords. While the majority of data was electronic for the purposes of this study, any physical copies or data were always stored in locked files and rooms when not being used. Full names of the participants were never used in electronic communication or unauthorized people, but were coded with one letter. All data will be appropriately disposed of when no longer needed for research.

IRB Approval

All research was conducted under the approval of the Institutional Review Board (IRB) at the University of Mississippi (Appendix A). Researchers obtained training to work with child participants through the Collaborative Institutional Training Initiative (CITI) program. Additionally, consent was obtained for all participants (Appendix B, C, D, & E).

CHAPTER II

METHODOLOGY

Participants

Researchers recruited a school district in north Mississippi to participate in the study. The school district participated in a pilot study the year prior, therefore researchers had previously established connections. After obtaining permission from the school superintendent, researchers communicated with an SLP employed at the school to determine which students needed intervention. There were four students who met criteria for hearing loss in the school district and consented to participate in the study. K, a seven year old female with bilateral profound sensorineural hearing loss, was the selected participant.

The SLP reported that K passed her newborn hearing screening, but began to display a language delay by 18 months. The delay was thought to be caused by autism, as K has two brothers with autism; however, she was diagnosed with moderately-severe sensorineural hearing loss at age four. Initially, she was fit with bilateral behind the ear (BTE) hearing aids. Her hearing loss continued to regress for two and a half years, and eventually the hearing aids could not provide sufficient auditory input. Due to the profound nature of her hearing loss, she became a cochlear implant candidate in the fall of 2019. K's parents opted for sequential implantation, and K was due to receive the implant in her left ear in December 2019. Her left ear was chosen first by her parents, as they wanted to preserve her better, right ear in case the surgery was unsuccessful. The original implantation was postponed to March 2020, but due to the COVID-19 pandemic had to be further postponed until May 2020. She received her left cochlear implant on

May 11, 2020. She was turned on approximately two weeks later, and the mapping process occurred until December 18, 2020.

K's academic performance suffered due to her hearing loss, and she was required to repeat kindergarten during the 2019-2020 school year. She received many accommodations and modifications in the classroom before her cochlear implant. These included but were not limited to: use of an FM system, preferential seating, one-on-one testing environments with the SLP, visual cues, tactile cues, modified assignments, and exemptions of grades that used verbal stimuli, such as spelling tests. K received speech and language therapy at school three times a week, aural rehabilitation one time per week, and speech intervention at a clinic one time per week. Classroom instruction, school intervention, and intervention in the clinic were all interrupted when the COVID-19 pandemic closed down schools and clinics in March of 2020. After K received her cochlear implant on her left ear in May of 2020, she was not able to participate in therapy during the mapping process due to parental concerns about in-person service provision. Additionally, a lack of internet connection at home prevented tele therapy possibilities.

Once school reopened in August of 2020, K began first grade and resumed speech and language therapy three times a week at school, but remained unable to attend intervention in the clinic. During speech and language therapy with the school SLP, K focused on phonemic skills that were not mastered the year before. Accommodations and modifications such as the use of an FM system, preferential seating, and modified assignments were still provided in the classroom; however K did not receive accommodations and modifications such as one-on-one testing environments and grade exemptions.

Materials

All assessments were implemented before and after K's cochlear implant in May of 2020. Language samples were collected over the course of the study to provide insight into K's language abilities over time, as a result of the cochlear implant and the modifications and accommodations. A picture book titled *Frog Where Are You?* (Mayer, 1969) was used to obtain both language samples using the story re-tell method. The book consists of only pictures that display the story of a boy and his dog searching for their friend, the frog. With the story-retell method, the clinician flips through the pages of the book with the child to provide a model for the story. Once the clinician has finished telling the story, the child is instructed to tell the story back to the clinician as they flip back through the book. The elicited story was recording using video and audio software.

Additionally, third quarter grades were gathered in February 2020 in kindergarten and in February 2021 in first grade to assess her classroom performance during her hearing and language growth. Her grades were assigned in mathematics, reading, and language arts by her kindergarten and first grade teachers. The grades that were gathered in 2020 were before her cochlear implant and revised IEP and the grades that were gathered a year later in 2021 were after the implant and revised IEP. It should be noted that during the third quarter when grades were assigned, K experienced several interruptions from school due to the COVID-19 pandemic and had difficulty completing schoolwork at home.

Analyzing Strategies

Researchers chose a case-study research method, which allowed us to closely follow one client and assess progress over the course of approximately one year. The focus of intervention in the study included K's cochlear implantation and speech and language services. Based off these intervention strategies, researchers were interested in K's longitudinal language

development, which was measured using language samples and academic grades. The COVID-19 pandemic was an extraneous variable in this study, as research plans and timelines shifted with school closures and quarantine orders. Intervention time was lost in November and December 2020 due to school closures and in January 2021 due to K having to quarantine twice.

The pretest-posttest comparison was implored to quantify the results of language intervention and cochlear implantation. As this study is a modified continuation of a pilot study on remote educational audiology services (Autry, 2020), pretest measures of academic grades and language skills were gathered in K's kindergarten year in the spring of 2020. This study seeks to focus on the analysis of narrative language samples gathered before and after her cochlear implant. At the end of her kindergarten year, K received her cochlear implant and returned to the classroom when schools opened back up in August of 2020. Intervention had been continuous throughout K's school years, but after assessments were completed by the SLP language goals and education plans were modified. The language samples were gathered to track K's language development with the implant and accommodations and modifications.

Researchers transcribed K's re-tell of the story using the video recording and type out K's utterances word by word. Her microstructural and macrostructural language skills were documented and analyzed with each language sample. Microstructure language skills measures include mean length of utterance (MLU), number of different words (NDW), and number of total words (NTW). In addition, the transcription was coded for errors including: past tense errors, missing verb, missing article, noun or pronoun errors, subject verb agreement errors, and incomplete utterances. The errors were agreed upon by two researchers and entered into language analysis software. The Systematic Analysis of Language Transcripts (SALT) software standardizes the process of eliciting, transcribing, and analyzing language sample. The software

provides a standard measures report that includes an analysis of transcript length, syntax and morphology, semantics, and errors.

Macrostructural language skills include measures such as order of events, character development, and listener awareness. The Narrative Scoring Scheme (NSS) was used to analyze the macrostructure of K's language abilities. The NSS is an assessment of a student's ability to provide a coherent narrative with correct story structure and grammar (SALT Software, 2017). Characteristics of the narrative that are scored include the introduction, character development, mental and emotional states, referencing/ listener awareness, conflict resolution, cohesion, and conclusion. Each category is scored on a 0-5 scale, with 0 being an indication of speaker errors such as telling a different story than the one that was presented or refusal to respond. A score of 1 indicates "minimal" use, 3 indicates "emerging" use, and 5 indicates "proficient" use of a skill. Scores of 2 and 4 are left open to the scorer's judgement. For example, the character development category would be scored as a 1 if the speaker is inconsistently mentioning the active characters of the story or characters necessary for advancing the plot are not present. A score of a 3 would be given if main and supporting characters are both mentioned, but not clearly distinguished from one another. A score of a 5 would be given if all characters are mentioned and are distinguished from one another and if the speaker narrates in first person while using a character voice, such as "Get out of that water", said the boy. Two researchers scored the narrative language samples independently and then met for a discussion and reached agreement on the scores for each category.

Pre-test Data Collection

The IRB approval obtained for this research study allowed researchers to access data through the school's records from the year before her cochlear implant. The Individualized

Education Plan (IEP) from before K's cochlear implant was released to researchers and indicated K's classroom grades, her academic goals, her language goals, her social skills with peers, and other observational data completed by faculty. The SLP met with researchers to further discuss K's levels of functioning in the classroom, provide background history, and decide on which modifications and accommodations were to be implemented based on K's needs. All of the data that was released from before K's cochlear implant is considered to be pretest data.

In March of 2020, before K's cochlear implant surgery, a language sample was conducted by researchers. The story re-tell language sample was implemented by two researchers who first told the *Frog Where Are You?* story to K then asked her to retell the story back to them. K's narrative was recorded and stored in a secure location to later be transcribed and analyzed. Her grades in reading, language arts, and mathematics were also recorded from the third quarter grading period in February 2020. It should be noted that K did not return to school after March 6, 2020 due to the COVID-19 pandemic.

Cochlear Implant and Modifications

After researchers gathered baseline data, K's specific language goals were identified and her IEP was modified to target these goals. An IEP from before K's cochlear implant in May of 2020 included many accommodations, modifications, and personnel support that continued into the next school year. Accommodations included: reading and paraphrasing all directions and items on tests and assignments, additional time to complete assignments, allowing K to mark answers on paper and pencil forms of assignments, and cluing K to stay on task. Modifications included shortened assignments to maintain attention and prevent fatigue. Personnel support included a collaboration with the SLP, general education, and special education teacher to ensure carryover from therapy sessions. Since this study is a continuation of the pilot study (Autry,

2020), educational audiology services, such as teacher recommendations, were implemented in the year before her cochlear implant as well. Based off these teacher recommendations, K was placed in the front of the classroom with her implanted ear facing the speaker and FM systems were used to amplify the speaker's voice.

While some of the accommodations and modifications that were made before K's cochlear implant continued to be implemented, K was not meeting her language goals; therefore her teachers and SLP amended her previous IEP. The revised IEP was focused on revisiting language skills that were previously missed due to her hearing loss. Since K progressed to first grade without mastering phonemic skills, intervention was focused on expanding her phonetic language abilities. The IEP amendments included structured phonics and reading instruction in the kindergarten classroom for two hours each morning to focus on sounds, letters, phonics, and phonemic awareness. The original IEP noted that K worked best in small groups or one-on-one, so individual tutoring sessions for math were implemented daily for 30 minutes and utilized a color cueing system. The color cueing system used certain colors for addition and certain colors for subtraction, which allowed K to associate math problems with a visual cue. K revisited phonics, phonemic awareness, and reading skills every afternoon to emphasize the acquisition of language skills. The Speech Perception Instructional Curriculum & Evaluation (*SPICE for Life*) was also implemented by K's SLP. The curriculum focused on functional listening skills such as listening in noise, auditory memory, and sound localization.

K received a cochlear implant in her left ear in May of 2020. The implant provided greater access to sounds and language that were most likely missed due to her hearing loss. To maximize the benefits of a cochlear implant, K received intervention focused on listening in noise. Due to the COVID-19 pandemic, K's intervention consisted of home therapy exercises

directed by her grandmother. The exercises included activities such as practice listening to speech in the presence of background noise.

Post-test Data Collection

Every measure that was completed before K's cochlear implant and IEP revision was completed again as a post-test measure. A second language sample was completed in September of 2020, at the beginning of K's first grade year. The mapping process was still occurring with K's cochlear implant during this time, which means the implant had not yet reached its optimal performance. Her grades were collected again in February 2021 during the third quarter, approximately a year after the collection of baseline grades. The results of post-test measures were predicted to show improved language skills and academic performance as an effect of the cochlear implant and accommodations and modifications implemented at school.

CHAPTER III

RESULTS

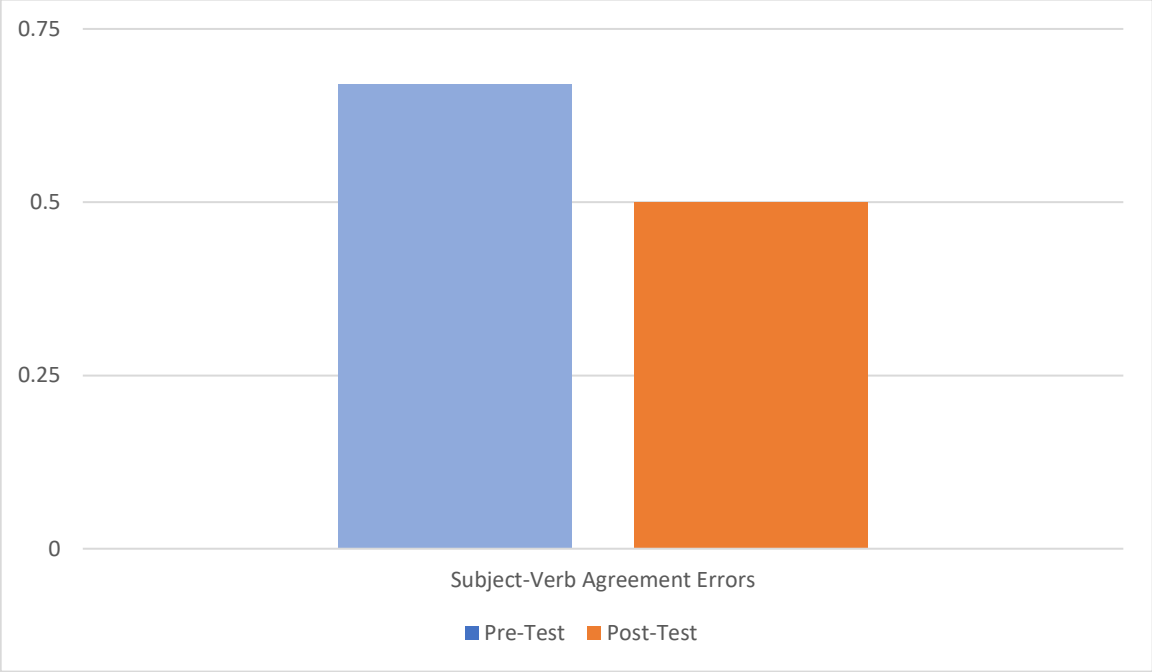
The results of the pre-test and post-test assessments are presented and compared in order to observe the effects of intervention and cochlear implantation on K's language skills. The microstructural and macrostructural language components assessed during the narrative language sample are presented for both the pre-test and post-test results.

Microstructure

Two researchers reviewed the transcriptions from K's language samples that were completed in March and September of 2020. Error analysis included the following error types: subject-verb agreement errors, past tense errors, missing verbs, missing articles, noun or pronoun errors, and incomplete utterances. These errors were decided upon due to their high frequencies in the sample and effects on K's communication. To account for different sample lengths, errors were counted every 20 utterances and then averaged for each error. The averages were compared for the pre- and post-test language samples.

Errors in subject-verb agreement were assigned when incorrect verbs were used for the subject, such as "he be nice" when the form "he is nice" should have been used. For the pre-test sample, errors averaged 0.67 per 20 utterances. As indicated in Figure 1, errors decreased in the post-test sample to 0.50 errors per 20 utterances.

Figure 1: Pre- and Post-Test Subject-Verb Agreement Errors



Past tense errors were assigned when K used present or future tense in place of past tense verbs. Since the language sample was implemented using the story re-tell method, the narrative should be explained in the past tense form. K displayed difficulties in this area and had a high frequency of past tense errors in both the pre- and post-test samples. The frequency of verb tense errors suggest that K may not understand that stories are meant to be told in past tense and that tense should be consistent throughout the story. The frequency did, however, slightly decrease in the post-test sample, as indicated in Figure 2. K produced an average of 3.33 past tense errors per 20 utterances in the pre-test sample, but this average decreased to 3.25 past tense errors per 20 utterances in the post-test sample.

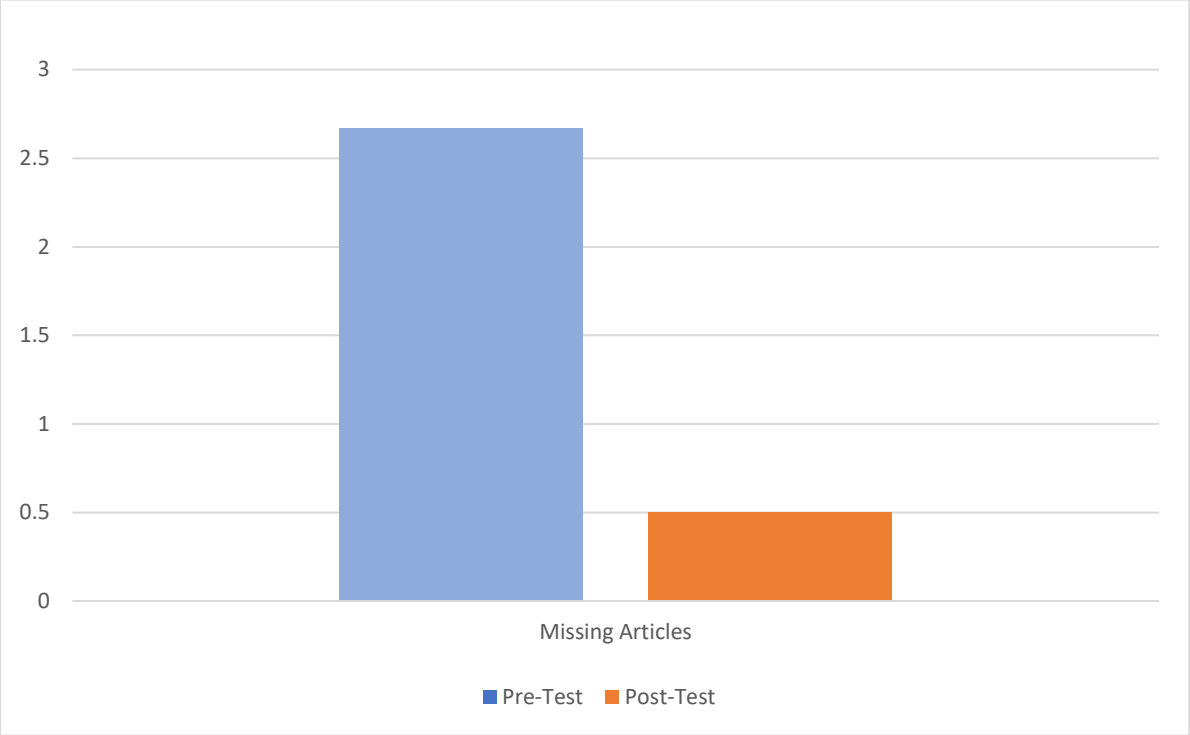
Figure 2: Pre- and Post-Test Past Tense Errors

Missing verb errors were the only microstructural errors that slightly increased from the pre-test to the post-test samples. These errors were assigned when K omitted the use of a verb necessary to complete a sentence or phrase, such as the utterance “frog on a jar.” In the pre-test language sample, K displayed missing verb errors, on average, 2.33 times per 20 utterances. In the post-test sample, she produced an average of 2.75 missing verb errors per 20 utterances. This increase is displayed in Figure 3. It was observed by researchers that linking verbs, such as “is”, “are”, and “was” were most commonly omitted in both the pre- and post-test language samples. While a moving average was used to account for different sample lengths, K did produce longer and more complete utterances in the post-test language sample which could have allowed for more verb errors.

Figure 3: Pre- and Post-Test Missing Verb Errors

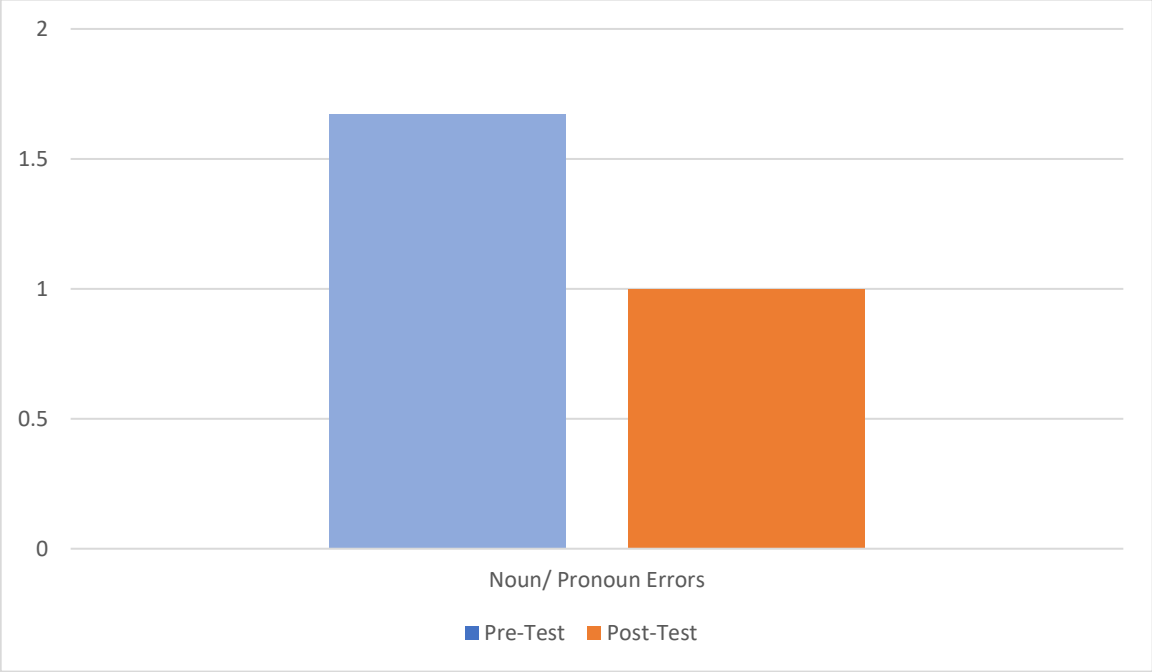
Missing article errors were assigned when K omitted the use of “a”, “an”, or “the”. For example, in the pre-test sample K would often produce utterances such as “go on boat” or “turtle mad”. The smaller linguistic units, such as articles, proved to be an area of difficulty in the pre-test sample. Before her cochlear implant and revised intervention, K produced an average of 2.67 missing article errors every 20 utterances. A significant decrease in these areas was observed in the post-test sample, as the frequency of omitted articles fell to 0.50 per 20 utterances. This decrease is shown in Figure 4. Researchers observed in intervention sessions that K’s use of smaller linguistic units appeared to increase with use of her cochlear implant and language intervention.

Figure 4: Pre- and Post-Test Missing Article Errors



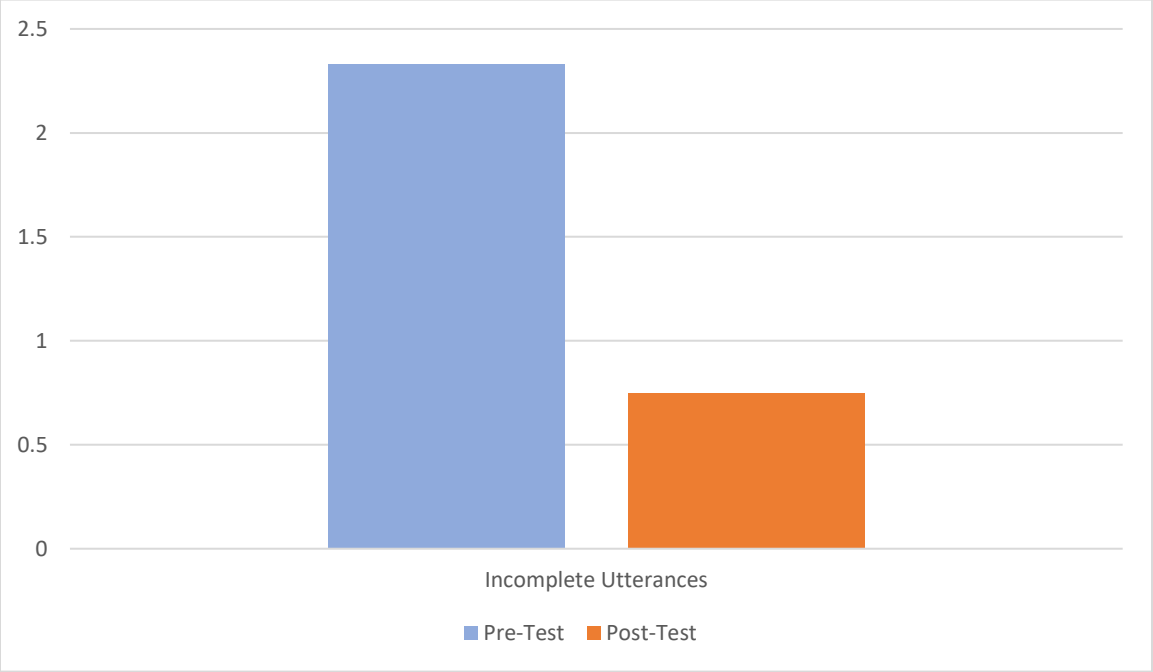
Noun/ pronoun errors also decreased in frequency in the post-test sample (Figure 5). These errors were assigned when the incorrect form of a pronoun was used, such as using "it" instead of "he", or when there was an omission of a noun or pronoun. Researchers observed that K produced excessive amounts of pronouns and needed prompting from the clinician to clarify which characters she was referring to. For example, K said "She is mad at him" and the clinician responded "Who is mad? He or she?". K was able to clarify and told the clinician she meant "he". K used notably less pronouns in the post-test sample, but instead referred to the characters' names such as "boy", "dog", and "frog". In the pre-test sample, K displayed an average of 1.67 noun/ pronoun errors per 20 utterances. The frequency of errors decreased to a 1.00 in the post-test sample.

Figure 5: Pre- and Post-Test Noun/ Pronoun Errors



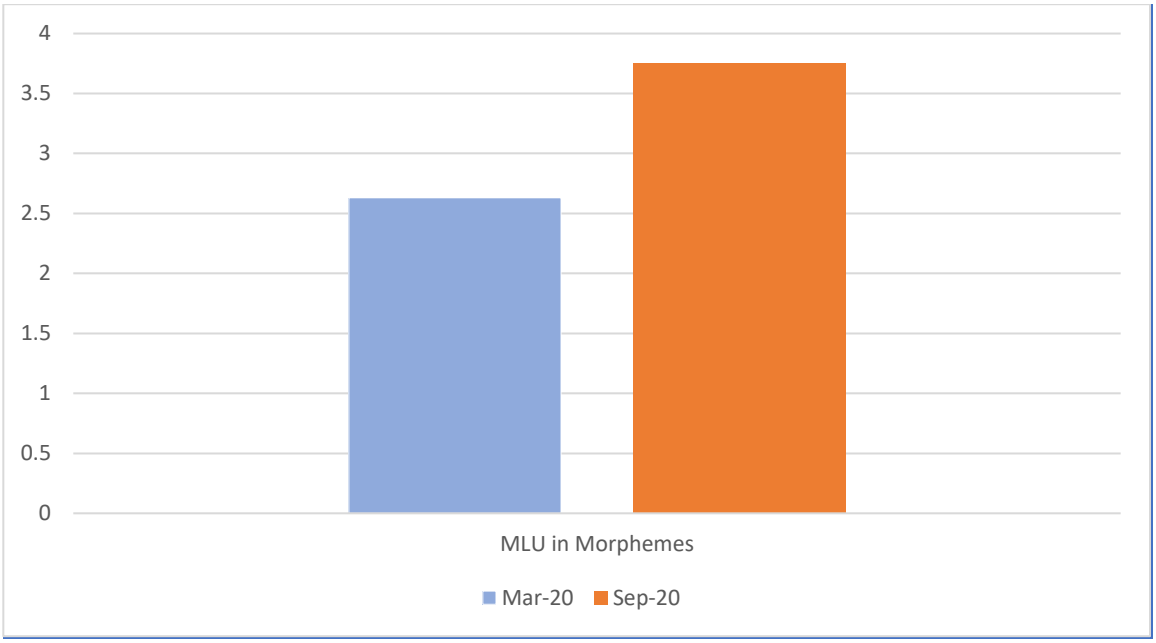
Lastly, incomplete utterance errors assigned when K did not offer a full thought, such as "find the", or when she produced spontaneous words and phrases that were off-topic from the plot of the story. The high frequency of incomplete utterances in the pre-test language sample indicated that K had difficulty expanding on her thoughts or lacked the language necessary to do so. In the post-test sample, however, K offered more complete thoughts and ideas relevant to the story and was able to better expand beyond simply naming items on the pages. In the pre-test language sample, she had an average of 2.33 incomplete utterances per 20 utterances. This decreased to an average of 0.75 incomplete utterances per 20 utterances in the post-test language sample, as shown in Figure 6.

Figure 6: Pre- and Post-Test Incomplete Utterance Errors



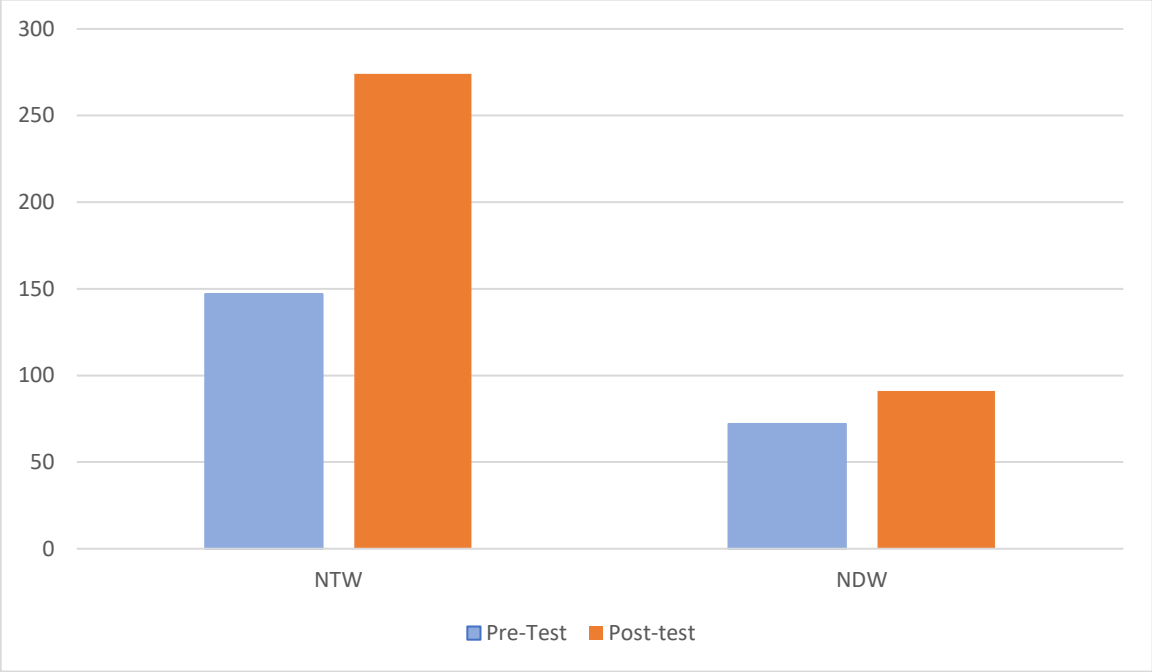
Additionally, researchers analyzed K's mean length of utterance (MLU), number of total words (NTW), number of different words (NDW). These measures provide information on the complexity of K's language skills. MLU is a measure of morphosyntactic skills, with higher scores indicating longer sentence length with more complex grammar. The measurement is a sound representation of the speaker's ability to string words together in utterance and produce more higher level words and phrases. K's MLU was 2.63 in the pre-test sample and 3.75 in the post-test sample as indicated in Figure 1. The significant increase that is seen in her MLU indicates that K's language increased in complexity and that her expressive language skills have grown since her cochlear implant and language intervention.

Figure 7: Pre- and Post-Test MLU



NTW and NDW were also used as microstructural language measurements. NTW counts all words used in a language sample, while NDW indicates lexical diversity. The language sample analysis showed that K produced 59 utterances for the pre-test sample and 80 for the post-test sample. As the lengths of her samples increased, her NTW and NDW increased as well. The increase, as displayed in Figure 2, suggests that K's lexicon and sentence length has increased as she began to receive more auditory input following her cochlear implant and language intervention at school.

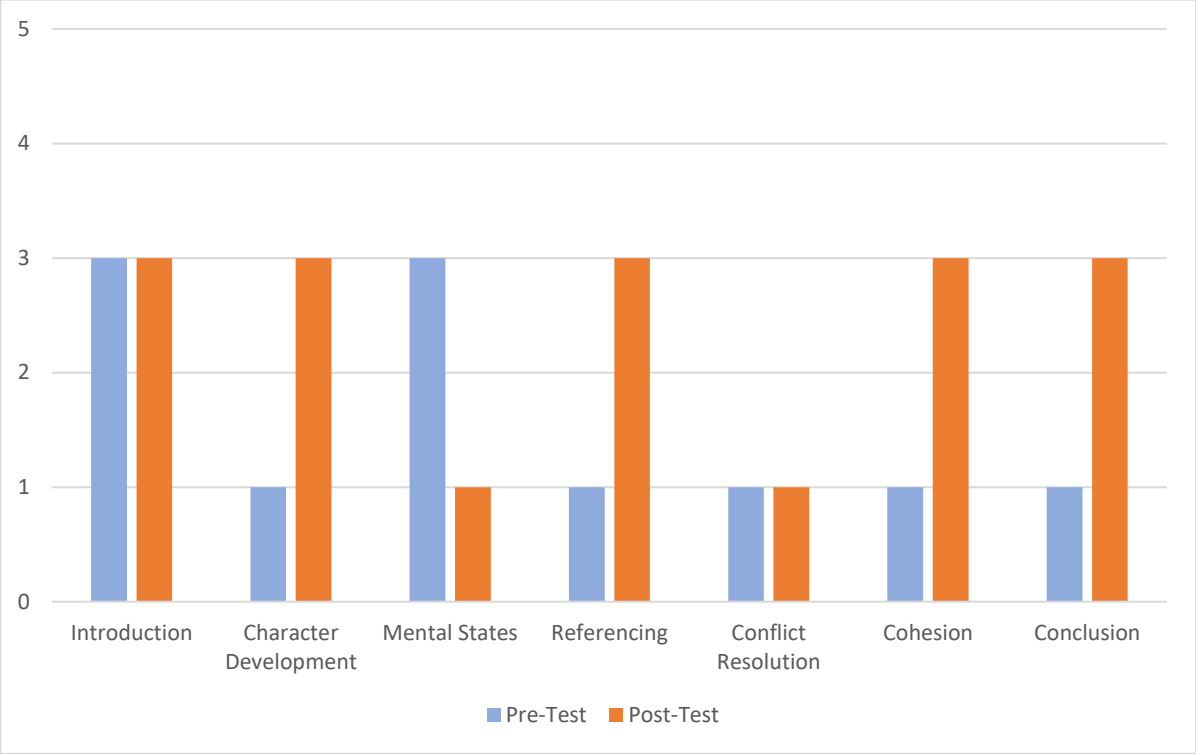
Figure 8: Pre- and Post-Test NTW and NDW



Macrostructure

K's use of story grammar was assessed using the Narrative Scoring Scheme. The NSS' seven categories are indicators of macrostructural language abilities. Using the transcriptions from the two language samples, researchers scored the seven characteristics of the narrative sample including the introduction, character development, mental states, referencing/ listener awareness, conflict resolution, cohesion, and conclusion on a scale of 1-5. The pre-test and post-test comparison for each category is displayed in Figure 9. The maximum score that can be achieved for the NSS is a 35. In the pre-test language sample gathered in March of 2020, K scored a total of 11 out of 35. In September of 2020 she scored a 17 out of 35.

Figure 9: NSS Scores Pre- and Post-Test



For the pre-test language sample in March of 2020, K's introduction was given a 3, which constitutes emerging use, due to her vague description of the main character, e.g., "you got a baby frog". The introduction category was assigned an "emerging" score of 3 in the post-test language sample due to K's brief description of the character and the setting.

The character development for K's pre-test language sample was scored as a 1 due to her inconsistent mentioning of the characters such as the dog. Her score improved in the post-test language sample. The character development category was scored as a 3, as K mentioned supporting characters but did not distinguish them from the main character.

The mental states category received a score of a 3 due to K's awareness of the emotions of the characters. Several times she pointed out feelings the characters most likely had about the events in the story, such as when the boy was angry or sad. K was sometimes able to expand on the cause of characters' emotions, for example she explained that the boy in *FWAY?* was mad

because another character spit on him. K's performance in this category decreased for the post-test language sample. Researchers ranked this category as a 1 due to a lack of explanation on the character's expressions and feelings throughout the narrative. Words such as "sad" and "mad" were not used as frequently in the post-test language sample.

For the pre-test language sample, referencing/ listener awareness was scored differently between researchers at first, but was decided as a 1 due to K's excessive use of pronouns and confusion with which characters she was referring to. For the post-test sample, the referencing/ listener awareness category was assigned a score of a 3 due to little use of antecedents; however K's narrative was easier to follow in the post-test sample due to greater use of nouns and clarifiers.

The Conflict/ Resolution and Event/ Reaction category was scored as a 1 for the pre-test sample due to a lack of focus on the story's conflict and mention of conflict not relevant to the advance the plot. K's performance remained low in this area for the post-test sample. The conflict resolution category was scored a 1 again, as conflicts mentioned in the narrative either did not advance the story line or were mentioned without resolution.

In K's pre-test language sample, the cohesion category was scored as a 1, as she did not show understanding of how the events on each page connected to form a narrative. Her performance improved following the cochlear implant and language intervention. In the post-test sample, the cohesion category was scored as a 3 because of K's order of events that followed the pictures in *Frog Where Are You?*, however there was an equal emphasis placed on the events in the story and transitions were often unclear or not present.

The conclusion category was scored as a 1 in the pre-test language sample due to a sudden end in narration by K. For the post-test sample, the conclusion category was scored as a 3

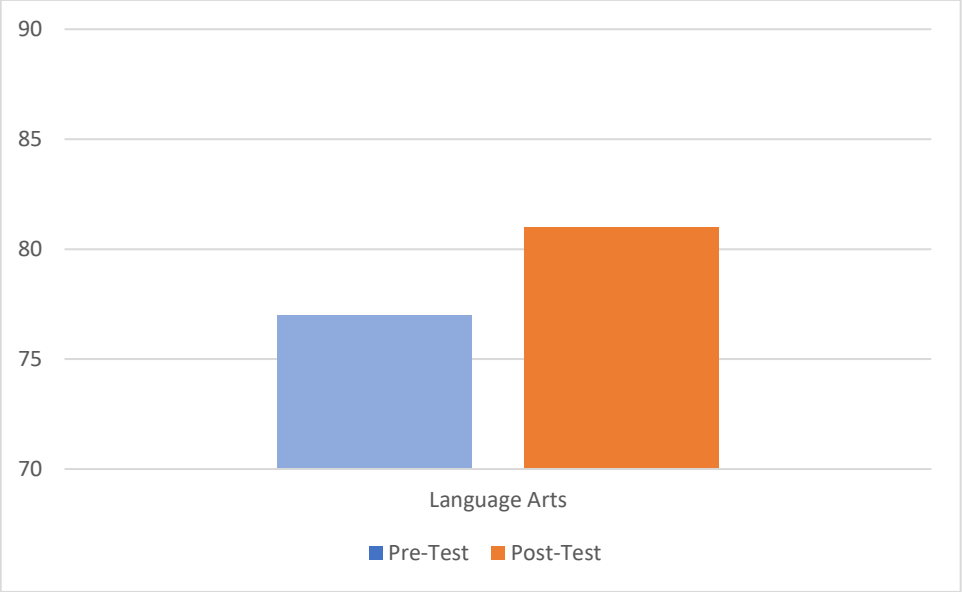
because K offered a conclusion of an event, e.g. she stated the frog could not jump high because it's little, but a conclusion of the narrative as a whole was not offered.

Grades

Along with assessing the impact of K's cochlear implant and intervention on her language skills, researchers also wanted to observe the impact on her academic performance in these areas. K's classroom grades were used as an indicator of academic performance in language arts and reading. The pre-test grades were gathered from school records from the third nine week period of her kindergarten year in February 2020. Observations from school faculty concluded that K had below average expressive and receptive language skills during her kindergarten year, making comprehension and retention of classroom material difficult.

K's classroom grades in language arts and reading were gathered again in the third nine weeks of first grade in February 2021. The comparison between pre-test and post-test grades are displayed in Figure 10 and Figure 11. K's language arts grade increased by four overall points, from a 77 to an 81.

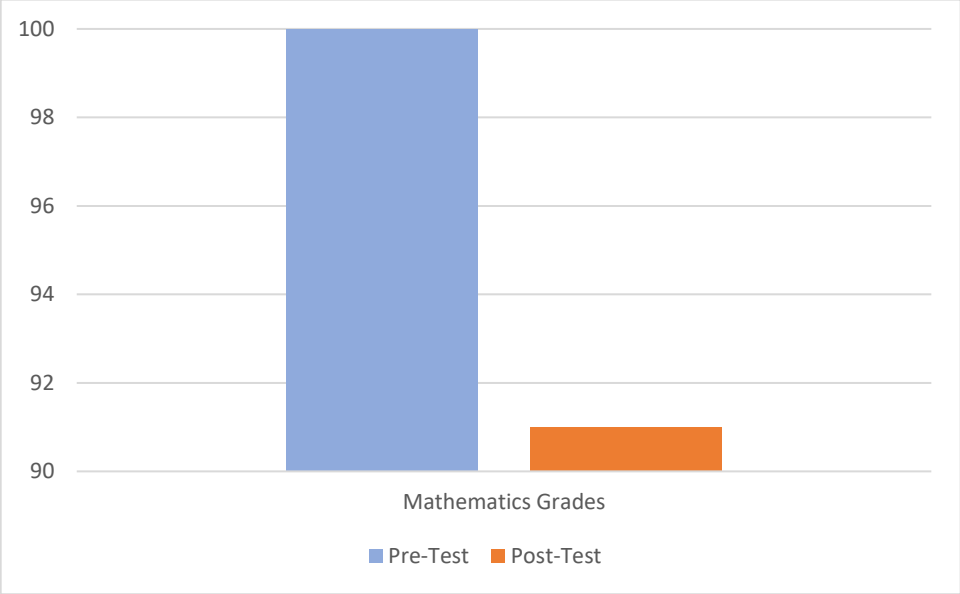
Figure 10: Pre- and Post-Test Language Arts Grades



Her grades in reading and mathematics, however, decreased from kindergarten to first grade, as shown in Figure 11 and Figure 12. K received a reading grade of 79 in February of 2020. In February of 2021, she received a grade of a 77, two points below her pre-test grade. Her It should be noted that her reading grades in kindergarten excluded many phonemic assignments in order to obtain a sufficient grade to progress to first grade. Many reading skills in kindergarten were not mastered before moving on to first grade, which caused her to fall behind her peers. Additionally, K's mathematics grade decreased from the pre- to post-test period. K received a kindergarten mathematics grade in February of 2020 of a 100. In February of 2021, during her first grade year, she received a grade of 91. The SLP also noted that mathematics skills in first grade were much more complex than in kindergarten, and that K progressed to first grade before fully mastering skills.

Figure 11: Pre- and Post-Test Reading Grades

Figure 12: Pre- and Post-Test Mathematics Grades



CHAPTER IV

DISCUSSION

This research study aimed to observe how unilateral cochlear implantation and accommodations and modifications affected one child's language skills and academic performance. Researchers predicted that K's microstructural language skills, macrostructural language skills, and classroom grades would improve with the implemented treatment measures. The methodology used by researchers was designed to assess her language skills and academic performance before and after her cochlear implant and revised language intervention, and compare the pre- and post-test assessments. As indicated by individual error, MLU, NTW, and NDW for microstructural language skills, and the Narrative Scoring Scheme for macrostructural language skills, K's overall language abilities improved significantly. Additionally, evaluation of her classroom grades indicated that she improved in language arts from kindergarten to first grade.

Interpretations of Microstructural Language Results

Children with hearing loss often display deficits in morphosyntactic abilities, such as word and sentence formation (Tomblin et al., 2015). To analyze K's language abilities on a word and sentence level, researchers selected six microstructural language errors common in K's expressive language and measured the frequencies of these errors for the pre- and post-test language samples. The errors included: subject-verb agreement errors, past tense errors, missing verbs, missing articles, noun or pronoun errors, and incomplete utterances. A moving average was calculated for each error every 20 utterances to account for different sample lengths. The results of the error analysis support the hypothesis that K's language skills would improve with

cochlear implantation and intervention, as every error category, excluding missing verb errors, reduced in frequency for the post-test sample. The reduction in errors suggest that the language intervention, along with accommodations and modifications implemented in the classroom, addressed many of K's language deficits. Additionally, greater access to speech sounds due to her cochlear implant could have increased her linguistic understanding. For example, ASHA points out that many children with hearing loss have difficulty understanding abstract words such as "the" or "is". These types of errors had high frequencies in the pre-test language sample, likely due to the fact that she was not hearing these sounds prior to her implant, as omission of these words significantly decreased in the post-test sample. K's ability to expand and provide more complete thoughts also improved, as indicated by a reduction in incomplete utterance errors. The implant likely allowed her to build lexical productivity and diversity as she heard and absorbed greater amounts of language. These results are consistent with literature that shows a positive correlation between the use of HAT and language skills (Walker et al., 2020).

Microstructure analysis also showed that the cochlear implant and treatment methods at school increased K's sentence complexity, lexical productivity, and lexical diversity. The results showed that her MLU, NTW, and NDW all increased from the pre- to post-test language samples. These findings are consistent with literature that displays a positive correlation between duration of implant use and MLU and NDW (Johanna & Geers, 2007). Researchers expect these measures to continue to increase with longer cochlear implant duration. Morphological knowledge is also expected to continue to increase. Children learn morphological knowledge, such as different parts of words, mainly through hearing others speak; therefore, children with hearing loss often show deficits in these areas (Trussell & Easterbrooks, 2017). K displayed major deficits in morphological understanding in the pre-test language sample. Morphological

endings, such as “ed”, were often omitted and contributed to the high frequency of past-tense errors. However, as indicated both by an increase in MLU and observations from researchers, K produced higher complexity words and utterances in the post-test language sample. A combination of increased hearing levels and revised intervention are likely the cause of K’s significant microstructural language growth.

Interpretations of Macrostructural Language Results

The ability to produce a coherent narrative is an indicator of future reading comprehension and academic achievement (Crosson & Geers, 2001). While literature shows that children who receive cochlear implants before age five yield the best outcomes for narrative ability, the results from K’s narrative language samples still indicate language growth. K’s overall NSS score increased from an 11 to a 17 out of 35. While there are still major language deficits present, the increase seen in most NSS categories suggests that K was better able to produce a coherent narrative due to increased hearing levels and reading skills targeted during language intervention. As stated with the microstructural language analysis, abstract concepts, such as story grammar, are difficult for children with hearing loss. The improvement seen in K’s NSS scores from pre- to post-test supports the claim that K better understands abstract words and concepts following the treatment measures.

Interpretations of Grades

Additionally, K’s grades in language arts increased from kindergarten to first grade. The grades evaluated in February of 2020 during her kindergarten year were prior to her cochlear implant and the implementation of accommodations and modifications. The grades evaluated in February of 2021 were after the treatment measures had been implemented. The four point increase in K’s language arts grade is likely due to the accommodations and modifications in the

classroom. Modifications such as shortened assignments and the emphasis placed on speech and language skills in intervention likely contributed to her growth in language arts. Her grades in reading and mathematics, however, decreased from kindergarten to first grade. This decrease could be due to several factors. K's revised IEP went into effect shortly before the third quarter grades were recorded. It should be noted that substantial amounts of classroom instruction was missed in the year between the grade recordings due to the COVID-19 pandemic. The SLP informed researchers that vital benchmarks in phonemic skills were not hit before K progressed to first grade. Since she had already repeated kindergarten, school teachers decided to not grade K on phonemic skills so she could progress to the next grade, however in first grade she was graded on these skills. The SLP observed that some of the learning material in reading and mathematics in the first grade classroom was too complex for K since benchmark skills were not mastered the year before. The revised IEP focused on revisiting foundational skills that were missed in the kindergarten year, therefore K was not absorbing a lot of new material in these areas. Lastly, the decrease in grades could be due to accommodations and modifications that were not implemented after K's cochlear implant. The SLP reported that during her kindergarten year, K was allowed to test one-on-one with unlimited time and with visual and tactile cues present. During her first grade year, K tested in small group environments in the special education classroom with time limits and no visual or tactile cues present. This could have influenced her testing scores drastically.

Researcher and Clinician Observations

The growth that was seen in K's language skills after her cochlear implant and revised intervention reaches beyond the data that is presented in this study. Researchers continued to meet virtually with K and the school SLP until February 2021. During these sessions, researchers

observed that K's conversational language abilities had expanded dramatically. Her compliance with clinicians and researchers and her motivation to take part in intervention activities indicate positive outcomes of intervention. Despite interruptions and setbacks due to COVID-19, K has continued to progress in her language development. Additionally, K continued to progress despite a lack of proper language modeling. The SLP reported that K's two brothers with autism were echolalic and mostly nonverbal, therefore K has limited opportunities to practice typical conversational skills in the home. Her language growth is highly impressive, especially considering the barriers that were present during 2020.

Researchers predict that with the addition of a cochlear implant on the right ear and the return to typical classroom and intervention settings, K's language skills and academic achievement will continue to improve. Improvements such as increased number of vocabulary words, the use of describing words, ability to sound out letters, ability to count syllables, and increased use of verbs were already seen in K's language. Benchmarks that were not obtained prior to her cochlear implant, such as following 2 multi-level directions with background noise present with 60% accuracy, have been achieved in the post-test period. Additionally, her progress in the classroom has been impressive. Though the results showed a grade decrease from kindergarten, her grades in all subjects have increased from the beginning of first grade in September of 2020 to the grading period in February of 2021, even despite all the interruptions brought by the COVID-19 pandemic.

Impact of COVID-19

The findings of this research study present valuable insight into the effects of the COVID-19 pandemic on intervention for people with disabilities. Specifically, for people with hearing loss, the use of masks greatly impaired communication abilities. Many people with

hearing loss rely on the ability to read lips while communicating, so the use of masks in all schools and public places increased hearing difficulties for these individuals. Additionally, parents and guardians of individuals with disabilities have experienced immense pressure and stress in the absence of typical service provision. Recent literature shows that the COVID-19 pandemic has increased economic pressure and caused psychological issues is the families of children with speech and language intervention needs (Tohidast et al., 2020). While K's language has improved, the lack of intervention and schooling for five months from March to August of 2020 and again in December to January had significant impact on her language growth. The growth would have increased even more if interruptions had not occurred.

Children who were already falling behind their peers and then required to participate in home-based schooling likely faced several obstacles when it came to education provision. K experienced many obstacles throughout this research study. Lack of structure and home support can greatly impede the ability to complete assignments and learn material. It was noted that K displayed much lower motivation to complete assignments and language intervention activities while at home. Since K was not in school for the five months from March to August of 2020, and then again for two months in December and January, her language growth likely suffered due to lack of exposure. Additionally, lack of internet connection at home did not allow for remote delivery of speech and language services. While the use of her cochlear implant did continue to aid in her language development, many language skills could have likely been acquired during the periods of interruption. Lastly, K was due to receive her second cochlear implant in January of 2021, however due to quarantine orders her surgery was postponed to March. When she received her second implant on her right ear in March of 2021, she missed additional classroom and intervention time due to recovery.

Limitations

Along with the limitations posed by the COVID-19 pandemic, there are several other limitations that occurred during this research study. First, the post-test language sample completed in September was during the mapping process for K's cochlear implant. The mapping process is a period of adjustment after the surgery, which means hearing has not yet reached optimal potential. Due to the postponement of her second cochlear implant, additional post-test data was not able to be gathered. Researchers had planned to assess K's language skills in March of 2021 to observe her language skills after the mapping process, however the assessment sessions were not able to be completed due to her surgery and the recovery that followed.

Another challenge faced was the lack of accessibility to the internet at home. It was difficult for researchers to get into contact with the parent and grandmother and home intervention with a clinician was not possible due to poor connection. K usually has speech and language therapy twice a week, but missed several weeks due to school closures and not being able to receive remote delivery services at home. Researchers were able to conduct assessments remotely when K was back in school, however the format of virtual assessments might have impacted K's performance. For example, during the remote language assessments K appeared to be more reluctant to speak and her speech was less intelligible due to poor sound quality.

The picture book and script for *Frog Where Are You?* was used virtually in the pre-test and post-test language sample. The increase in K's language skills could also be attributed to becoming familiar with the plot, characters, and setting. Additionally, K appeared to become more comfortable with virtual assessment sessions over time. Her level of comfort and willingness to respond to researchers and clinicians could have impacted her performance. However, there is a six-month gap between the pre- and post-test so it is unlikely that K

remembered the story and experimenter's remodeling. Therefore, her progress in macrostructure and microstructure skills should be results of the cochlear implant and school services.

Since this is a case study, results from intervention measures cannot be generalized to other children with hearing loss. The small sample size allowed for in-depth analysis, however the effects of similar intervention measures may vary across subjects. This research aimed to provide meaningful information on cochlear implant and intervention outcomes, which can greatly contribute to future research.

Lastly, while researchers believe much of K's language growth is due to the implemented treatment of cochlear implantation and intervention, some of the growth that was observed in K's language skills could be attributed to factors such as age, classroom environment, classroom teachers, stress levels, or familiarity with assessments. These contaminating factors may be better controlled in future studies.

Implications for Future Research

The results of this research study provide meaningful information on a single subject's language development, however in future research several factors could improve the research design and the validity of results. A greater sample size, assessment of stress levels, and more measurements could greatly benefit the results of this research.

Though the single subject design allows for in depth analysis, adding more participants could allow for greater generalization of results. Along with adding more participants with hearing loss who receive cochlear implants and intervention services, the addition of teachers, parents, and clinicians to the participants could add valuable insight to the research. Children with hearing loss require a team of parents, teachers, and clinicians to aid in language development and personal growth. Including these people in the research could provide

information on how to best implement services and intervention. The stress levels of these individuals could also expose barriers that exist with service provision. Adding stress assessments for both children and adults may highlight areas of needed intervention and help address underlying issues such as lack of support, financial resources, or time.

While it was the goal of this research study to utilize a variety of language assessments to measure K's language development, due to the COVID-19 pandemic and time constraints, only one mode of language assessment was used. To gain a greater understanding of a child's auditory and language levels, assessments such as the Peabody Picture Vocabulary Test (PPVT), the Clinical Evaluation of Language Fundamentals (CELF), and the Test of Auditory Processing Skills (TAPS) could be implemented. While language sample analysis provides meaningful data, the addition of a wider variety of language assessments could better indicate a child's strengths and weakness.

Conclusion

The aim of this research study was to assess the language skills and academic performance of one child with hearing loss before and after a unilateral cochlear implant and educational audiology services. The researcher's predicted that K's language skills would improve with the implemented treatment was accurate, and results indicated significant improvements in the micro- and macrostructure of K's language abilities. Researchers also predicted that K's grades in language arts, reading, and mathematics would improve. Only language arts grades displayed improvement from the pre- to post-test period, possibly due to several factors that affected K's classroom performance was significantly affected by service disruption caused by the COVID-19 pandemic. The results of this study provide valuable insight into the outcome of cochlear implantation and educational audiology services as it pertains to

language skills in children with hearing loss. In continuing research, data on stress levels of participants, additional language assessments, and more participants would greatly contribute to these results.

APPENDIX A
IRB APPROVAL

THE UNIVERSITY of MISSISSIPPI
Office of Research and Sponsored Programs

9/2/2020

Dr. Lowe
CSD

Dr. Hao
CSD

IRB Protocol #:	**20-045**
Title of Study:	**Educational Audiology for Mississippi: Telepractice For DIrect Service Provision**
Approval Date:	**9-2-20**
Expiration Date:	**n/a**

Dear Dr. Lowe and Dr. Hao:

This is to inform you that your application to conduct research with human participants has been reviewed by the Institutional Review Board (IRB) at The University of Mississippi and the criteria for IRB approval of research at 45 CFR §46.111 have been determined to be satisfied. **as Expedited under 45 CFR 46.110, category 7** The criteria for IRB approval of research at 45 CFR §46.116, §46.404 and §46.408 have been determined to be satisfied for research involving children.

Research investigators must protect the rights and welfare of human research participants and comply with all applicable provisions of The University of Mississippi's Federalwide Assurance 00008602. Your obligations, by law and by University policy, include:

- Research must be conducted exactly as specified in the protocol that was approved by the IRB.
- Changes to the protocol or its related consent document must be approved by the IRB prior to implementation except where necessary to eliminate apparent immediate hazards to participants.
- **Only the approved, stamped consent form may be used throughout the duration of this research unless otherwise approved by the IRB.**
- A copy of the IRB-approved informed consent document must be provided to each participant at the time of consent, unless the IRB has specifically waived this requirement.
- Adverse events and/or any other unanticipated problems involving risks to participants or others must be reported promptly to the IRB.
- Signed consent documents and other records related to the research must be retained in a secure location for at least three years after completion of the research.
- Submission and *approval* of the *Progress Report* must occur before continuing your study beyond the expiration date above.
- The IRB protocol number and the study title should be included in any electronic or written correspondence.
- If research is to be conducted during class, the PI must email the instructor and ask if they wish to see the protocol materials (surveys, interview questions, etc) prior to research beginning.

If you have any questions, please feel free to contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Sincerely,

Miranda Core
Research Compliance Specialist, Research Integrity and Compliance

P.O. Box 1848 | University, MS 38677-1848 | (662) 915-7482 | Fax (662) 915-7577 | www.olemiss.edu

APPENDIX B

SCHOOL DISTRICT CONSENT

To whom it may concern:

I am writing to request permission to include students and employees of your school district in an educational audiology telepractice study taking place at the University of Mississippi titled "**Educational Audiology for Mississippi: Telepractice For Direct Service Provision**". The goal of the study is to discover whether telehealth services are an effective and efficient tool to train, inform, and guide teachers on the implementation of appropriate accommodations in the classroom for students with hearing loss. With the permission of their parents, participating students will receive educational audiology services utilizing a telehealth model. Also included in the study will be several speech and language tests that will be administered via telecommunication to assess participants language skills throughout the academic school year. These services and monitoring tests will be provided at no charge to the students or the school district. FERPA and HIPAA guidelines will be strictly adhered to for the purpose of protecting participant privacy. Participating students and school districts will be assigned a number or letter designation to be used in all documentation for the duration of the study, and all recordings will be completed and stored using HIPAA compliant software. Should your school district choose to participate, we ask only that all teachers and students included in the research study agree to comply for the entire academic school year and complete all data forms in a timely manner. The students may choose to withdraw at any point with no consequences to them. Please find attached the drafts of the assent and consent forms to be used with your students and parents.

Thank-you for your consideration,

Dr. Rebecca Lowe

Dr. Ying Hao

APPENDIX C

CHILD CONSENT FORM

Assent Form for Children (Ages 7-13)

I would like to ask you to help me with a project that I am doing at The University of Mississippi. If you agree, you would be asked some questions about pictures that I show you and play some word games for about one hour. You will be allowed some breaks. I also would like to record a short conversation between us for my project.

You can decide to stop doing any of these activities anytime you want to. Just let us know or talk to your speech-language pathologist, and there are no consequences if you decide to stop.

What questions do you have about these activities?

Will you do this?

Response (circle): **YES** **NO**

Name: Date:

APPENDIX D

PARENT CONSENT FORM

Parent Consent to Participate in Research

Study Title: *Educational Audiology Model for Mississippi: Telepractice for Direct Service Provision*

Investigators:

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Dr. Ying Hao
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Key Information for You to Consider
• **Voluntary Consent**. You are being asked to volunteer for a research study. It is up to you whether you choose to participate or not. There will be no penalty or loss of benefits to which you are otherwise entitled if you choose not to participate or discontinue participation. • **Purpose**. The purpose of this research is to identify a new model of educational audiology service provision which will work for the state of Mississippi until we reach the level of educational audiology in which other states have long achieved. • **Duration.** It is expected that your participation will last one academic year. • **Procedures and Activities.** You will be asked to implement certain language-facilitating strategies to improve language performance for your children with hearing impairments and fill out related assessment. • **Risks.** There are no risks to this research. • **Benefits**. Some of the benefits that may be expected include benefits to parents with improved language-facilitating strategies and reduced stress level. • **Alternatives.** Participation is voluntary and the only alternative is to not participate.

By checking this box, I certify that I am 18 years of age or older.

1. You will complete a questionnaire to assess stress levels of parents with children with hearing loss.
2. You will undergo parent training in which recommendations are given to aid in speech and language development of your child.
3. You will provide feedback on the progress of your child throughout the study.

Time required for this study

This study will last a full academic year.

Possible risks from your participation

There are no possible risks of your participation.

Benefits from your participation

Potential benefits are that you will have increased confidence in your abilities to support your child's speech and language development.

Confidentiality

Electronic data will be password protected. Any physical data will be retained in a locked file cabinet. All responses from participants will be categorized using a subject number with no identifying information attached. Numerical and statistical data organized by subject number will be maintained in the principal investigator's office until no longer needed for presentation or publication purposes. At that time, all data collection and summary forms will be disposed of in an appropriate manner consistent with University guidelines.

Right to Withdraw

You do not have to volunteer for this study, and there is no penalty if you refuse. If you start the study and decide that you do not want to finish, just tell Dr. Rebecca Lowe or Dr. Ying Hao. Whether or not you participate or withdraw will not affect your current or future relationship with the University of Mississippi.

IRB Approval

This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions or concerns regarding your rights as a research participant, please contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, then decide if you want to be in the study or not.

Statement of Consent

I have read the above information. I have been given an unsigned copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.

Furthermore, I also affirm that the experimenter explained the study to me and told me about the study's risks as well as my right to refuse to participate and to withdraw.

Permission for Use of Electronic Signature (if applicable)

By typing my name, I am signing this document electronically. I agree that my electronic signature is legally equivalent to my manual signature.

Signature of Participant Date

Printed name of Participant

APPENDIX E

TEACHER CONSENT

Teacher Consent to Participate in Research

Study Title: *Educational Audiology Model for Mississippi: Telepractice for Direct Service Provision*

Key Information for You to Consider
• **Voluntary Consent**. You are being asked to volunteer for a research study. It is up to you whether you choose to participate or not. There will be no penalty or loss of benefits to which you are otherwise entitled if you choose not to participate or discontinue participation. • **Purpose**. The purpose of this research is to identify a new model of educational audiology service provision which will work for the state of Mississippi until we reach the level of educational audiology in which other states have long achieved. • **Duration.** It is expected that your participation will last one academic year. • **Procedures and Activities.** You will be asked to implement certain strategies, technology, and modifications in your teaching of children with hearing impairments, and fill out related assessments. • **Risks.** There are no risks to this research. • **Benefits**. Some of the benefits that may be expected include benefits to teachers and school personnel at administering appropriate services to hard of hearing children. • **Alternatives.** Participation is voluntary and the only alternative is to not participate.

☐ By checking this box I certify that I am 18 years of age or older.

What you will do for this study

1. You will undergo teacher training during which researchers will train you in different strategies, technologies, and modifications that you will utilize in your classroom with hearing impaired children.
2. You will fill out an assessment every 9 weeks dictating the effectiveness of the new techniques.
3. You will participate in stress level assessment to report stress level for working with children with hearing loss.

Time required for this study

This study will last a full academic year.

Possible risks from your participation

There are no possible risks of your participation.

Benefits from your participation

Potential benefits are that teachers and school personnel may have an increased understanding of how to administer appropriate services to hard of hearing children.

Confidentiality

Electronic data will be password protected. Any physical data will be retained in a locked file cabinet. All responses from participants will be categorized using a subject number with no identifying information attached. Numerical and statistical data organized by subject number will be maintained in the principal investigator's office until no longer needed for presentation or publication purposes. At that time, all data collection and summary forms will be disposed of in an appropriate manner consistent with University guidelines.

Right to Withdraw

You do not have to volunteer for this study, and there is no penalty if you refuse. If you start the study and decide that you do not want to finish, just tell Dr. Rebecca Lowe or Dr. Ying Hao. Whether or not you participate or withdraw will not affect your current or future relationship with the University of Mississippi.

IRB Approval

This study has been reviewed by The University of Mississippi's Institutional Review Board (IRB). The IRB has determined that this study fulfills the human research subject protections obligations required by state and federal law and University policies. If you have any questions

or concerns regarding your rights as a research participant, please contact the IRB at (662) 915-7482 or irb@olemiss.edu.

Please ask the researcher if there is anything that is not clear or if you need more information. When all your questions have been answered, then decide if you want to be in the study or not.

Statement of Consent

I have read the above information. I have been given an unsigned copy of this form. I have had an opportunity to ask questions, and I have received answers. I consent to participate in the study.

Furthermore, I also affirm that the experimenter explained the study to me and told me about the study's risks as well as my right to refuse to participate and to withdraw.

Permission for Use of Electronic Signature (if applicable)

By typing my name, I am signing this document electronically. I agree that my electronic signature is legally equivalent to my manual signature.

Signature of Participant Date

Printed name of Participant

Appendix F

Frog Where Are You?
by Mercer Mayer

Page	Script
1	There once was a boy who had a dog and a pet frog. He kept the frog in a large jar in his bedroom.
2	One night while he and his dog were sleeping, the frog climbed out of the jar. He jumped out of an open window.
3	When the boy and the dog woke up the next morning, they saw that the jar was empty.
4	The boy looked everywhere for the frog. The dog looked for the frog too. When the dog tried to look in the jar, he got his head stuck.
5	The boy called out the open window, "Frog, where are you?" The dog leaned out the window with the jar still stuck on his head.
6	The jar was so heavy that the dog fell out of the window headfirst!
7	The boy picked up the dog to make sure he was ok. The dog wasn't hurt but the jar was smashed.
8 - 9	The boy and the dog looked outside for the frog. The boy called for the frog.
10	He called down a hole in the ground while the dog barked at some bees in a beehive.
11	A gopher popped out of the hole and bit the boy right on his nose. Meanwhile, the dog was still bothering the bees, jumping up on the tree and barking at them.
12	The beehive fell down and all of the bees flew out. The bees were angry at the dog for ruining their home.
13	The boy wasn't paying any attention to the dog. He had noticed a large hole in a tree. So he climbed up the tree and called down the hole.
14	All of a sudden an owl swooped out of the hole and knocked the boy to the ground.
15	The dog ran past the boy as fast as he could because the bees were chasing him.
16	The owl chased the boy all the way to a large rock.
17	The boy climbed up on the rock and called again for his frog. He held onto some branches so he wouldn't fall.
18	But the branches weren't really branches! They were deer antlers. The deer picked up the boy on his head.
19	The deer started running with the boy still on his head. The dog ran along too. They were getting close to a cliff.
20 - 21	The deer stopped suddenly and the boy and the dog fell over the edge of the cliff.
22	There was a pond below the cliff. They landed with a splash right on top of one another.
23	They heard a familiar sound.
24	The boy told the dog to be very quiet.
25	They crept up and looked behind a big log.
26	There they found the boy's pet frog. He had a mother frog with him.
27	They had some baby frogs and one of them jumped toward the boy.
28-29	The baby frog liked the boy and wanted to be his new pet. The boy and the dog were happy to have a new pet frog to take home. As they walked away the boy waved and said "goodbye" to his old frog and his family.

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