UNIVERSITY OF CINCINNATI

Date: 20-May-2010

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hereby submit this original work as part of the requirements for the degree of:

Master of Arts

in Communication Sciences and Disorders

It is entitled:

Impact of Cognition on Language Skills of Children with Developmental Disabilities and Cochlear Implants

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Impact of Cognition on Language Skills of Children with Developmental Disabilities and Cochlear Implants

A thesis submitted to the

Department of Communication Sciences and Disorders

College of Allied Health Sciences

University of Cincinnati

in partial fulfillment

of the requirements for the degree of

Master of Arts

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B.A. Communication Sciences and Disorders

The Ohio State University

May 27th, 2010

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ABSTRACT

The objective of this study was to examine the relationship between cognition and language outcomes for children with cochlear implants and developmental disability and those with developmental disability alone. Language outcomes for the two groups were compared. The subjects consisted of a group of 4 children with cognitive disabilities and cochlear implants and their controls matched on age and cognitive ability. Subjects ranged in age from three to seven years old. Cognitive scores were derived from the non-verbal cognitive subtest from the Revised Gessell Developmental Schedules, and language scores were obtained using the Preschool Language Scale – 4th Edition (PLS-4). Statistical analysis examining the relationship between language and cognitive scores revealed a significant positive correlation between language and cognitive ability for the subject group with developmental disabilities and cochlear implants. There was not a significant relationship for the control group. Children with developmental disabilities and cochlear implants performed significantly below their matched peers with developmental disabilities and normal hearing on language measures. Children with developmental disabilities and normal hearing consistently performed at or above their cognitive level on language measures, while children with developmental disabilities and cochlear implants performed significantly below cognitive level. Although children with cochlear implants did not perform as well as controls with developmental disabilities and normal hearing, qualitative improvements were evident. All children in the cochlear implant subject group demonstrated increased receptive and expressive language skills following implantation, and three out of four of these children also demonstrated improved language quotients when compared to early language testing completed prior to implantation.

TABLE OF CONTENTS

CHAPTER I: INTRODUCTION AND A

REVIEW OF THE LITERATURE……..……7

Factors Impacting Outcomes for Children Receiving

Cochlear Implants……....8

IQ as a Predictive Factor of Success for Children Receiving

Cochlear Implants……..10

Outcomes for Multi-Handicapped Children with

Cochlear Implants: Benefits and Challenges……11

Motor Disorders and Vision Disorders: Impact on Language

Development in Multi-handicapped Children ……..15

Cognition as a Predictor of Success for Children with

Cochlear Implant and Developmental Disability……..17

CHAPTER II: METHODS……20

Hypotheses……20

Subjects……..21

Materials……22

Procedures……..22

Data Analysis……...……..24

CHATER III: RESULTS.....27

CHAPTER IV: DISCUSSION……33

Conclusions……41

Limitations……42

Future Research……43

REFERENCES……45

LIST OF FIGURES AND TABLES

Table 1: Age, NVCQ, Total LQ, and Disability for subjects with cochlear implants and their age and developmentally matched controls……24

Figure 1. Relationship Between Cognition and Language Skills for Children with Developmental Disabilities and Cochlear Implants……27

Figure 2. Relationship Between Cognition and Language Skills for Children with Developmental Disability……29

Figure 3. LQ-NVCQ: Median Cognitive-Language Discrepancy for Children with Developmental Disabilities and Cochlear Implants Compared to Children with Developmental Disabilities and Normal Hearing……..….30

Table 2. Cognitive-Language Discrepancy: CI Subjects Compared to Controls……31

Table 3. Language in Children with Development Disability: Comparing Skills Pre- and Post- Cochlear Implant……...……36

Table 4. Total Language Quotients for Subject Group Pre- and Post- Cochlear Implantation……39

CHAPTER I:

INTRODUCTION AND REVIEW OF THE LITERATURE

This study was conducted as part of a larger research project investigating outcomes for children with developmental disabilities and cochlear implants. The subjects were selected from a previously recruited pool of subjects enrolled in the larger study at an urban Midwest hospital. The purpose of the larger study, "Outcomes for Deaf Children with Developmental Disabilities", was to investigate language outcomes for children with developmental disabilities and cochlear implants when compared to controls with developmental disabilities only. There is a limited body of research investigating outcomes for children with developmental disability and cochlear implants. Most studies have been limited to single case studies and qualitative observations. Studies with quantitative evidence are still needed in order to determine best practice when working with children with developmental disabilities whose families are considering cochlear implantation. There are a number of challenges when conducting research on cochlear implants within this group. It is difficult to quantitatively measure outcomes in the areas of speech perception, speech production, and language from pre-implantation to post-implantation. Also, the subject groups tend to be very heterogeneous, combining cognitive, visual, and motor disabilities into one subject group. This may introduce confounding factors into outcome data. The focus of the current study is to examine a more homogeneous subject group by eliminating subjects with vision and motor disabilities and looking at the impact of cochlear implantation in subjects with cognitive delay only. The relationship between cognition and language will be examined in both groups. Language outcomes for the group with cognitive disabilities and cochlear implants and cognitive disabilities only will be compared.

A cochlear implant is a surgically inserted device designed to directly stimulate the auditory nerve with an electrical signal. Cochlear implants are designed for use in individuals who are severely-profoundly deaf and may not receive significant benefit from traditional amplification systems. Cochlear implants were approved for use by the FDA in 1985 for adults who are post-lingually deaf. The guidelines for implantation have changed drastically in the last 25 years and cochlear implants are now approved for children who are profoundly deaf as young as 12 months of age (ASHA, 2004). Candidacy must be determined by a thorough medical, audiological, and psychological evaluation. For children, it must also be determined that the proper environmental supports are in place to optimize success with the implant. Outcomes for children who receive cochlear implants are extremely variable, although benefits are typically seen in speech perception, speech intelligibility, and language development (Moog & Geers, 2003). There are a variety of factors that impact a child's success with an implant, including child and family characteristics, implant characteristics, and educational factors (Geers et al., 2002). Determining outcomes and making recommendations for implants in children with developmental disabilities is even more complicated. Current research in this area has yielded mixed results (Hamzavi, 2000; Waltzman, Scalchunes, & Cohen, 2000). Further research is needed in order to help cochlear implant teams and families make individualized decisions about children with developmental disabilities being considered for cochlear implantation.

Factors Impacting Outcomes for Children Receiving Cochlear Implants

The ultimate goal of cochlear implantation in young children is to achieve auditory perception adequate for developing age appropriate speech and language skills. Outcomes for children implanted early in life are extremely variable and depend on a wide range of predictive factors. Generally, benefits are seen in all areas for this population including auditory

discrimination, speech perception, speech production, and receptive and expressive language. Moog & Geers (2003) found that almost 50% of 8-9 year olds with at least 4 years of experience with their implant had speech intelligibility scores within the normal range for their age. Over half of these children were also reading at grade level. However, the amount of benefit is dependent on several factors. Geers and colleagues (2002) divided factors affecting outcomes into three areas. These included child and family characteristics, implant characteristics, and educational factors. Child and family characteristics included age at time of implantation, years of experience with the cochlear implant, age at onset of deafness, performance IQ, family size, and parent education. Implant characteristics included type of speech processor, number of active electrodes, and the dynamic range of frequencies. Educational factors included intervention setting, communication mode, hours of therapy, and parent participation.

Overall, implant characteristics accounted for the greatest variance in outcomes at 24%. Child and family characteristics accounted for 18% of variance and educational factors accounted for 12% of variance. Performance IQ was the most influential of the individual characteristics of the child and family. IQ was found to have a significant impact in all areas including speech perception, speech production, spoken language development, and reading. Age of implantation and amount of time with the implant did not contribute significant variance to the outcomes. While education of the parents was not significant, children from smaller families tended to have better language outcomes. The type of speech processor was the most significant variable among implant characteristics. Children with the newer SPEAK processor and more active electrodes performed better on measures of speech perception, speech production, spoken language, and reading. Oral communication was the most significant predictor of outcomes among educational factors, accounting for significant variance in speech

and language outcomes. Children who were educated in an oral education mode had better outcomes in speech perception, speech production, spoken language, and reading than children educated in a total communication mode (Geers et al., 2002).

Another study examining the support and involvement of the parents and quality of parent training found that these were important in predicting the progress a child could potentially make with his or her implant. Realistic goals of the family and therapists also contributed to the success of the child with the implant. Family counseling and education was an important predictor of the child's speech recognition and verbal expression potential (Hamzavi, 2000).

IQ as a Predictive Factor of Success for Children Receiving Cochlear Implants

Many studies have indicated IQ to be the most significant predictive factor in determining outcomes for children with cochlear implants. A child's IQ can impact several outcome areas including speech perception, receptive language, expressive language, and reading skills. Dawson, Bubsy, McKay, and Clark (2002) examined the performance of 24 children with cochlear implants on visual and auditory sequential short term memory tasks. They assessed nonverbal intelligence using the nonverbal scale of the Kaufman Assessment Battery for Children. In the normal hearing control group the correlation between nonverbal IQ and receptive language skills was .46. In the group of children with cochlear implants, the correlation between nonverbal IQ and receptive language was .74. These results were significant for both groups. Overall, the spatial memory subtest of the nonverbal IQ task was found to be the strongest predictor of receptive language for the cochlear implant subject group. Performance on this task accounted for 55% of the variance in receptive language scores.

Geers, Brenner, and Davidson (2003) examined factors associated with the development of speech perception in 181 children implanted with cochlear implants. They found that only two factors were significantly correlated with speech perception scores. These were performance IQ and family size. Higher IQ and smaller family size were associated with higher speech perception scores. They concluded that nonverbal intelligence is the most important predictive factor for speech perception skills.

Outcomes for Children with Multiple Disabilities and Cochlear Implants: Benefits and Challenges

Limited research has been conducted to date examining outcomes for children with multiple disabilities and cochlear implants. There are unique benefits and challenges when considering cochlear implantation in this complex group. Child and family characteristics, implant characteristics, and educational factors are further complicated by the presence of an additional disability. There have generally been mixed results describing outcomes in this population. Although most studies agree on some qualitative benefits in the area of connectedness, auditory attention, and speech perception, it can be difficult to quantify these improvements (Waltzman et al., 2008; Berrettini et al., 2008; Wiley et al., 2005; Fuduka, 2003). There are also issues surrounding the definition of developmental disability and the wide variety of developmental disabilities that are typically grouped together for the purposes of research studies. Developmental disability as a general term may include cognitive delays, learning delays, ADHD, fine or gross motor delay, vision disability, cerebral palsy, and autism. Each of these disabilities has a unique set of characteristics that can contribute to both strengths and weaknesses in various domains of speech and language development. Combining these disabilities into a single subject group creates a very complex interaction of individual factors.

These unique differences between children with different disabilities have the potential to create very heterogeneous subject groups for which it can be difficult to yield meaningful statistical results. There is also an additional issue of the age at which a child was implanted and whether they were diagnosed with a disability before or after the implant was received. Regardless of the complicated nature of this issue, there is an existing body of research that has found benefit for children with cochlear implants and developmental disabilities (Waltzman et al., 2008; Berrettini et al., 2008; Wiley et al., 2005; Fuduka, 2003).

Hamzavi (2000) examined the outcomes and benefits of cochlear implantation in ten children with multiple disabilities. All children were pre-lingually deafened and had another co-occurring disability. Additional disabilities included learning difficulty, cognitive delay, autism, hyperactive behavior, and motor disability. Outcomes were described both objectively and subjectively in each of the ten subjects. Quantitative improvements were measured by increased speech perception scores on the Evaluation of Auditory Responses to Speech (EARS) test battery. Changes in auditory behaviors were also described to incorporate qualitative observations. Prior to implantation, none of the subjects were showing a response to speech. Overall, subjects with a wide variety of disabilities demonstrated either quantitative or qualitative improvements in speech perception and response to sound. There was a wide range of benefits ranging from 90% sentence recognition and ability to communicate in simple sentences, to differentiating murmurs and voices in the environment. Only one child did not receive any stated benefits, although five children out of ten received only minimal benefits in the area of responding to sounds in the environment. Benefits were extremely variable from child to child, but it was not determined how the individual characteristics of the child impacted outcomes. Trends in the data showed the greatest benefit for children with moderate learning

disability and deafness only. One subject with autism demonstrated significant qualitative and quantitative gains in speech perception and overall communication skills. Subjects who showed the least benefit from an implant included those with severe motor deficits and/or severe intellectual disability. The subject who showed no benefit was blind and had a severe intellectual disability.

Waltzman et al. (2000) examined the impact of multiple handicaps on speech perception skills in 29 children who were profoundly deaf with cochlear implants. The subject group included children with a wide range of additional disabilities. Motor delays, autism, dyspraxia, cognitive delay, learning disability, visual delays, cerebral palsy, PDD, and ADD were some of the disabilities that comprised the subject group. Although results were variable for each individual, on average the subject group improved speech perception skills with one year of experience with the cochlear implant. There was also a trend towards continued gains in speech perception as experience with the cochlear implant increased. Although the subject group with additional disabilities made slower progress when compared to a group of children with deafness only, benefits were still stated for the group with multiple disabilities. These included improved auditory skills, communication skills, social interactions, and increased awareness to their environment.

Berrettini et al. (2008) examined the correlation between outcomes and perceived benefits per parent report for 23 children with multiple disabilities and cochlear implants. The subject group included children with developmental disabilities including cognitive delay, language and learning disorders, PDD, ADHD, ODD, depression, CP, epilepsy, and CNS malformation. In this group 74% of subjects were in the lowest speech perception category (0-1) prior to receiving their implant. Twenty six percent of subjects were in the mid-range of speech

perception (2-5) and none of the subjects were in the highest speech perception category. Sixty-nine percent of these children used gestures and behaviors only for communication and only 28% of these children used oral language. These children were re-evaluated in these domains 1 to 5 years after receiving their implants. The average length of time between implantation and the post-implant evaluation was 2.5 years. After having 1-5 years of experience with a cochlear implant, 53% of children were in the highest speech perception category (6), and only 13% remained in the lowest speech perception category (0-1). The percentage of these children communicating with oral language also increased from 28% to 69%, with only 28% continuing to use gestures and behaviors only. On questionnaires concerning post implant improvements parents reported that 74% of children had improved speaking skills; 96% had improved peer interactions; 100% were more attentive and interested at home; 100% worked better with siblings and classmates; and 96% were more likely to communicate wants and needs.

Wiley, Jahnke, Meinzen-Derr, and Choo (2005) examined qualitative benefits of cochlear implants in 16 children with multiple disabilities using parent interview. Responses were transcribed and coded. Eighty percent reported increased awareness to environmental sounds and increased attentiveness and interest at home. Differences in communication methods were also reported from pre-implant to post-implant. Prior to receiving their cochlear implant, five children were communicating with behaviors only; four were communicating with behavior and sign; five were communicating with sign; and one was communicating with oral language and sign. After implantation, three continued to communicate with behaviors; one communicated with behavior and sign; six communicated with sign; and five communicated with oral language. Eighty percent of parents agreed that their child was better able to express their wants and needs after receiving their implant.

Fukuda (2003) sought to describe the development of language in one ten-year old male with approximately 5 years of experience with a cochlear implant. The subject had language, cognitive, and motor delays. Within 15 months, improvements were seen in the areas of auditory perception, awareness of environmental sounds, differentiation of pitches, discrimination of voices, response to oral directions without lip reading, identification of a distant sound source, and following teacher directions in noise. Word recognition increased from 0% before implantation to 75% at two years post. Vocabulary increased from no words spoken before implantation to three-word sentences within one year. This case study described one child with multiple disabilities who was able to make a significant amount of progress with a cochlear implant. In this case, the researchers concluded that his cochlear implant likely allowed for his language skills to catch up to his cognitive ability, allowing for rapid progress in the domains of expressive language and word recognition.

Motor Disorders and Vision Disorders: Impact on Language Development in Children with Multiple Disabilities

Many studies looking at children with developmental disabilities who receive cochlear implants have utilized heterogeneous subject groups that combine children with cognitive disability, visual disability, and motor disability. Very few studies report on the unique impact that motor and visual disability may have on the development of speech perception and language in this population. Motor and visual disability may introduce specific confounding factors into language acquisition due to poor motor control of the articulators and decreased sensory input. Pennington (2008) described special considerations for communication in children with cerebral palsy. Motor impairments can limit intelligibility and affect language development. Children with gross motor difficulties related to cerebral palsy tend to be more passive communicators and

have a limited range of communicative functions. This can adversely affect language development as well as interaction and pragmatic skills that are associated with expressive communication. Literature looking specifically at cochlear implants in children with motor and visual disabilities will be reviewed in order to establish a need for studies that isolate specific disability groups in an attempt to minimize individual variation and associated confounding factors.

Meinzen-Derr, Wiley, Grether, and Choo (2010) examined the relationship between cognitive skills and language development in 20 children with multiple disabilities. The revised Gessell Developmental Schedules was administered to assess five developmental domains including gross motor, fine motor, nonverbal cognitive performance, personal-social, and language. Gross motor quotients were derived by dividing the child's test age performance by the child's chronological age. Gross motor functioning was found to be negatively correlated with expressive language abilities. Higher gross motor skills were associated with higher expressive language skills. Expressive language quotients decreased by 1% for every unit decrease in gross motor quotient.

Hamzavi (2000) examined the outcomes and benefits of cochlear implantation in ten children with multiple disabilities. Subjects who showed the least benefit from an implant included children with severe motor deficits and/or severe intellectual disability. The only subject who did not exhibit any benefit was blind and had a severe intellectual disability.

Daneshi (2007) examined auditory perception scores in 60 children with deafness and additional disabilities before and after they received a cochlear implant. The subjects were divided into 7 groups based on their additional diagnoses including mild cognitive delay,

moderate cognitive delay, learning disability, ADHD, cerebral palsy, congenital blindness, and autism. Auditory perception was assessed using the Persian auditory perception task. All groups showed statistically significant improvements in auditory perception, except for the groups with autism and congenital blindness. While this study did not look at language scores, speech perception is a necessary precursor to developing spoken language. Speech perception is necessary for auditory comprehension and acquiring expressive communication. If subjects were unable to make progress in speech perception, it can be deducted that they are also making little progress in language development.

Cognition as a Predictor of Success for Children with Developmental Disabilities and Cochlear Implants

The association between cognitive skills and the development of speech and language skills in children with cochlear implants and no additional disabilities has been reviewed. It is important to consider how cognition also plays a role in predicting outcomes for children with multiple disabilities and cochlear implants. Dawson et al. (2002) speculated that IQ scores may be a more significant predictor of language skills when IQ is in the low average or below average range. This means that cognition would be a more significant predictor of success in children with developmental disabilities who have below average cognitive skills. This illustrates the importance of examining the impact of IQ on language when making decisions about implantation of children in this complex group.

Meinzen-Derr et al. (2010) examined the relationship between nonverbal cognition and language development in 20 children with cochlear implants and developmental disabilities. Seventy-five percent of the children had cognitive delays and 55% of the children had motor

delays. The correlation coefficient for non-verbal cognitive quotient and receptive language was r=.79, while the correlation coefficient for non-verbal cognitive quotient expressive language was r=.77. This reveals a highly significant relationship between cognitive level and receptive and expressive language development. In this study, non-verbal cognitive quotient was the strongest predictor of language ability and was highly predictive of language outcomes post-implantation.

There is one known study that has isolated cognitive delay as a disability and examined outcomes for cochlear implants in this group. Holt and Kirk (2005) examined outcomes between two subject groups including one group with mild cognitive delay and cochlear implants and one group with cochlear implants only. They found no significant differences between the two groups in auditory integration and word and sentence recognition. In the area of receptive vocabulary, children with cognitive delays scored significantly lower with minimal gains when compared to the control group. Children with cognitive delay also had significantly lower expressive language skills compared to children with cochlear implants receiving oral communication instructions. While the children with typical cognition had significantly better outcomes, the majority of children with cognitive delays who were tested more than once demonstrated some improvements in speech and language skills.

Current literature examining the factors linked to language outcomes in children with cochlear implants has been reviewed. The benefits and challenges of implantation in children with multiple disabilities have been described. The role of cognition in language development in this population has been introduced, and the need for additional research in this area has been established. A need still exists for the role of cognition to be investigated in children with multiple disabilities and cochlear implants so that we may better understand how this

relationship between language and cognition manifests in this population. The current literature has not yet examined this relationship with controls with developmental disability and typical hearing. Motor and visual impairments in the subject group were eliminated to examine the language outcomes in a subject group of cochlear implant and cognitive delay only when compared to controls matched on cognitive ability.

The research questions investigated in this study include:

1. Are language and cognitive scores positively correlated for children with developmental disability and cochlear implants?

2. Are language and cognitive scores positively correlated for children with developmental disability and normal hearing?

3. How do these groups compare in terms of cognitive-language discrepancy when language outcomes are measured in the context of cognitive level?

CHAPTER II:

METHODS

The current study examined the relationship between cognition and language in a group of children with developmental disabilities and cochlear implants and a group with developmental disabilities and normal hearing. Language outcomes were measured by performance on the Preschool Language Scale – 4th Edition (PLS-4) (Zimmerman, Steiner, & Pond, 2002) and cognition was measured through performance on the nonverbal cognitive subtest of the Gessell Revised Developmental Schedules (Ball, 1977). Research describing the relationship between cognition and language is necessary in order to best inform parents and professionals about potential outcomes and skill growth for children in both groups. In order to isolate cognition as a predictive factor, other motor and vision disabilities must be excluded. The following hypotheses have been formulated:

Hypothesis #1: Cognition is positively correlated with language skills as measured by the Revised Gessell Developmental Schedules and the PLS-4 for children with developmental disability and a cochlear implant.

Hypothesis #2: Cognition is positively correlated with language skills as measured by the Revised Gessell Developmental Schedules and the PLS-4 for children with developmental disability and normal hearing.

Hypothesis #3: Children with developmental disabilities and normal hearing have language skills commensurate with their cognitive level, while children with developmental disabilities and cochlear implants have language skills below their cognitive ability.

These hypotheses were investigated using a retrospective case-control design to describe the relationship between post-implantation language skills. A case-control design utilizes two subject groups in which one group has a condition and the other group does not. Both groups of children had developmental disabilities in this study. The variable impacting outcomes was the presence of a severe-profound hearing loss surgically treated with a cochlear implant. Language skills were measured by the PLS-4 at least one year following a developmental assessment in which non-verbal cognitive scores were obtained using the Revised Gessell Developmental Schedules. Children ranged in age from three to seven years old at the second point of testing. Children in the subject group received a cochlear implant following early developmental assessment and had at least one year of experience with an implant before language testing was conducted. All subjects in the current study were previously enrolled in the larger study taking place at a Midwest urban pediatric hospital titled, "Outcomes for Deaf Children with Developmental Disabilities".

Subjects

The sample of eight children consisted of four children with cognitive delays and cochlear implants their age and developmentally matched controls with cognitive delay only. Subjects were matched by age and non-verbal cognitive quotients derived from the Revised Gessell Developmental Schedules. In the overall sample, subjects with cochlear implants were selected from a chart review of the cochlear implant registry. Eligibility required that the child was between three and six years of age, received an implant by age five, and had been identified with an additional disability. Disabilities were diagnosed through a developmental assessment with a Pediatrician who specializes in Developmental Medicine. Developmental assessments were conducted before the age of three years in most subjects. Additional disabilities included

cognitive delay, fine and gross motor delay, vision disability, cerebral palsy, autism, and ADHD. Control subjects were identified through chart review in the Division of Developmental and Behavioral Pediatrics. For the purposes of this study, subjects with vision and motor disabilities were eliminated so that the impact of cognition alone on language could be determined. Only four of the original 15 matched pairs met inclusion criteria.

Materials

The PLS-4 is a standardized measure of receptive and expressive language. The PLS-4 assesses receptive language skills including response to sound, understanding words and phrases, and following directions. Expressive language skills assessed by the PLS-4 include play and interaction skills, combining sounds, and the use of words and sentences. The PLS-4 yields a standard score and age equivalents for receptive language, expressive language, and total language. The Revised Gessell Developmental Schedules is typically used to assess language, motor, cognitive, and social development in children under age three. It contains 5 subtests: Gross Motor, Fine Motor, Non-Verbal Cognitive, Personal Social, and Language.

Procedures

Data was collected using the PLS-4 and the Revised Gessell Developmental Schedules. The data utilized for analysis in this study was previously collected during the larger study, "Outcomes for Deaf Children with Developmental Disabilities". Data was obtained through chart review of these previously recruited subjects.

The PLS-4 was given one year post cochlear implant to assess language development. It was administered by a speech-language pathologist who specializes in treating children with developmental disabilities at a Midwestern urban pediatric hospital. The PLS-4 was

administered verbally and also administered using sign language with children who were using sign as a mode of communication. Administration in sign language did elevate the total age equivalents of two of the children by four months. Verbal scores were used for the purpose of consistency in data analysis. Standard scores were not utilized for the purposes of data analysis due to the floor effect of the PLS-4 as many of the subjects obtained the lowest standard score possible of 50. Age equivalents were used in order to increase the range of variability in skills demonstrated by the children with developmental disabilities and cochlear implants. The total age equivalent which is derived from combined performance on the receptive and expressive language portions was used for the purposes of data analysis.

Non-verbal cognitive quotients were derived from the performance on the Non-Verbal Cognitive subtest. The Revised Gessell Developmental Schedules was administered by a Developmental Pediatrician as part of a developmental assessment to determine pre-implant skill levels in the domains of cognition, motor skills, and language.

Language and cognitive quotients were derived using age equivalents from the PLS-4 and the Revised Gessell Developmental Schedules. It was necessary to utilize quotients in order to increase sensitivity of these measures for children with low functional skills. The child's age equivalent on the tests that were administered was divided by the child's chronological age and multiplied by 100 in order to determine the language and cognitive quotients. Therefore, a language or cognitive quotient of 100 would indicate that the child was demonstrating skills appropriate to his or her age level. Table 1 displays data for the subjects who qualified for inclusion in the study and their age and developmentally matched controls. The subject chart details the developmental disability, age, non-verbal cognitive quotient and total language quotient for each child included in the study.

Table 1: Age, NVCQ, Total LQ, and Disability for subjects with cochlear implants and their age and developmentally matched controls

Cochlear Implant	Developmental Disability	Age in months	NVCQ*	Total LQ*	Control Subjects	Developmental Disability	Age in months	NVCQ*	Total LQ*
1	Cognitive	44.5	75	62.92	1	Cognitive, ADHD	57.3	75	99.48
2	Cognitive	49.6	70	18.15	2	Cognitive, Behavior	67.8	68	115.04
3	Cognitive	55.9	42	14.31	3	Cognitive	64	45	43.75
4	Cognitive, Oral Motor	69.1	75	50.65	4	Cognitive	79.5	80	85.53

*NVCG: Non-verbal Cognitive Quotient, LQ= Language Quotient

Data Analysis:

Hypothesis #1: Cognition will be positively correlated with language skills for children with developmental disability and a cochlear implant.

The sample size for this analysis is 4 children with developmental disability and cochlear implant. Values for the non-verbal cognitive quotient were derived from performance on the Non-Verbal Cognitive subtest of the Revised Gessell Developmental Schedules, while values for the language quotient were derived from the total language age equivalent on the PLS-4. The

relationship between cognition and language in this group was analyzed using a Spearman Correlation Coefficient. The Spearman is a ranked correlation coefficient that was selected to analyze Hypothesis #1 and Hypothesis #2 due to small sample size. Ranked correlation coefficients allow for the numbers to be analyzed by ranking them in order, rather than using the true numbers in the data.

Hypothesis #2: Cognition will be positively correlated with language for children with developmental disability and normal hearing.

The sample size for this analysis is 4 children with developmental disability only and typical hearing. Values for the non-verbal cognitive quotient were derived from performance on the Non-Verbal Cognitive subtest of the Revised Gessell Developmental Schedules, while values for the language quotient were derived from the total language age equivalent on the PLS-4. The relationship between cognition and language in this group was analyzed using a Spearman Correlation Coefficient.

Hypothesis #3: Children with developmental disability and normal hearing have language skills commensurate with their cognitive level, while children with developmental disability and a cochlear implant have language skills below their cognitive ability.

The sample size for this analysis is 8. This includes four children with developmental disabilities and cochlear implants and four children with developmental disabilities and normal hearing matched on age and developmental level. Language outcomes for the two groups were compared using Univariate Analysis. This allowed for median discrepancy between language quotient and developmental quotient to be compared for each group. In this way, language outcomes for both groups are examined in the context of cognitive ability. Median discrepancies

between language and cognitive quotients will reveal how each group is performing on language outcomes based on their cognitive ability.

CHAPTER III

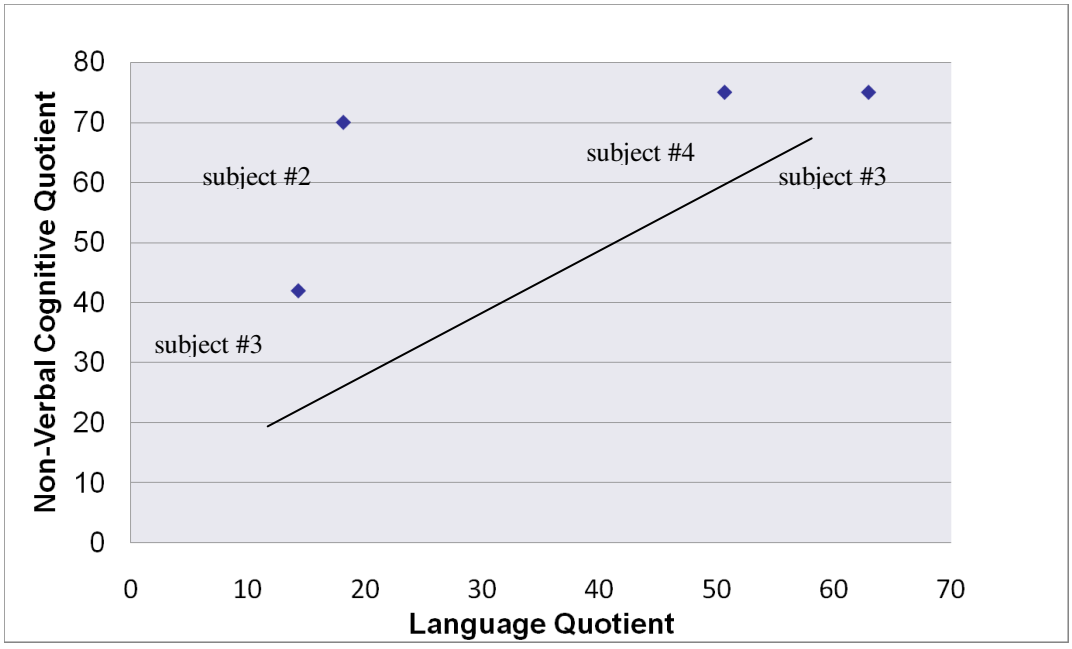
RESULTS

Statistical analysis was used in order to examine the stated hypotheses. The methods and analysis have been stated and the results are as follows:

Hypothesis #1: Cognition will be positively correlated with language skills for children with developmental disability and a cochlear implant.

A Spearman correlation coefficient was used in order to determine the relationship between cognition and language in children with developmental disability and a cochlear implant. A strong positive correlation, r=.95, was identified for this group. The significance level of this measure was p=.05 indicating that these results are statistically significant. The relationship between cognition and language skills in this group is displayed in Figure 1.

Figure 1: Relationship Between Cognition and Language Skills for Children with Developmental Disabilities and Cochlear Implants



As Figure 1 shows, there was a strong statistically significant correlation between cognition and language skills in this group. As cognitive quotients increased, language quotients increased as well.

Hypothesis #2: Cognition will be positively correlated with language for children with developmental disability and normal hearing.

A Spearman correlation coefficient was used in order to determine the relationship between cognition and language in children with developmental disability and a normal hearing. There was not a statistically significant relationship between language and cognition in this group. The correlation coefficient, r=.20, indicates a weak relationship in the positive direction. The significance level of this measure was p=.80 indicating that these results are not statistically significant. These results may be attributed to an outlier in the small sample, n=4, that had lower cognitive skills and the highest language scores. The relationship between cognition and language skills in this group is displayed in Figure 2.

Figure 2: Relationship Between Cognition and Language Skills for Children with Developmental Disability and Normal Hearing

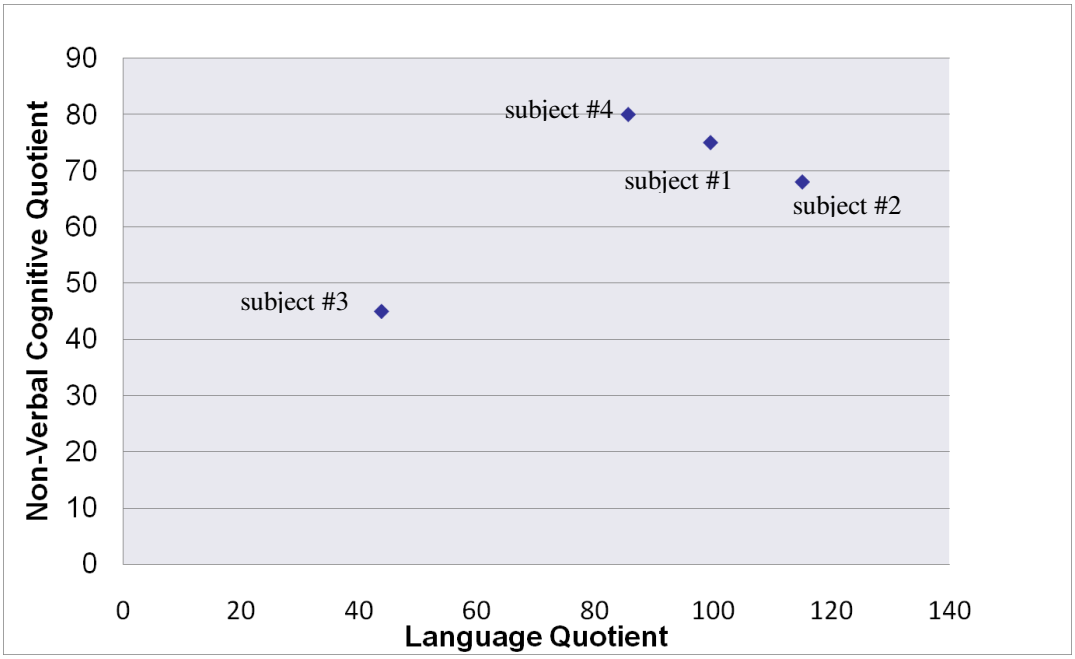


Figure 2 displays the outlier in the sample who had a nonverbal cognitive quotient of 68 and a total language quotient of 115. The outlier is identified as Subject #2 on the graph. While language and cognition were not found to be correlated in this group of four children, it is not likely that these results reflect the rest of the population.

Hypothesis #3: Children with developmental disability and normal hearing have language skills commensurate with their cognitive level, while children with developmental disability and a cochlear implant have language skills below their cognitive ability.

Univariate analysis was used in order to compare language outcomes for each group based on the median discrepancy between language quotients (LQ) and non-verbal cognitive quotients (NVCQ). The median language discrepancy for the cochlear implant subjects

[*Language Quotient minus Developmental Quotient*] was -26.02. This means that on average children with a developmental disability and cochlear implant had language quotients that were 26 points *below* their cognitive quotients. The significance level for this measure was p=.125. This is approaching significance considering the small sample size, n=4. The median difference for the control subjects [*Language Quotient minus Developmental Quotient*] was 15.00. This means that on average children with a developmental disability and normal hearing had language quotients 15 points *above* their cognitive quotients. The significance level for this measure was p=.25. Figure 3 displays the median differences for both groups.

Figure 3: LQ-NVCQ: Median Cognitive-Language Discrepancy for Children with Developmental Disabilities and Cochlear Implants Compared to Children with Developmental Disabilities and Normal Hearing

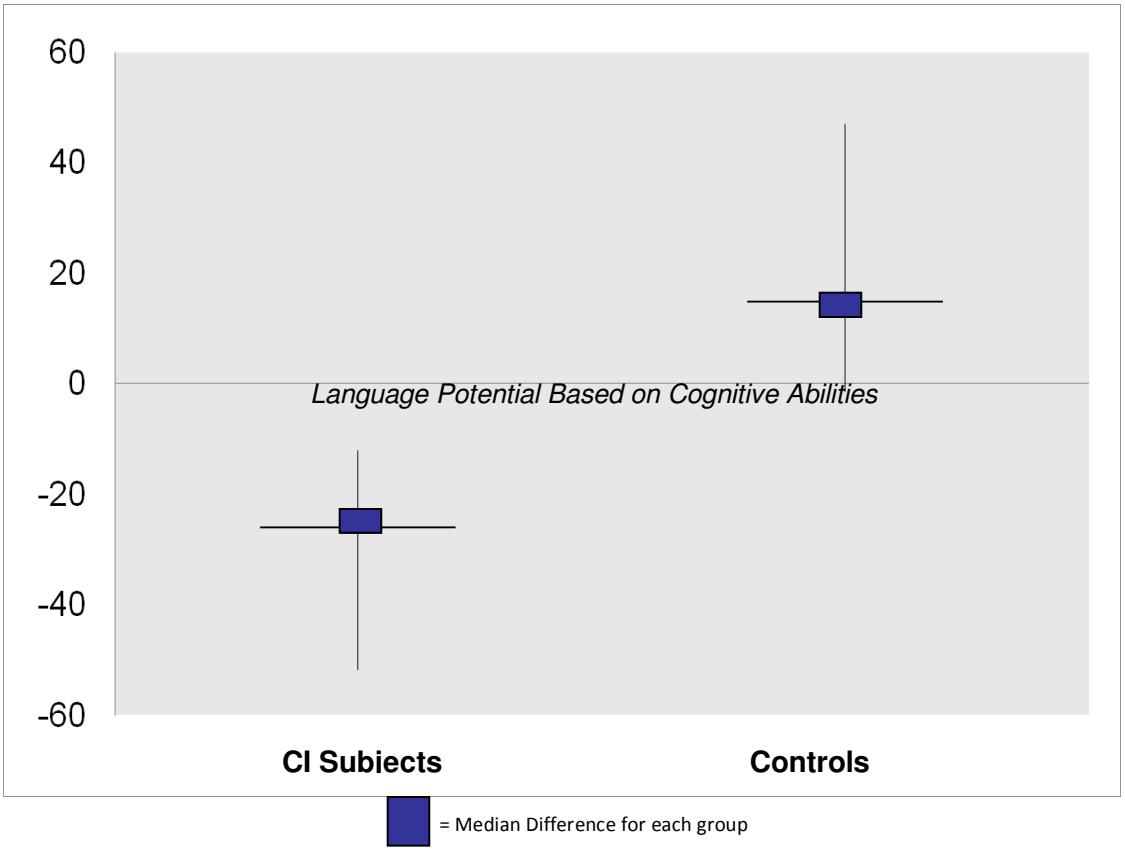


Figure 3 displays the range of differences between language ability and non-verbal cognitive quotient for the subjects in both groups, and also illustrates the median difference for each group. This figure shows that the cochlear implant subjects are performing well below their language potential based on cognitive abilities, while controls with developmental disabilities and normal only are performing at or above their cognitive potential. On average, the control group had language quotients 46 points higher than the subjects with developmental disabilities and cochlear implants. Cognitive-language discrepancies are broken down for each matched pair in Figure 5.

Table 2: Cognitive-Language Discrepancy: CI Subjects Compared to Controls

CI Subjects **LQ- NVCQ**	**Control Subjects** **LQ-NVCQ**
-12.08	24.48
-51.85	46.96
-27.69	-1.25
-24.35	5.53

This table shows that children with developmental disabilities and cochlear implants are demonstrating language quotients ranging from 12 to 51 points below their cognitive quotients. Control subjects are demonstrating language quotients ranging from nearly commensurate with their cognitive level to 46 points above their cognitive level. Based on the information in Table

1 involving language and cognitive quotients for each subject, we can also see that the control group with developmental disabilities and normal hearing has language quotients that range from 29.44 to 96.89 higher than the subjects they were matched to with developmental disabilities and cochlear implants. These elevated language scores exist in the control group even though their cognitive skills were determined to be nearly equal to the children with developmental disabilities and cochlear implants.

CHAPTER IV:

DISCUSSION

The results of the current study have indicated that there is a positive relationship between cognition and language for the subjects with developmental disabilities and cochlear implants. The relationship between cognition and language was not significant in the group with developmental disabilities and normal hearing. It is not likely that cognition is more predictive of language skills in one group versus the other. It is more likely that the outlier in the control group did not allow for this trend to be established. The positive relationship between cognition and language supports the literature reviewed in which positive correlations were also seen between cognition and language for children with hearing loss (Meinzen-Derr et al., 2010; Holt and Kirk, 2005; Watson, Sullivan, & Jensen, 1982). It is important to note that a positive correlation between cognition and language does not indicate a causal relationship. We cannot assume that higher cognition led to higher language skills or vice versa. We can simply state that these two constructs are associated by the fact that as cognitive scores increase, language scores also increase. Cognition was the individual factor most highly correlated with language scores in the larger study sample. Age of implantation was not found to be significantly related to language outcomes in the larger study. It is not clear whether or not age of implantation would be significantly related to language outcomes in the selected subset of the sample utilized for statistical analysis in this study.

It was found that the control group with developmental disabilities and normal hearing demonstrated language skills at or above their cognitive level, while the subjects with developmental disabilities and cochlear implants demonstrated language skill below their

cognitive ability. Cognitive and language scores utilized for analysis were obtained at least one year apart for all subjects. It is possible that fluctuating skills in conjunction with early interventions may have influenced changes in cognition and language over time. Cole, Dale, and Mills (1992) examined the stability of cognitive-language discrepancy over a two year period and found significant differences in the gap between cognition and language when measured at different points in time (Cole et al., 1992). In the subject group, cognition was tested before cochlear implantation, while language was tested at least a year after implantation. Cognition and language were also tested at least one year apart in the control group. Because testing was not performed at the same time, it is possible that fluctuations in these values between pre and post testing may have impacted the correlations between cognition and language.

One aim of this study was to remove motor and vision disability from the sample in order to look at the relationship between cochlear implants and cognitive disability alone and associated language outcomes. The impact of motor and vision disabilities was described in the literature review, in order to justify the exclusion of these subjects from the current study. The current study was founded on the notion that these additional disabilities may cause confounding factors in language development due to poor motor control of the articulators and dual sensory deprivation. It was then speculated that a subset of children with cognitive delay only may look different in terms of outcomes compared to the larger group. However, the results for the subset included in this study were comparable to the results from the overall study. When comparing outcomes for both groups, results indicated that subjects with developmental disabilities and normal hearing performed significantly higher on language measures when compared to their matched subjects with developmental disability and a cochlear implant. In the literature reviewed, children with developmental disabilities and cochlear implants performed below their

peers with *cochlear implant only*. The current study matched children by developmental disability and utilized hearing status as the independent variable. Even when the effect of developmental disability on language was accounted for through this matching, the children with cochlear implants performed well below their matched peers on measures of language ability. In one respect, the performance of the control group was likely elevated due to the presence of an outlier with language scores significantly higher than his cognitive scores. Even if this case were removed from the comparison we would still see children with developmental disabilities and normal hearing performing at or above their cognitive potential, while children with developmental disabilities and cochlear implants performed well below their cognitive potential.

Although cognitive and language scores were highly correlated for the subjects with cochlear implants, these children are not reaching their language potential based on cognitive ability. These results may indicate that children with developmental disabilities and cochlear implants cannot be expected to experience the higher levels of language development seen in children with developmental disabilities and normal hearing. The literature reviewed supports the notion that children with cochlear implant and developmental disability also do not do as well as children with *cochlear implant only.* The literatures on this topic, combined with the results of the current study, indicate that overall, children with multiple disabilities (deafness and developmental disability) do not perform as well as children with a singular disability (deafness only or developmental disability only) (Waltzman et al., 2000).

The subjects in the current study also received early language testing prior to receiving their cochlear implant. This data was included as part of the larger study in which these subjects were enrolled. Early language testing took place between 1 and 3 years before post implant testing. When comparing early language scores with the post-implantation language outcomes

described in this study, there is evidence for qualitative benefit for the children with developmental disabilities receiving cochlear implants. All subjects with cognitive disability and deafness in the current study demonstrated growth in both receptive and expressive language skills after receiving a cochlear implant. When discussing these improvements, it is important to note that increasing skills would be expected over time. Data presented in Table 3 describes language improvements seen in the subject group from pre-implantation to post-implantation.

Table 3: Language in Children with Development Disability: Comparing Skills Pre- and Post- Cochlear Implant

CI Subjects	**Time Between Pre and Post Testing**	**Pre –Cochlear Implant**		**Post –Cochlear Implant**	
		Receptive Language	Expressive Language	Receptive Language	Expressive Language
Child #1	1 yr, 11 mo.	Scattered skills up to 18 mo.	Scattered skills up to 24 mo.	Scattered skills up to 36 mo.	Scattered skills up to 36 mo
Child #2	1 yr, 7 mo.	Scattered skills up to 12 mo.	Scattered skills up to 6 mo.	Scattered skills up to 18 mo.	Scattered skills up to 18 mo.
Child #3	2 yr, 4 mo.	Scattered skills up to 6 mo.	Scattered skills up to 6 mo.	Scattered skills up to 18 mo.	Scattered skills up to 18 mo
Child #4	3 yr, 7 mo.	Scattered skills up to 18 mo	Scattered skills up to 24 mo	Scattered skills up to 54 mo	Scattered skills up to 42 mo.

Scattered scores were based on expected skills for each age range as categorized by the PLS-4. The time between the two points of testing ranged between 1 year, 7 months and 3 years, 7 months. As evidenced by Figure 2, all subjects showed improvement in receptive and expressive language skills following cochlear implantation.

Subject #1 demonstrated receptive language growth in following directions, understanding inhibitory words, understanding verbs in context, understanding pronouns, and overall concept knowledge. Expressive growth was seen in combining sounds, imitating words, using words for a variety of pragmatic functions, using words more than gestures, combining words, using plurals, and asking questions.

Subject #2 demonstrated receptive language growth in locating the source of a sound, discriminating sounds, understanding simple commands with cues, and appropriate use of objects in play. Expressive growth was seen in protesting with vocalizations, combining sounds to form syllables, playing simple games, and nonverbal communication behaviors.

Subject #3 demonstrated receptive language growth in responding to sounds in the environment, anticipating what will happen next, understanding simple commands with cues, understanding "no-no", and using objects appropriately in play. Expressive growth was seen in protesting through vocalizations, combining sounds to form syllables, seeking attention, participating in a play routine, babbling two syllables together, use of pointing and showing, and initiating a turn-taking routine.

Subject #4 demonstrated receptive language growth in responding to sounds in the environment, following directions, ability to make inferences, and knowledge of advanced concepts. This child demonstrated the most significant growth over time. The child had only

mastered 7 measured receptive language skills prior to implantation. After three years of experience with his cochlear implant, this child had mastered 42 of the measured receptive language skills. Expressive growth was seen in the area of using five to ten words, using a variety of consonant-vowel combinations, use of words more than gestures to communicate, naming words in photographs, answering what and where questions, using a variety of nouns, verbs, modifiers, and pronouns, and using quantity concepts. The child had 13 measured expressive language skills prior to testing and 36 expressive language skills after more than one year of experience with a cochlear implant. This vast increase in skills is likely reflective of the fact that his post-implant language testing was done over 3 years after early language testing in this subject.

While it would be expected that natural growth of skills would occur over time, it is significant to note that three out of four subjects with cochlear implants also had improved language quotients at the second point of testing. Language quotients measure skills in the context of chronological age. This means that improvements in language skills were significant in three out of four children even when advanced age was accounted for. Pre- and post-implantation language quotients are displayed in Table 4 below.

Table 4. Total Language Quotients for Subject Group Pre- and Post- Cochlear Implantation

CI Subjects	Total Language Quotient Pre-CI	Control Subjects
Child #1	55	62.92
Child #2	27.6	18.15
Child #3	8.3	14.31
Child #4	29.3	50.65

Total language quotients for the pre-implantation language testing were estimated by averaging receptive language quotients and expressive language quotients. This can be expected to be a fairly valid indicator of true language quotient, considering total language scores combine receptive and expressive subtests. Based on the data in Table 3, Child #3 is the only subject who did not have advanced language skills relative to her age following cochlear implantation. All other subjects showed skill growth relative to their respective ages at the two points of testing.

Cognition was found to be significantly correlated with language outcomes in the cochlear implant subject group. Language results for both groups were also described in relationship to cognitive potential. The relationship between cognition and language was described in this study in order to address a need for predictors of success to be identified in children with multiple disabilities being considered for cochlear implantation. Based on the

results of this study, we would expect to see higher cognition as a positive predictor of success for the area of language development. While cognitive scores may be a useful predictive factor of success, it is important to exercise caution when discussing the relationship between cognition and language. Historically cognitive abilities have sometimes been used to determine eligibility and service provision for children with developmental disabilities (Miller & Chapman, 1980). Cognitive referencing is the practice of using cognitive-language discrepancy in order to determine whether or not services should be received.

The Cognitive Hypothesis theory states cognitive abilities will dictate language potential, and that certain cognitive skills are necessary in order to acquire language (Cromer, 1976). This has been used to justify denying services to children with developmental disability and language disability if their language abilities are determined to be commensurate with their performance on cognitive measures. The American Speech-Language-Hearing Association (ASHA) takes a position against cognitive referencing stating that cognitive ability as a factor itself should not be used solely to determine potential benefit of speech-language services. Eligibility and intervention should instead be based on the individual needs of each client and functional need for language in their day to day life. ASHA also states that there is still potential benefit for children receiving language interventions even if their low language level is commensurate with low cognitive level (National Joint Committee, 2005).

Cole, Dale, and Mills (1990) examined the benefits of language intervention in a group of children with language skills below their cognitive ability compared to children with commensurate cognitive and language skills. According to the cognitive referencing theory, the children with low language scores compared to their cognitive scores should receive more benefit from speech-language interventions. Findings revealed that children with commensurate

cognition and language made similar gains in receptive vocabulary when compared to children exhibiting a cognitive-linguistic gap. There were also no significant differences in benefit in the areas of receptive and expressive language. The children with language skills below their cognitive level made more significant progress only in the area of basic language concepts.

It is important to consider the practice of cognitive referencing in the application of the results from the current study. The results indicated that cognition is highly correlated with language outcomes for children with developmental disabilities and cochlear implants. While cognitive abilities may be one useful predictor of success for children with developmental disabilities and cochlear implants, it is important to consider all individual factors when making a decision regarding cochlear implantation. All children with developmental disabilities and cochlear implants in the current study were performing below their language potential based on cognitive ability. This means that it is unlikely that this population would be denied services in light of cognitive referencing. Regardless, all individual factors and needs should be considered when determining appropriate speech-language intervention for this population.

CONCLUSIONS

This study examined the relationship between cognition and language in a subject group of children with developmental disabilities and cochlear implants and a control group with developmental disabilities and normal hearing. Children with developmental disabilities and cochlear implants performed significantly below their peers with developmental disabilities and normal hearing. The results in this study were consistent with the findings in the overall study from which the subset was selected. Although children with cochlear implants were not

performing as well as controls with developmental disability only, qualitative improvements were evident. All children in the subject group with cochlear implants demonstrated increased receptive and expressive language skills following implantation, and three out of four of these children also demonstrated improved language quotients. This means that improvements in language skills cannot be accounted for by increasing chronological age alone. These qualitative observations demonstrate benefit for the population with developmental disabilities and cochlear implants in the areas of awareness to sound, understanding words, following directions, combining sounds, producing meaningful vocalizations, using words for a variety of communicative functions, and increased overall interaction and play skills.

Limitations

One major limitation of the current study was the small sample size. Subjects with motor and visual disability were eliminated from the sample in order to establish a more homogeneous subject group and examine the impact of cognitive delay only. In order to examine a homogeneous subject group, small sample size had to be accepted. The small sample size, n=8, made statistical analysis difficult. Results should also be interpreted with caution considering that it is difficult to generalize the outcomes of four matched pairs to the entire population. This sample size was also not large enough to account for an outlier in the group who had language scores well above his established cognitive quotient. This skewed the results examining the correlation between language and cognitive ability in this group. The relationship between cognition and language was not found to be significant in this group, although it is unlikely that there is not a significant relationship between these two constructs.

An additional limitation in this study is that cognitive and language quotients were obtained at least one year apart for both groups. Cognitive quotients were also derived from a developmental assessment performed below the age of three in most subjects. Younger age at the time of cognitive assessment is correlated with decreased reliability and stability of cognitive scores over time (Niccols & Latchman, 2002).

A final limitation of this study is that children with developmental disabilities, as a group are generally difficult to test using formal measures. The stated outlier in the control group with high language scores compared to his cognitive ability was also listed as having a behavior disability per developmental assessment. One may speculate that behaviors may have impacted performance during early cognitive testing and that his cognitive score was an underestimate and did not reflect true cognitive abilities.

Future Research

Future research should focus on studies in this population with larger, more homogeneous subject groups. It is difficult to simultaneously achieve large and homogeneous subject groups in this population. Achieving this aim in the future may rely on collaboration between multiple medical facilities in order to increase the number of potential cases that can be examined. Future research should also consider language trajectories for children with cochlear implants and multiple handicaps and what language skill growth can be expected over time. Studying skill growth and trajectories for these children is important for many reasons. This information may help us better educate parents about appropriate expectations for their child with developmental disability receiving a cochlear implant. It may also help clinicians determine how much therapy is appropriate for these children, and how they might better focus therapy

towards specific goals. Finally, if we can study skill growth over time for children receiving services, it may allow us to evaluate our early intervention programs and determine which interventions are most beneficial. Children with developmental disabilities and cochlear implants comprise a special population with unique needs. Further research about children in this population will allow for better decision making and increased quality of information available to parents and professionals.

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