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The early language environment and effect of parental counseling on adult language exposure of children with unilateral and mild bilateral hearing loss

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THE EARLY LANGUAGE ENVIRONMENT AND EFFECT OF PARENTAL COUNSELING ON ADULT LANGUAGE EXPOSURE OF CHILDREN WITH UNILATERAL AND MILD BILATERAL HEARING LOSS

by

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***Abstract:* This pilot study investigated the early language environment of children with unilateral and mild to moderate bilateral hearing loss. A one-time educational session with a parent is assessed for its ability to increase parental speech to children with unilateral and mild to moderate bilateral hearing loss.**

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Abbreviations

AWC = Adult Word Count

CTC = Conversational Turn Count

CV = Child Vocalizations

CDI = Communicative Development Inventory

CPA = Conditioned Play Audiometry

DLP = Digital Language Processor

LENA = Language ENvironment Analysis

VRA = Visual Reinforcement Audiometry

A child's exposure to language early in life has lasting effects on a variety of outcomes, including language development, educational ability, and cognitive ability (Forget-Dubois et al., 2009; Hart & Risley, 1992; Hoff & Naigles, 2002; Hoff, 2003; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Walker, Greenwood, Hart, & Carta, 1994; Zimmerman et al., 2009). Hart and Risley (1992) investigated the relationship between parental language characteristics and children's IQ scores. Forty families that were representative of the range of typical American families' size, race, and socioeconomic status were selected. Parent-child interactions were observed in the home for 27 months during hour-long observations once a month. The children were observed before, during, and after they learned how to talk. After analyzing parental characteristics and the interactions between the parent and child, the authors concluded that the amount of parenting per hour and the quality of parental verbalizations to the children were strongly related to the socioeconomic status of the family and the child's IQ at 36 months old. In a follow-up longitudinal study investigating the development of children previously enrolled in a study by Hart and Risley (1989), which showed that differences in parental time, attention, and talking were associated with the children's vocabulary and IQ from 7 to 36 months old, Walker et al. (1994) repeatedly examined the verbal ability, academic achievement, and language abilities of 32 children during the time they were in kindergarten through third grade. The language differences found from 7 to 36 months old were significantly correlated to the children's verbal ability, academic achievement, and language abilities once the child reached kindergarten through third grade. Also, language production at 7 to 36 months of age accounted for significant variance predicting standardized language and academic achievement at 5 to 10 years of age above the variance accounted for by SES alone. Therefore, differences in child language ability due to different parental language exposures have been shown to affect

academic achievement as the child grows older. Caskey, Stephens, Tucker, and Vohr (2014) examined how the number of adult words during a 16 hour recording period in the preterm infants' NICU environment at 32 and 36 weeks gestational age correlated with cognitive and language scores at 7 and 18 months corrected age. Higher numbers of adult words in the NICU positively correlated (correlation coefficient ranged from 0.32-0.53 with $p \leq 0.05$) with higher cognitive and language scores at 7 and 18 months corrected age. Exposure to adult speech throughout children's early years has been shown to have long lasting language, cognitive, and educational effects.

Of the many factors that may be related to differences in parental language, socioeconomic status has been widely documented to impact differences in child-directed speech, which then relates to differences in children's language abilities (Hoff, 2003; Rowe, 2008). Socioeconomic status has been also shown to relate to the amount parents speak to their children, which in turn affects the child's language ability (Hart & Risley, 1992). A study comparing three different maternal education levels and spontaneous language samples from 240 three year old children found significant linear trends across maternal education level for four of the five measures of child language (Dollaghan et al., 1999). Significant differences between children with higher and lower socioeconomic status were found in vocabulary learning and language processing efficiency by the time the children were 18 months old, and when followed longitudinally, a six month gap in cognitive performance was found at 24 months of age between the children in families from higher and lower socioeconomic status (Fernald, Marchman, & Weisleder, 2013). Differences in parental language exposure are significant: Hart and Risley (1995) concluded from their sample of 42 children observed longitudinally over 2.5 years that by age four, an average child in a professional family will have had experience with almost 45

million words, an average child in a working- class family will have had experience with 26 million words, and an average child in a family receiving welfare will have experience with 13 million words. The significant differences in exposure to language affect how children in families of different socioeconomic statuses learn language.

Previous research has studied the effect of the child's age on adult language exposure. Some studies suggest that parental speech does change based on the child's age. A cross-sectional study compared mothers' speech to children aged 8, 18, and 28 months. Significant differences were found between the speech addressed to 18 month olds and 28 month olds, indicating a higher number of words per utterance and more complex speech to the older children. No significant differences were found between the speech directed at 8 month olds compared to 18 month olds (Phillips, 1973). A longitudinal study by Kavanaugh and Jirkovsky (1982) examined the parental language of four families approximately once every four weeks for eight months. No significant difference was found in the parents' mean length of utterance directed at the child when the child was 9, 11.5, and 15 months of age. The amount of self-repetition did significantly decline with the child's age, indicating that the parent did not feel the need to repeat things as much to capture the child's attention as the child grew older. A longitudinal study of 50 families analyzed the caregiver language using home visits when the child was 14, 18, 22, 26, and 30 months old. There was no significant change over time in the number of utterances or sentences spoken by the parents, but there were significant changes over time in the complexity of words and sentences spoken (Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007). Further research is needed to better understand how parental speech may vary with a child's age.

Another factor that may influence a child's early language exposure is day care exposure and the quality of the day care. McCartney (1984) investigated 166 children from nine day care centers and assessed the quality of the day care, the children's language development, and the family background and home environment. When controlling for family background, the quality of the day care environment predicted the children's language development. Also, children who were in day care with higher levels of caregiver speech had higher language scores than children whose day care environment had higher levels of peer speech. A longitudinal study investigating 733 children found that the quality of the preschool through second grade classroom correlated with children's language scores over time (Peisner-Feinberg et al., 2001). A child's exposure to language in day care and preschool settings can have effects on their speech and language abilities.

Birth order has also been shown to affect language abilities in children and parental language when speaking to their children. Children who were first born had higher levels of language comprehension than later born children at 18 and 36 months of age (Zambrana, Ystrom, & Pons, 2012). Mothers have been shown to use more language centered around activities and social exchanges when speaking to a second born child and his or her older sibling, and more language-focused language when speaking to the second born child without the sibling (Oshima-Takane & Robbins, 2003). The exposure to different linguistic aspects of language may affect the rate and pattern of language exposure. The differences in the language exposure of young children based on their birth order may affect their language abilities early in life, but further study is needed to determine whether any long term differences exist.

Linguistic Exposure in Children with Unilateral and Mild Hearing Loss

Previous studies have investigated the early language environment in children who have bilateral hearing loss. Aragon and Yoshinaga-Itano (2012) used the Language ENvironment Analysis (LENA) system, which uses full day recordings which are analyzed using LENA software to report the adult word count, conversational turn count, and child vocalization count in the child's environment during the recording, to describe the language environment of deaf or hard of hearing children in Spanish speaking families. VanDam, Ambrose, and Moeller (2012) used the LENA system to collect recorded samples of children's natural language environments in 22 children aged 24-36 months with varying degrees of hearing loss and eight age-matched normal hearing peers. The adult word count and the number of conversational turns between the adult and child were compared between the children with hearing loss and children with normal hearing. There was no significant difference between the children with hearing loss and the children with normal hearing for the number of adult words and conversational turns. Among the children with hearing loss, the severity of the hearing loss (measured by the pure tone average) and the amount of aided audibility (measured by the speech intelligibility index) were associated with the amount of parental speech. Less hearing loss and better aided audibility correlated with higher counts of adult words and conversational turns. This suggests that parents may be influenced by how much environmental speech their child can access.

However, there is little research focusing on the early language environment of children with unilateral and mild bilateral hearing loss. Children with unilateral and mild bilateral hearing loss are a population of special interest because historically they have not been treated with as many interventions as children with higher degrees of hearing loss. Children with unilateral hearing loss have been considered to have little disadvantage as long as speech and language developed well using the one good ear. Many children were not given any intervention

and often the hearing loss went undetected before the implementation of newborn hearing screenings (Bess & Tharpe, 1984).

However, more recent research has shown that children with unilateral and mild bilateral hearing loss have a substantial incidence of educational and behavioral problems. In a study investigating 172 children with unilateral hearing loss, 59% of the children had experienced either academic or behavioral problems in school. Children with more severe hearing losses in their poorer ear did not have a higher incidence of school problems than children with milder losses (Brookhouser, Worthington, & Kelly, 1991). Bess, Dodd-Murphy, and Parker (1998) investigated the educational performance of children with minimal sensorineural hearing loss, including children with unilateral sensorineural hearing loss, mild bilateral sensorineural hearing loss (average pure tone thresholds between 20 and 40 dB HL bilaterally) and high frequency sensorineural hearing loss (air conduction thresholds greater than 25 dB at two or more frequencies above 2000 Hz). Children in third grade with minimal sensorineural hearing loss were found to have worse scores on measures of educational performance compared to children with normal hearing. However, this difference was not seen among sixth and ninth graders. Children with minimal sensorineural hearing loss also received poorer scores than normal hearing children on teacher-completed surveys of academics, attention, and communication, and were more likely than their normal-hearing peers to repeat one or more grades.

Research also supports that unilateral and mild bilateral hearing loss in children is associated with worse speech and language abilities than those of their normal hearing peers. A study comparing 6 to 12 year old children with unilateral hearing loss to their normal hearing siblings showed that the children with unilateral hearing loss had worse scores on language comprehension, oral expression, and oral composite measures of the Oral and Written Language

Scales (Lieu, Tye-Murray, Karzon, & Piccirillo, 2010). A study by Davis, Elfenbein, Schum, & Bentler (1986) investigated 40 children with varying degrees of hearing loss and found that children's language abilities and educational performance was quite variable and could not be predicted based only on degree of hearing loss. The assumption that greater hearing loss always causes greater difficulty with language is not supported by that study. Children with mild hearing losses had a wide range of linguistic abilities, showing that children with all degrees of hearing loss can experience linguistic and academic difficulties.

Due to the difficulties that unilateral and mild bilateral hearing losses present, these children may require more access to speech signals at a meaningful level than children with normal hearing in order to develop speech and language. Binaural hearing has been shown to have many advantages over monaural hearing, including binaural summation (Shaw, Newman, & Hirsh, 1947), the head shadow effect (Bess & Tharpe, 1984), localization (Jongkees & van der Veer, 1958), and binaural release from masking (Bess & Tharpe, 1984). Therefore, unilateral hearing losses can cause the speech signal to become degraded in noisy environments or when the speaker is not speaking directly toward the better ear. Mild hearing losses have also been shown to alter language acquisition abilities and be associated with speech delay (Schönweiler, Ptok, & Radü, 1998). Because children with unilateral and mild bilateral hearing loss may require a clearer speech signal than children with normal hearing to develop speech and language, research is needed on the characteristics of the signal the children are receiving.

In order to provide children with unilateral and mild bilateral hearing loss access to these sounds, counseling of the child's caregiver may help increase the child's adult language exposure. Suskind et al. (2013) investigated the effectiveness of a one-time educational intervention with 17 non-parental caregivers of typically developing children between 10 to 40

months of age. A baseline recording of a typical day for the child using LENA technology was obtained, and measures of adult language such as adult word count and conversational turn count were analyzed. The caregivers were then educated on how to improve the child's language environment, the results from their baseline recording, and goals for the next recording. Six weekly recordings were obtained following the educational session. There was a significant and lasting increase in both adult word count and conversational turn count after the educational session compared to before the educational session. This supports that a one-time educational session for a child's caregiver can help enhance the child's early language environment.

Another parent-directed intervention, Project ASPIRE, uses LENA feedback and parental counseling with the goal of enriching the language environment of young children with hearing loss from underserved populations. A pilot study included 11 children and their parents who participated in two baseline 16-hour LENA recordings, a 60 minute educational home visit, and three post-intervention LENA recordings with feedback over the phone following each recording. The educational session focused on the importance of providing language to children and ways to increase language and talk to their children. Parents were also provided with quantitative linguistic feedback following each LENA recording which involved sharing the adult word count, conversational turn count, and child vocalization count data, and using this information to set goals for the next recording session. Compared to the second baseline recording, the conversational turn count and child vocalization count significantly increased following the intervention and the adult word count increased and approached statistical significance. Education and LENA feedback helped improve the children's parental language exposures in these preliminary findings for Project ASPIRE (Sacks et al., 2014).

In order to provide appropriate early intervention services for children from birth to three years of age with hearing loss, telecommunication and distance technology have been implemented when in-person services are not available. It is often challenging to provide in-person early intervention services due to a lack of qualified professionals, the geographical location of the family and the availability of services in that area, and funding limitations (Nelson, Bradham, & Houston, 2011). Telepractice has been shown to provide positive outcomes for the audiological, speech, listening, and language needs of children with hearing loss (Houston & Stredler-Brown, 2012). A 2010 survey by the National Center for Hearing Assessment and Management showed that 42% of the state Early Hearing Detection and Intervention programs had some sort of telepractice or were planning to implement telepractice. Telepractice can improve timeliness of services, can be received in the family's home setting, and can improve the child and family outcomes (Houston & Stredler-Brown, 2012).

Because children with unilateral and mild bilateral hearing loss historically have not been accessing intervention services but have been shown to have linguistic and educational difficulty, there is a need for more information about the quality of parental language exposure for this specific population and how to fill the need for services for this population. The current study aims to provide preliminary data on the characteristics of the early linguistic environment of children with unilateral hearing loss and mild to moderate bilateral hearing loss. Also, to address the need for intervention services in this population, the efficacy of a short, one-time educational session with a parent provided over the phone is assessed for its ability to increase parental speech to children with unilateral and mild to moderate bilateral hearing loss.

Methods

This study was approved by the Washington University in St. Louis School of Medicine Human Research Protection Office to perform research on human subjects prior to beginning this study. Informed consent was obtained from a parent of the participating child prior to participation in the study.

Participants

Children aged 6 months to 4 years with hearing loss in one or both ears were recruited to participate in this study. Eligible children had either unilateral hearing loss or mild-moderate bilateral hearing loss. For the purposes of study recruitment, unilateral hearing loss was defined as hearing loss (thresholds of 30 dB HL or greater at frequencies tested) in one ear and normal hearing (average of 25 dB HL or less at tested frequencies from 250-2000 Hz and a threshold at 4000 Hz of less than 30 dB HL) in the other ear. Mild-moderate bilateral hearing loss was defined as at least one tested threshold in both ears between 25-50 dB HL with no threshold higher than 75 dB HL. The hearing loss was required to be sensorineural, or mixed or conductive loss for which no medical or surgical treatment was planned that could bring hearing to normal levels during the study. Children were excluded from this study if they had ongoing temporary or fluctuating conductive hearing loss, such as due to otitis media; a major medical problem associated with known cognitive impairment, such as Down syndrome or a congenital cytomegalovirus infection; a known cognitive impairment defined as an IQ of less than 70; and/or parents who do not speak English in the home.

Potential participants were identified through a review of medical records in the Department of Otolaryngology at Washington University School of Medicine, and through referrals from the Central Institute for the Deaf and the Moog Center for Deaf Education.

Parent(s) of children identified through medical record review from Washington University School of Medicine were mailed a letter describing the study and requesting their participation and/or were contacted over the phone to describe the study and request their participation. If the parent agreed to participate, they were scheduled to come in for the first study visit. The parent was required to sign written consent to participate in this study and to allow participation of their child in this study.

Materials

The full day recordings of the language environment of the children in this study were made and analyzed using the LENA Research Foundation digital language processor (DLP) and software package.

LENA Digital Language Processor (DLP). The LENA DLP is a small recording device weighing approximately two ounces which records up to 16 hours of audio. The LENA DLP has an on/off button, a record button, a single microphone, a display, and a USB port to plug into a computer or a wall charger. The child wears the DLP in a protective pocket on a specially-designed t-shirt which keeps the DLP at a relatively stable distance from the child's mouth.

LENA software. The LENA software was developed by LENA Research Foundation scientists to analyze audio data and segment sounds to label them in one of nine categories: male adult, female adult, target child, other child, noise, overlapping vocals, electronic media (e.g., TV and radio), silence, and uncertain/fuzzy (LENA Foundation, 2011). These segments are used to generate reports which include the following variables: *Adult Word Count (AWC)*: number of adult words spoken to and near the child; *Conversational Turn Count (CTC)*: number of

conversational interactions between a child and an adult in which one speaker initiates with a speech sound such as a coo, babble, or word and the other speaker responds within five seconds (overlapping speech segments, coughs, cries, and vegetative sounds are not included); *Child Vocalizations (CV)*: a speech segment spoken by the key child that is surrounded by a pause of greater than 300 milliseconds (vegetative sounds, cries, or other fixed-signal sounds are not included); *Percentage of Meaningful Speech*: usable speech information included in the AWC, CTC, and CV analysis; *Percentage of Distant and Overlapping Speech*: speech which is typically six or more feet away from the DLP, overlapping speech, and speech that does not fit statistical models; *Percentage of TV and Electronic Sounds*: audio from television, radio, and other electronics; *Percentage of Noise*: bumps, rattles, and other non-human signals; and *Percentage of Silence and Background*: silence, quiet, and vegetative sound (LENA Foundation, 2011).

Procedure

Each parent and child participated in one study visit, an initial recording session in his or her home, an educational session over the phone, and a final recording session in the home.

Study visit. To ensure the participants met inclusion criteria for the study, hearing thresholds were obtained from the participant's most recent and/or most complete audiogram(s) from medical records at Washington University School of Medicine Department of Otolaryngology. Audiograms from the medical records obtained air conduction hearing thresholds using pure tone audiometry. If the participant did not have a complete audiogram in the medical record to indicate the child met inclusion criteria, air conduction thresholds were obtained using a GSI 61 clinical audiometer. Etymotic ER-3A insert earphones were used in all

participants except in cases of aural microtia and atresia, where Telephonics TDH-50P circumaural headphones were used. Professional calibration of the GSI 61 clinical audiometer was performed prior to this study to meet ANSI standards. Air conduction threshold testing was completed in a sound-treated test booth. Thresholds were obtained at 500, 1000, 2000, and 4000 Hz, or as many thresholds as possible were obtained before the participant fatigued of testing. Based on the patient's age and developmental ability, either Visual Reinforcement Audiometry (VRA) or Conditioned Play Audiometry (CPA) procedures were used to obtain thresholds. VRA involved playing a tone and training the child to turn his or her head in response to the tone by rewarding him or her by lighting up an animated Mickey Mouse toy. The intensity of the tone was then reduced to find the softest level that the child would respond to by turning his or her head at two out of three presentations. CPA involved teaching the child to either put a ring on a post or put a peg in a peg board in response to a tone. The intensity of the tone was reduced to find the softest level the child would respond to by placing the toy at two out of three presentations.

The parent(s) of the child were then taught how to use the LENA digital language processor (DLP). A member of the research team explained that the LENA DLP is a device that children wear to record all language in their environment. It records 16 hours continuously within approximately a 6-10 foot radius. The parent(s) were instructed on how to turn on the DLP and put it in the pocket of the specially designed LENA t-shirt to hold the DLP while the child wears it. They were instructed to begin recording as soon as the child wakes up in the morning until the child goes to sleep for the final time that evening. The parents were instructed to make an uninterrupted recording, and if the shirt could not be worn, such as during bath time or when the child is sleeping, the parents were be told to place the shirt with the DLP inside as

close to the child as possible. For the child's safety, parents were instructed to remove the DLP from the t-shirt when the child is in the car, place it nearby the child, and then put the DLP back in the shirt once the child is out of the car. If their child is in day care, the parent(s) were told to choose a day when the child is not in day care to make the recording. Similar recording procedures were used in collecting the LENA Natural Language Study data (Gilkerson & Richards, 2008).

Parent(s) completed a questionnaire consisting of 22 questions regarding the parents' educational level, the child's birth order, the amount of time the child is cared for outside the home, a brief medical and hearing history of the child, and the child's demographic history. Participants were informed that they were not required to answer any questions they did not want to answer. The parent questionnaire can be found in Appendix A.

Parent(s) completed the MacArthur-Bates Communicative Development Inventory (CDI), a parental questionnaire used to assess language and communication in infants and young children. The MacArthur-Bates CDI Words and Gestures form was completed for children between 9 and 15 months old, and the Words and Sentences form was completed for children between 16 and 36 months old. Parent(s) were instructed to answer all items based on their knowledge of their child's speech and language, and were free to skip any items they did not wish to answer.

The parent(s) then took the LENA DLP, LENA t-shirt, written instructions on how to use the LENA DLP, and return shipping materials home.

Initial home recording and LENA analysis. The parent(s) completed the first recording at home for 16 hours on one full day. The parent(s) shipped back the LENA DLP and

LENA t-shirt for analysis using the provided shipping materials. Once obtained by the research team, the LENA data was downloaded to the computer through a USB port and analyzed using the LENA software. The LENA report includes the eight measurements described above. These measures are also shown hourly by time of day. The LENA software provides the total number of AWC, CTC, and CV recorded during the entire duration of the recording and a projected number of AWC, CTC, and CV for a 12 hour recording. For the purposes of this study, the projected AWC, CTC, and CV for a 12 hour recording were analyzed. The LENA software provides percentile ranks based on the distribution of the LENA normative sample made up of children with normal hearing and typical development for the adult word count, conversational turns, and child vocalizations (Gilkerson & Richards, 2008). The percentile rankings are based on the projected AWC, CTC, and CV for a 12 hour recording. The LENA system only analyzed data and there was no access to the recorded voices by the researchers. Only the analyzed results were available and the recorded voices were digitally erased after the data was automatically analyzed. There was no transcription of the vocal recordings.

Educational session. Once the analysis of the LENA data was completed, the researcher called the parent(s) on the phone and gave a short, thirty minute educational session focusing on their LENA analysis results and strategies for improving the quantity and quality of the speech directed toward their child. During the session, the results from the LENA analysis were shared. The parents were told the total number of adult words and conversational turns recorded during the day and how their number of adult vocalizations and number of conversational turns compares to the LENA normative sample in the form of a percentile ranking. Parents were told about the child's environment at different times of day, such as time periods with the most and least adult vocalizations and conversational turns, and the researcher worked with the parents to

determine what could have been happening to contribute to their speech and ways to increase speech during those times. For example, if there was a time of day with a high percentage of distant speech, the researcher worked with the parent to determine why there was distant speech and if the parent could position themselves closer to the child or turn off competing background noise so the child could benefit from hearing that speech. Parents were counseled on strategies to increase the amount of meaningful speech exposure for their child, such as speaking directly to their child within a three foot radius, talking about objects the child is focusing on rather than what the parent is focusing on, describing every detail of what the child is doing to the child, turning off background noise while speaking to the child, and establishing routines where language is repeated. These strategies are based off of "Top Ten Strategies for Parents" developed by Jill Bader (1999) which are counseling strategies commonly used by teachers of the deaf when working with children and their families to develop listening and spoken language skills in children with hearing loss. See Appendix B for the communication strategies handout for descriptions of the strategies discussed. The parents were told that a written summary of their LENA results and a communication strategies handout would be included in the next shipment for their reference.

Final recording session. After the educational session, parents were shipped a blank LENA DLP, the LENA t-shirt, written instructions on how to use the LENA recorder, a new MacArthur-Bates Communicative Development Inventory, a written summary of their LENA results including graphs of AWC, CTC, and audio environment by hour of the day, a communication strategies handout, and return shipping materials. See Appendix C for an example of the LENA results summary handout. The communication strategies handout listed the communication strategies discussed during the educational session. The parent(s) used the

LENA DLP to make another full day recording of their child's environment one week following the day of the counseling session. The second recording session was also made on the same day of the week as the first recording session for consistency. The same recording instructions were given for the second recording. They also completed the MacArthur-Bates CDI following their second recording. They then shipped the recorder, clothing, and MacArthur-Bates CDI back to the research team. The second recording was analyzed in the same way as the first. After the final recording was analyzed, a research team member called the parent on the phone to briefly share the results from the final LENA analysis. Any differences between the first and second recording were shared.

Statistical Analysis

Demographic data was analyzed by computing means, standard deviations, and medians of the participants' ages, number of years of mother's education, number of years of father's education, and the number of hours the children are cared for outside the home. The AWC, CTC, and CV from the baseline LENA recordings were analyzed by computing *z* scores for each participant in reference to the LENA normative sample. Means and standard deviations were computed for the audio environment variables of the baseline recordings. Correlation analysis using Spearman's rho was completed to assess for correlations between the AWC, CTC, or CV of the baseline recordings to number of years of maternal education, paternal education, number of hours the child is cared for outside the home, and age of the child. Paired t-tests were used to analyze the difference between the post-educational AWC, CTC, and CV and the pre-educational AWC, CTC, and CV as well as the post-educational AWC percentile rankings, CTC percentile rankings, and CV percentile rankings compared to the pre-educational AWC percentile rankings, CTC percentile rankings, and CV percentile rankings. Due to the small sample size of

MacArthur Bates CDI results, statistical analysis was not completed and results were analyzed individually.

Results

A total of 35 eligible participants were identified for this study. Of those potential participants, eight consented to participate. One participant left the study after attempting to make the first recording due to the child's inability to tolerate wearing the recorder. Therefore, a total of seven children and their parent(s) participated in this study.

Demographic Characteristics of Participants

The demographic characteristics of participants are summarized in Table 1. Three participants are male and four participants are female. The hearing history of participants is summarized in Table 2. Six of the seven participants had unilateral hearing loss, and in two of six participants the right ear was poorer while in four of six participants the left ear was poorer. One participant had bilateral hearing loss. See Figures 1-3 for audiometric thresholds of participants. Of note was the medical history of Participant 5, who spent four weeks in the NICU after birth, spent 1-2 days on the ventilator, and underwent craniosynostosis repair surgery.

Early Language Environment of Children with Unilateral and Mild-Moderate Bilateral Hearing Loss

The average baseline recording adult word count (AWC) for all seven participants was 15,901 words (*SD* = 7493), the average conversational turn count (CTC) for all participants was 749 (*SD* = 544), and the average child vocalization count (CV) for all participants was 2853 (*SD*

= 2021). AWC, CTC, and CV *z* scores were computed for each participant in reference to the LENA normative sample. *z* scores between +1 to -1 indicate scores within the average range for typically developing children with normal hearing, with a *z* score of zero indicating results at the mean of the normative sample. Two of seven (29%) participants fell within the average range for the baseline recording AWC, three of seven (42%) were above the average range, and two of seven were below the average range (29%). For the baseline recording CTC, five of seven participants fell within the average range (71%), two of seven were above the average range (29%), and no participants were below the average range. When analyzing CV, three out of seven (43%) participants were in the normal range, three of seven (43%) participants were above the normal range, and one of seven (14%) participants was below the normal range. These results are depicted in Figure 4.

The audio environment of the participants was also analyzed in the baseline recording. The average percentage of the recording time the seven participants listened to each auditory environment is as follows: silence for 47% (*SD* = 23%), noise for 2% (*SD* = 1%), television and electronic sounds for 11% (*SD* = 10%), distant/ overlapping speech for 22% (*SD* = 16%), and meaningful speech for 18% (*SD* = 6%).

AWC, CTC, and CV of the baseline recordings were each individually tested for Spearman's rho correlations with the following demographic characteristics: number of years of maternal education, number of years of paternal education, number of hours the child is cared for outside the home, and age of the child. No significant correlations were found. See table 3 for a summary of correlation results.

LENA Outcome Measures Pre and Post Educational Session

The raw number of AWC and the percentile scores of AWC compared to the normative sample were analyzed for differences between the post-education session recording and the baseline pre-education session recording. Of the seven participants, five had an increase in the AWC and AWC percentile scores after the recording session compared the baseline (71%). See Figures 5 and 6 for individual participant results. The increase in AWC post-educational session (M = 17180, SD = 6720) compared to the AWC pre-educational session (M = 15901, SD = 7493) was not statistically significant. The increase in AWC percentile scores post-educational session (M = 71, SD = 39) compared to the AWC percentile pre-educational session (M = 63, SD = 38) approaches statistical significance. See Table 4 for a summary of paired samples t-tests results for AWC.

The raw number of CTC and the percentile scores of CTC compared to the normative sample were analyzed for differences post-educational session compared to pre-educational session. One out of seven participants had an increase in CTC and CTC percentile scores after the recording session compared to the baseline (14%). See Figures 7 and 8 for individual participant results. There was no significant difference between the CTC post-education (M = 654, SD = 369) compared to CTC pre-education (M = 749, SD = 544). There was also no significant difference between the CTC percentile scores post-education (M=68, SD=34) and pre-education (M=70, SD=30). See Table 4 for a summary of paired samples t-tests results for CTC.

The numbers of CV and percentile scores of CV compared to the normative sample pre and post educational session were also analyzed. Three out of seven participants had an increase in CV after the recording session compared to the baseline (43%). See Figures 9 and 10 for individual results. There was no significant difference between the CV post-education (M =

2435, *SD* = 1518) compared to the CV pre-education (*M* = 2853, *SD* = 2021). There was no significant difference between the CV percentile scores post-education (*M* = 61, *SD* = 38) and pre-education (*M* = 63, *SD* = 38). See Table 4 for a summary of paired samples t-tests results for CV.

Subjectively, Participant 1's mother was very interested in the results of the LENA recordings and was very motivated to utilize the communication strategies. She reported that she did try to apply the communication strategies and use the knowledge from the LENA recording. She did notice that she was talking and interacting more with her child on the second recording day than the first day. Participant 3's mother noted that she did not notice a difference between the first recording day and the second recording day and she just went about her normal day. Participant 4 is enrolled full time in a school for the deaf where she receives therapy and her parents receive extensive parental counseling and coaching. Therefore, her mother noted that she had already learned the communication strategies that we discussed. Participants 5, 6, and 7 all reported being motivated to utilize the strategies and they felt as though they were talking more during the second recording than the first. One notable result from Participant 5's recording was a large number of adult words recorded at 10 PM in the baseline recording, after the child had already gone to bed. During the second recording, more adult words were recorded consistently during the child's waking hours, so the improvement made in terms of words heard during waking hours may be more than measured by the raw numbers in the recordings.

MacArthur Bates CDI Outcomes

Parents of children 1, 2, and 6 completed the MacArthur Bates CDI Words and Gestures form. All three children had an increase in the number of phrases understood and number of

words understood post-educational session compared to pre-educational session. When analyzing the percentile rankings for number of phrases understood and words understood compared to children of the same age who are typically developing and have normal hearing, the percentile rankings also increased for all three children post-educational session compared to pre-educational session. This would suggest that the children made gains in the number of phrases and words understood beyond the gains expected just due to growing older. Two out of three children had increases in the number of words produced and total gestures produced and increases in percentile rankings for words produced and total gestures post-educational session compared to pre-educational session. See Figures 11 through 15 for results.

Parents of children 3, 4, 5, and 7 completed the MacArthur Bates CDI Words and Sentences form. The parent of child 7 only completed a form pre-educational session. Because some children were older than the ages for which percentile norms for the form are available, the scores were analyzed for the 50^{th} percentile age equivalent (in months) using the MacArthur Bates norms of typically developing peers with normal hearing. The number of months of delay was then calculated by subtracting the age equivalent of the child's score from the child's actual age. Child 3 was not delayed compared to her typically developing peers for words produced, so percentile rankings were used. Other than Child 3's number of words produced, all four children were delayed in all areas compared to typically developing peers of the same age in the pre-educational session survey. Of the three parents who completed both surveys, all three children showed increases in the number of words the child produced post-educational session compared to pre-educational session, but only two of three children showed either an increase in the percentile ranking for words produced or a reduction in number of months delayed for words produced. Two of three parents reported an increase in the number of word forms their child

used, and one child had a decrease in the number of months delayed when comparing post-educational session to pre-educational session. All three children had an increase in the number of word endings used and a decrease in the number of months delayed for post-educational session compared to pre-educational session assessments. One of three children had an increase in the complexity of sentences used and a decrease in months delayed when comparing post-educational assessments to pre-educational assessments. See Figures 16 through 20 for results.

Discussion

This pilot study examined the characteristics of the early language environment of seven children with unilateral or mild-moderate bilateral hearing loss and the efficacy of a short, one time educational session with a parent to enrich the language environment of the children. There was a large amount of variability in how many adult words, conversational turns, and child vocalizations were present in each child's environment, with counts ranging from just below the average range to well above the average range compared to the LENA normative sample. This large variability in the early language environments of these young children shows that some families are at a greater need for intervention than others. Although the differences between recording sessions were not statistically significant, five out of seven children were exposed to more adult words during the post-educational recording than during the pre-educational recording, which supports that using the LENA, the LENA results, and the communication strategies can facilitate an increase in the number of adult words spoken in the language environments of the young children. There was not an increase in the number of conversational turns or child vocalizations in the majority of subjects after the educational session compared to before the educational session, which suggests that this educational session did not target improvement in these areas and was more effective for increasing adult words than facilitating

interactions between the child and adult or child speech. Results from the MacArthur Bates CDI showed improvements in some areas of the children's language abilities after the counseling session, but due to only collecting three subjects' data for each form, it is difficult to make strong conclusions based on such a limited sample size.

Early Language Environment of Young Children with Unilateral and Mild-Moderate Bilateral Hearing Loss

The baseline recording results show substantial variability present in the early language environments in this sample of children with unilateral and mild-moderate bilateral hearing loss. Even within this sample of similarly high parental levels of education, where all parents graduated from high school, the majority of mothers obtained college degrees (71.43%) and three mothers obtained graduate degrees, there was a wide range of how many adult words, conversational turns, and child vocalizations were present, with very large standard deviations for all three measures. When comparing the results of these baseline recordings to age-matched peers who are typically developing and who have normal hearing, there was a wide range of AWC, CTC, and CV, with participants performing just below the average range of typically hearing peers up to well above the average range. Similar results were found by VanDam, Ambrose, and Moeller (2012) when comparing LENA recordings of children with hearing loss to the age-matched LENA Natural Language Study normative database. The majority of children (23 out of 30 for AWC per hour and 18 out of 30 for CTC per hour) fell within the average range for AWC per hour and CTC per hour compared to the normative sample, and the remaining children were above the average range. For both AWC/ hour and CTC/hour, there was a wide range, with *z* scores ranging from almost -1 to about +2 standard deviations from the LENA Natural Language Study mean. The current study's results support these findings, as the current

findings ranged from just outside the average range to well above the average range for AWC (range from -1.2 to +3.4 standard deviations from the LENA Natural Language Study mean), CTC (range from -0.9 to +3.8 standard deviations from the LENA Natural Language Study mean), and CV (range from -1.0 to +2.9 standard deviations from the LENA Natural Language Study mean).

These results are encouraging in that five of the seven children were exposed to the average number or more of adult words that would be available to a child with normal hearing, and all participants were within the average range or above for number of conversational turns. However, the children with hearing loss who are experiencing numbers of adult words and conversational turns similar to children with typical hearing may still be not receiving as much language exposure as they need to develop speech and language at a similar rate as their peers with normal hearing. Children with unilateral and mild-moderate bilateral hearing losses are more at risk for language delay compared to peers with normal hearing (Lieu, Tye-Murray, Karzon, & Piccirillo, 2010; Schönweiler, Ptok, & Radü, 1998). Consequently, AWC and CTC within the average range for children with normal hearing may not be sufficient language exposure for children with unilateral and mild-moderate bilateral hearing loss. These families could benefit from intervention services and counseling to help enrich the language environment in the home beyond that of a child with normal hearing.

The audio environment analysis of the participants provided interesting insights into the signals the children with hearing loss are receiving over the course of their day. The average percentage of time the children were exposed to television and electronic sounds during their day was 11%, with participants ranging from 2% to 26%. Negative effects on language and cognitive development of young children watching television have been found (Zimmerman &

Christakis, 2005; Zimmerman, Christakis, & Meltzoff, 2007), so in young children with hearing loss where language development is a concern, watching television should be minimized. However, the LENA data reports not only television but all electronic sounds, so when viewing this LENA data it is important to confirm with the parents the type of signal that was present. For example, one parent reported that the electronic sound recorded by the LENA was the child's bedtime music. Also of note is the high average percentage of distant and overlapping speech (22%) and its comparison to the percentage of meaningful speech (18%) available in the auditory environment of the research participants. Children with hearing loss, including unilateral and mild-moderate bilateral hearing loss, have increased difficulty separating a signal from background noise (Bess & Tharpe, 1984) and localization (Jongkees & van der Veer, 1958), which would make distant/ overlapping speech even harder to hear and understand compared to their peers with normal hearing.

No significant correlations were found between the AWC, CTC, or CV of the baseline recordings when correlated to the number of years of maternal education, paternal education, number of hours the child is cared for outside the home, or the age of the child. This is in disagreement with previous studies which have shown a relationship between socioeconomic status and parental talk (Hart & Risley, 1992; Hart & Risley, 1995). The lack of significant correlations found in the present study may be due to the small sample size, the high variability of the data, and selection bias. Future studies should utilize a larger sample size in order to assess correlations and effects of these variables on LENA outcome measures.

LENA Outcome Measures Pre and Post Educational Session

The majority of participants who participated in this study demonstrated an increase in the number of adult words spoken during the recording one week following the educational session compared to the pre-educational session recording. This demonstrates that providing the educational session can be efficacious to increase the number of adult words in the child's environment. This is a similar result to the AWC increase found in studies using LENA outcomes and education to improve the language environment of typically developing children (Sacks et al., 2014; Suskind et al., 2013). The effectiveness of the educational session varied among the participants. Subjects 4, 5, and 6 began with a very high AWC, with percentile rankings of 99th, 95th, and 88th, respectively. Consequently, a ceiling effect was observed and there was very little room for these parents to increase the amount of adult words spoken. Subjects 5 and 6 did have increases in the AWC, but they were more modest increases as they had a very high number of adult words originally and therefore it was difficult to increase the AWC by a large amount. Subject 4 was a unique case because this child is enrolled full time in a school for the deaf where she receives language therapy and her parents receive parental coaching and counseling on how to work with their child to improve her language ability. She is also the only participant with mild-moderate bilateral hearing loss, while all other participants have unilateral hearing loss. This participant's baseline AWC, CTC, and CV were all in the 99th percentile compared to normal hearing peers and her mother reported during the educational session that she had already been taught the communication strategies through the school. The ceiling effect, in that there was very little room to increase the AWC when it was so high at baseline, and the fact that the mother had already been taught the communication strategies may explain why there was no improvement seen in Participant 4. Due to Participant 4 being a unique case compared to the other participants, if Participant 4 were excluded from paired t test

analysis, the difference between post-educational session AWC (M = 13655, SD = 4997) and pre-educational AWC (M = 16058, SD = 6603) approaches statistical significance, $t(5) = 1.984$, $p = 0.104$. Therefore, the difference in post-educational session AWC compared to pre-educational session AWC is more apparent in the remainder of participants who had not received the communication strategies in the past.

The educational session was the most effective in increasing AWC in the participants whose baseline recording AWC was in the average range compared to peers with normal hearing. Participant 1 had the largest increase in AWC of any of the subjects, with an increase of 8,016 words. Participant 7 had the second largest increase in AWC with an increase of 2,862 words. These two participants both had a baseline recording AWC that was not so high that there was no room for improvement, but within the average range compared to their peers with normal hearing (Participant 1 was at the 81st percentile and Participant 7 was at the 55th percentile). These parents were originally saying just as many words as an average parent of a child with normal hearing would say. Although this would be the average number of adult words a child with normal hearing would hear, this may not be enough for a child with hearing loss who is at risk for language delays. Therefore, the counseling session acts to increase the number of words the parent says to the child. Both parents were very motivated to utilize the information from the educational session to increase the number of adult words their child hears. Motivation has been shown to have an important impact on students' performance in educational settings (Liu, Bridgeman, & Adler, 2012), therefore, the motivation of the parents to apply the educational session likely had an impact on the amount of increase in adult words following the educational session.

The educational session was less effective with Participants 2 and 3, who began with the lowest AWC from the baseline recording. These participants were slightly below the average range for AWC compared to the normative sample, so these parents should be targeted for intervention to increase the language exposure of their children. However, Participant 2 had less of an increase in AWC than the participants who began with an AWC in the average range, and Participant 3 did not have any increase in AWC. Subjectively, the mother of Participant 3 reported that she did not notice a difference between the first and second recording. This educational session may have produced the best results with parents who were originally performing within the average range for typically developing children because these parents began with a good foundation of speech and the education was able to help them improve upon their already existing communication abilities. It may have been less effective in parents who began speaking at low levels of words because these parents began at a below average AWC and may require more intervention services over time rather than a short, one time educational session to see results.

There was no significant improvement in the CTC or CV post-educational session compared to pre-educational session. This result differs from previous studies which also used LENA outcomes and parental counseling to aim to enrich the child's early language environment. A study by Suskind et al. (2013) provided a one-time educational session to non-parental caregivers of typically developing children and found a significant increase in both AWC and CTC. Sacks et al. (2014) provided education to parents of children with hearing loss in low socioeconomic status families and demonstrated an increase in AWC, CTC, and CV post-education compared to baseline. The present study used a different educational session than the one used in these studies, as the session was also performed over the phone rather than in person.

The type of education given in the present study may focus solely on ways to increase the number of adult words spoken, rather than the interactions between adults and the child and child vocalizations. Also, the present study investigated children with hearing loss from well-educated families instead of children with normal hearing or children from families with low socioeconomic status. The differences in the populations being studied may play a role in the differences in the CTC and CV outcomes.

MacArthur Bates CDI Outcomes

The MacArthur Bates CDI is a parent report form which assesses language and communication skills of young children. The Words and Gestures form is used for younger infants and children, and all three subjects had increases in the number of phrases understood and number of words understood as well as increases in the percentile ranking compared to norms of same-age peers with normal hearing. This would suggest that these children increased the number of phrases and words they understood beyond what would be expected from just growing older. These three participants all had increases in the AWC post-educational session compared to pre-educational session, so it is possible the increase in adult words helped the children make gains in their communication and language abilities. However, this conclusion cannot be made without further investigation due to many confounding factors that may have also played a role in the children's language abilities, such as language exposures at day care or from other caregivers, time spent with peers, etc.

The Words and Sentences form is used for older children, and the three children assessed with this form showed gains in several areas following the educational session, such as words produced and number of word endings used. However, the results were variable and some

children made gains in some areas while not improving in other areas. Interestingly, Participants 3 and 4 did have an increase in number of words produced and percentile ranking of words produced compared to norms, but the LENA results showed no increase in AWC, CTC, or CV. Therefore, the language gains may have been due to other factors such as language exposure in day care, other language therapies received, or language exposure on days that were not recorded. Further investigation is needed to understand which factors play a role in these language gains of young children.

The MacArthur Bates CDI results should be interpreted very cautiously because the small sample size makes it difficult to draw any significant conclusions from the results. Also, the MacArthur Bates CDI is a parental report measure which relies on the parent's perception of the child's language abilities. There may be bias from the parent when filling out the forms the second time, as the parent may want their child to have made gains in his or her language abilities. In addition, many factors contribute to language gains made by children, so it cannot be determined exactly what factors caused any changes in the children's language abilities.

Limitations of the Study

The results of this study must be interpreted cautiously when applying these results to other children with unilateral or mild-moderate bilateral hearing loss. The participants who participated in this study were all highly educated families, which may have influenced the results and cannot be generalized to families with less education. Also, the families who participated in this study volunteered their time and efforts without monetary compensation, so they were highly motivated to participate in research and learn about their children's language environment through the study. The motivation of the parents to volunteer to participate in this

research may have caused a bias in the result, as this type of parent may have been more likely to utilize the educational session than a parent less interested in their child's language environment.

Due to logistical issues of transporting a limited number of LENA DLPs to each participant and receiving them back from participants, parents received the written summaries of their LENA results and communication strategies at various times following the educational session. This may have influenced results because some parents had access to their written results and communication strategies for a longer period of time before the second recording than other parents. This may have provided some parents more time to fully understand the results and utilize the communication strategies once they had access to the written information.

Due to the small sample size of this study, only one child participated with mild-moderate bilateral hearing loss while the remaining children had unilateral hearing loss. Also, the child with mild-moderate bilateral hearing loss was in a unique situation where she receives language therapy in school and her parents already received parental counseling which included the communication strategies discussed in this study. Therefore, this child's results should not be generalized to other children and should be viewed more as an individual case study.

Interpreting the LENA outcome variables of AWC and CTC and how they relate to the language development of children with hearing loss is complex. Words included in the AWC are words spoken by an adult close to the microphone of the LENA DLP worn by the child. These words are presumed to be within the child's range of hearing, however, a child with hearing loss's ability to hear these words may be affected by whether or not the speech was closer to their better or poorer ear, the child's aided audibility if amplification is used, and the clarity of the signal which can be affected by background noise and reverberation. The AWC, CTC, and

CV data in this study were not evaluated at different decibel levels, for example, the number of adult words that were present at 70 dB SPL compared to the number of adult words present at 55 dB SPL. Analyzing the AWC, CTC, and CV at different decibel levels may provide a better picture of how many words are audible to children with hearing loss. The AWC also does not distinguish whether the adult words spoken were directed to the child or directed elsewhere, such as toward another adult or a different child. A study by Shneidman, Arroyo, Levine, and Goldin-Meadow (2013) investigated how the number of child-directed words and overheard words heard by children at age two and a half affected the vocabulary size of the children at age three and a half. The number of child-directed words and number of overheard words were counted from transcriptions of videotapes of the children made in the children's homes for 90 minutes. The number of child-directed words from caregivers predicted the later vocabulary of the children, but overheard words did not predict the later vocabulary of the children. Therefore, child-directed speech is very important for the vocabulary development of all children, and may be even more important to children with hearing loss who may have trouble overhearing speech that is slightly further away and not presented directly to them. Since the LENA AWC measure cannot distinguish between child-directed and overheard speech and cannot report the quality of the language but only the quantity, the effects of the AWC measure should be interpreted cautiously. Also, a study by Zimmerman et al. (2009) which investigated the associations between the LENA outcomes of AWC and CTC and language development of typically developing children found that the effects of AWC on child language development were significant but were partially mediated by CTC. The effects of CTC on language development were significant alone and were not mediated or reduced by AWC. Therefore, parent-child interactions may have more effect on language development in children than simply exposing

children to adult words, which should be taken into consideration when interpreting the effects of the LENA variables.

Future Directions

This study provides valuable information that can be used when planning for future studies investigating the early language environment and the effect of an educational session with parents in children with unilateral and mild-moderate bilateral hearing loss. In order to avoid the ceiling effect, future interventions to increase parental language exposure should target participants who have AWC and CTC within the average range or lower so the parents have room to increase the number of words spoken. The parents' motivation to improve their child's language environment could be assessed using a survey or other repeatable measure prior to and following the educational session in order to measure any effect of motivation on the LENA outcomes. Also, a future study could investigate whether participants whose baseline recordings are below the average range for normally hearing peers require more education than participants whose baseline recordings are within the average range to obtain similar gains in LENA variables after the education session.

The current study utilized a short, one-time educational session over the phone and then provided the parents with written results. Performing the educational session over the phone was unique compared to previous studies that provided parental education sessions in person (Sacks et al., 2014; Suskind et al., 2013). This study showed increases in AWC but no increases in CTC or CV. Future studies could compare the benefits of performing the educational session in person with the parents to giving the educational session over the phone. Also, future educational sessions could focus on more parental-child interaction in an effort to increase CTC

and CV as well as AWC. Finally, in addition to a second recording one week following the education session, multiple follow up recordings could be utilized to assess the longitudinal results of the education session over a longer period of time.

Conclusion

Seven young children between 9 and 36 months of age with unilateral or mild-moderate bilateral hearing loss participated in this study to provide preliminary data on the characteristics of the early linguistic environment of children with unilateral hearing loss and mild to moderate bilateral hearing loss. Also, the efficacy of a short, one-time educational session with a parent provided over the phone was assessed for its ability to increase parental speech to children with unilateral and mild to moderate bilateral hearing loss. Results indicated a large variability in the amount of adult words, conversational turns, and child vocalizations are present in the children's environments. Following the educational session, the majority of participants demonstrated an increase in the number of adult words in the child's environment. The increase in the AWC percentile rankings compared to same-age peers who are typically developing and have normal hearing approached statistical significance. No increase in the number of conversational turns or child vocalizations was noted. These results indicate that a short, one-time educational session over the phone may be effective in increasing the number of adult words spoken in the language environments of young children with unilateral and mild-moderate bilateral hearing loss, but further research is needed to assess the language outcomes of the children and to develop interventions to also target an increase in the number of conversational turns and child vocalizations.

Works Cited

Aragon, M., & Yoshinaga-Itano, C. (2012). Using Language ENvironment Analysis to improve outcomes for children who are deaf or hard of hearing. *Seminars in Speech and Language, 33*(4), 340–53.

Bader, J. (1999). *Top ten strategies for parents*. Colorado, USA: Hear at Home.

Bess, F. H., Dodd-Murphy, J., & Parker, R. A. (1998). Children with minimal sensorineural hearing loss: Prevalence, educational performance, and functional status. *Ear and Hearing, 19*(5), 339-354.

Bess, F. H., & Tharpe, A. M. (1984). Unilateral hearing impairment in children. *Pediatrics, 74*(2), 206–216.

Brookhouser, P., Worthington, D., & Kelly, W. (1991). Unilateral hearing loss in children. *Laryngoscope, 101*(12), 1264–1272.

Caskey, M., Stephens, B., Tucker, R., & Vohr, B. (2014). Adult Talk in the NICU with Preterm Infants and Developmental Outcomes. *Pediatrics, 133*(3), e578-e584.

Davis, J., Elfenbein, J., Schum, R., & Bentler, R. (1986). Effects of mild and moderate hearing impairments on language, educational, and psychosocial behavior of children. *Journal of Speech and Hearing Disorders, 51*, 53–62.

Dollaghan, C. A., Campbell, T. F., Paradise, J. L., Feldman, H. M., Janosky, J. E., Pitcairn, D. N., & Kurs-Lasky, M. (1999). Maternal education and measures of early speech and language. *Journal of Speech, Language, and Hearing Research, 42*(6), 1432–43.

Fernald, A., Marchman, V. A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science, 16*(2), 234–48.

Forget-Dubois, N., Dionne, G., Lemelin, J. P., Pérusse, D., Tremblay, R. E., & Boivin, M. (2009). Early child language mediates the relation between home environment and school readiness. *Child Development, 80*(3), 736–49.

Gilkerson, J., & Richards, J. A. (2008). The LENA Natural Language Study. LENA Foundation, Boulder, CO.

Hart, B., & Risley, T. R. (1989). The longitudinal study of interactive systems. *Education & treatment of children, 12*(4), 347-358.

Hart, B., & Risley, T. R. (1992). American parenting of language-learning children: Persisting differences in family-child interactions observed in natural home environments. *Developmental Psychology, 28*(6), 1096–1105.

Hart, B., & Risley, T. R. (1995). Meaningful differences in the everyday experience of young American children. Baltimore, MD, US: Paul H Brookes Publishing.

Hoff, E. (2003). The specificity of environmental influence: socioeconomic status affects early vocabulary development via maternal speech. *Child Development, 74*(5), 1368–78.

Hoff, E., & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development, 73*(2), 418–33.

Houston, K. T., Stredler-Brown, A. (2012). A model of early intervention for children with hearing loss provided through telepractice. *Volta Review, 112*(3), 283-296.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27*(1), 236–248.

Huttenlocher, J., Vasilyeva, M., Waterfall, H. R., Vevea, J. L., & Hedges, L. V. (2007). The varieties of speech to young children. *Developmental Psychology, 43*(5), 1062–83.

Jongkees, L., & van der Veer, R. (1958). On directional sound localization in unilateral deafness and its explanation. *Acta Oto-Laryngologica, 49*, 119–131.

Kavanaugh, R., & Jirkovsky, A. (1982). Parental speech to young children: A longitudinal analysis. *Merrill-Palmer Quarterly, 28*(2), 297–311.

LENA Foundation (2011). *User guide LENA Pro v3.2.* Retrieved from http://www.lenafoundation.org/DownloadPath.aspx/mht/public/LENA/v3.3.3/LENA_Pro_User_Guide.

Lieu, J. E. C., Tye-Murray, N., Karzon, R. K., & Piccirillo, J. F. (2010). Unilateral hearing loss is associated with worse speech-language scores in children. *Pediatrics, 125*(6), e1348–55.

Liu, O. L., Bridgeman, B., & Adler, R. M. (2012). Measuring learning outcomes in higher education: Motivation matters. *Educational Researcher, 41*(9), 352–362.

McCartney, K. (1984). Effect of quality of day care environment on children's language development. *Developmental Psychology, 20*(2), 244–260.

Nelson, L., Bradham, T. S., & Houston, K. T. (2011). The EDHI and early intervention connection. *The Volta Review, 111*(2), 133-149.

Oshima-Takane, Y., & Robbins, M. (2003). Linguistic Environment of Secondborn Children. *First Language, 23*(1), 21–40.

Peisner-Feinberg, E. (2001). The relation of preschool child-care quality to children's cognitive and social developmental trajectories through second grade. *Child Development, 72*(5), 1534–1553.

Phillips, J. (1973). Syntax and vocabulary of mothers' speech to young children: Age and sex comparisons. *Child Development, 44*(1), 182–185.

Rowe, M. L. (2008). Child-directed speech: relation to socioeconomic status, knowledge of child development and child vocabulary skill. *Journal of Child Language, 35*(1), 185–205.

Sacks, C., Shay, S., Repplinger, L., Leffel, K.R., Sapolich, S.G., Suskind, E., Tannenbaum, S., & Suskind, D. (2014). Pilot testing of a parent-directed intervention (Project ASPIRE) for underserved children who are deaf or hard of hearing. *Child Language Teaching and Therapy, 30*(1), 91 –102.

Schönweiler, R., Ptok, M., & Radü, H. J. (1998). A cross-sectional study of speech- and language-abilities of children with normal hearing, mild fluctuating conductive hearing loss,

or moderate to profound sensorineural hearing loss. *International Journal of Pediatric Otorhinolaryngology, 44*(3), 251–8.

Shaw, W. A., Newman, E. B., & Hirsh, I. J. (1947). The difference between monaural and binaural thresholds. *Journal of Experimental Psychology, 37*(3), 229–42.

Shneidman, L. A., Arroyo, M. E., Levine, S. C., & Goldin-Meadow, S. (2013). What counts as effective input for word learning? *Journal of Child Language, 40*(3), 672–86.

Suskind, D., Leffel, K. R., Hernandez, M. W., Sapolich, S. G., Suskind, E., Kirkham, E., & Meehan, P. (2013). An Exploratory Study of "Quantitative Linguistic Feedback": Effect of LENA Feedback on Adult Language Production. *Communication Disorders Quarterly, 20*(10), 1-11.

VanDam, M., Ambrose, S. E., & Moeller, M. P. (2012). Quantity of parental language in the home environments of hard-of-hearing 2-year-olds. *Journal of Deaf Studies and Deaf Education, 17*(4), 402–20.

Walker, D., Greenwood, C., Hart, B., & Carta, J. (1994). Prediction of school outcomes based on early language production and socioeconomic factors. *Child Development, 65*(2), 606–21.

Zambrana, I. M., Ystrom, E., & Pons, F. (2012). Impact of gender, maternal education, and birth order on the development of language comprehension: a longitudinal study from 18 to 36 months of age. *Journal of Developmental and Behavioral Pediatrics, 33*(2), 146–55.

Zimmerman, F., & Christakis, D. (2005). Children's television viewing and cognitive outcomes: a longitudinal analysis of national data. Archives of Pediatrics & Adolescent Medicine, 159(July 2005), 619–625.

Zimmerman, F. J., Christakis, D. A., & Meltzoff, A. N. (2007). Associations between media viewing and language development in children under age 2 years. *The Journal of Pediatrics, 151*(4), 364–8.

Zimmerman, F. J., Gilkerson, J., Richards, J. A., Christakis, D. A., Xu, D., Gray, S., & Yapanel, U. (2009). Teaching by listening: the importance of adult-child conversations to language development. *Pediatrics, 124*(1), 342–9.

Table 1

Demographic Characteristics of Participants

Participant	Gender	Age (months)	Birth order	Total # of children	Mother education (# of years)	Father education (# of years)	Hours cared for outside home	Enrolled in parent infant program?
1	M	15	2	2	20	14	40	Yes
2	F	9	1	1	16	16	10	Yes
3	F	28	1	2	18	18	50	Yes
4	F	29	1	2	18	16	5	Yes
5	F	35	2	2	13	14	60	Yes
6	M	14	1	1	16	16	0	No
7	M	36	1	1	13	13	40	Yes
Mean (*SD*)		23.7 (10.9)			16.3 (2.6)	15.3 (1.7)	29.3 (23.9)	
Median		28			16	16	40	

Table 2

Hearing History of Participants

Participant	Gender	Age (months)	Type of hearing loss	Etiology	Hearing aid use
1	M	15	UHL-Right	Unknown	None
2	F	9	UHL- Left	Unknown	Left hearing aid
3	F	28	UHL- Left	Unknown	Left hearing aid
4	F	29	BHL	Pendred Syndrome	Bilateral hearing aids
5	F	35	UHL- Left	Hypoplastic left cochlear nerve	BAHA soft band
6	M	14	UHL- Right	Right aural atresia and microtia	None
7	M	36	UHL- Left	Left aural atresia and microtia	BAHA soft band

*All participants had presumed congenital hearing loss identified at birth.

Abbreviations:

UHL: Unilateral hearing loss

BHL: Bilateral hearing loss

Table 3

Results of Spearman's rho correlation analyses

	Correlation Coefficient	*p*
AWC*Maternal education	-0.073	0.876
AWC*Paternal education	-0.262	0.570
AWC*Hours cared for outside home	-0.270	0.558
CTC*Maternal education	0.092	0.845
CTC*Paternal education	0.206	0.658
CTC*Hours cared for outside home	-0.054	0.908
CV*Maternal education	0.312	0.496
CV*Paternal education	0.449	0.312
CV*Hours cared for outside home	0.090	0.848
AWC*Age of child	0.286	0.535
CTC*Age of child	0.321	0.482
CV*Age of child	0.321	0.482

Abbreviations:

AWC: Adult word count

CTC: Conversational turn count

CV: Child vocalizations

Table 4

Results of paired samples t-tests

	$t(6)$	p (two-tailed)
AWC post – AWC pre	0.842	0.432
CTC post – CTC pre	-1.148	0.295
CV post – CV pre	-1.761	0.129
AWC percentile post – AWC percentile pre	2.238	0.067*
CTC percentile post – CTC percentile pre	-0.771	0.470
CV percentile post – CV percentile pre	-0.661	0.533

*$p < 0.10$ (90% confidence interval)

Abbreviations:

AWC: Adult word count

CTC: Conversational turn count

CV: Child vocalizations

Post: Post-educational session

Pre: Pre-educational session

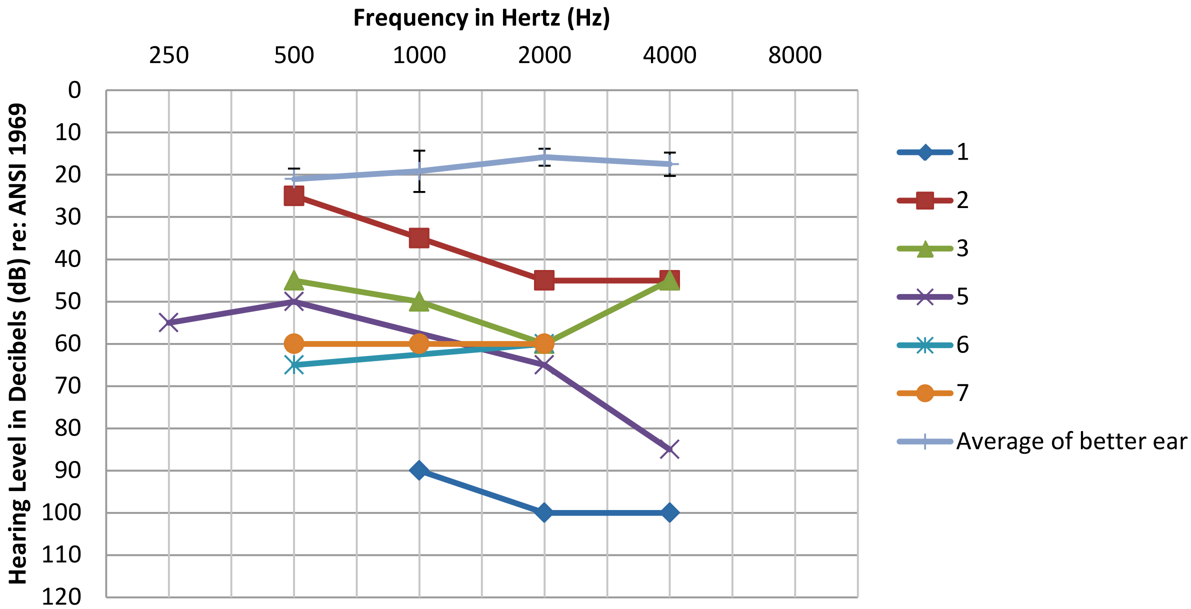

Figure 1. Average of better hearing ear (±1 SD) air conduction audiometric thresholds for all participants with unilateral hearing loss and individual air conduction audiometric thresholds of the poorer hearing ear of each participant with unilateral hearing loss.

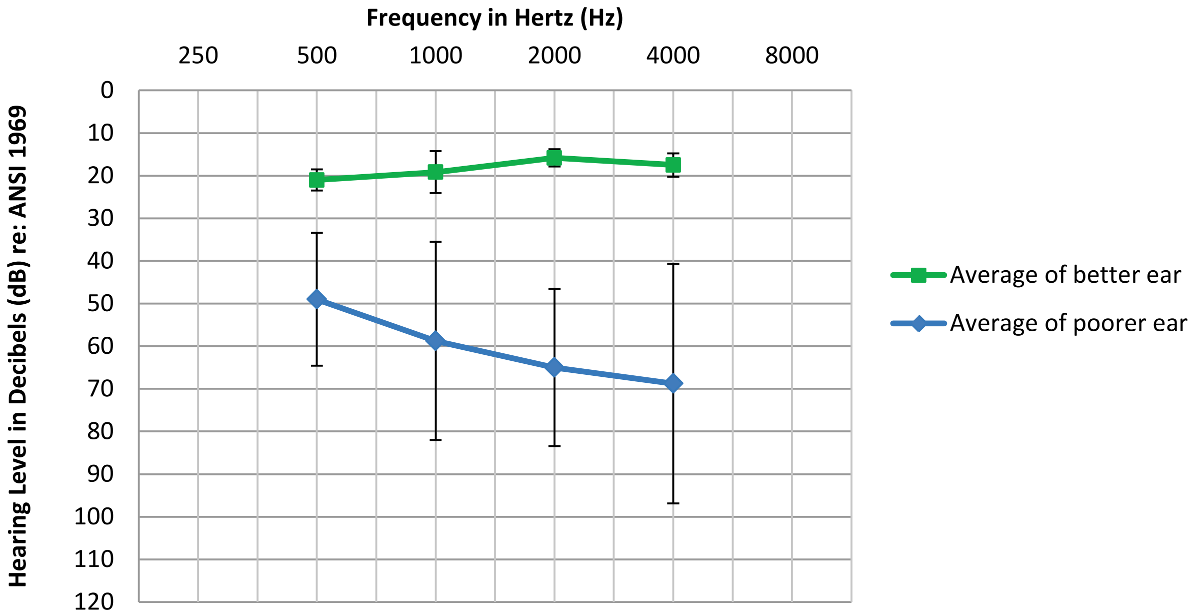

Figure 2. Average of better hearing ear (±1 SD) and poorer hearing ear (±1 SD) air conduction audiometric thresholds for all participants with unilateral hearing loss.

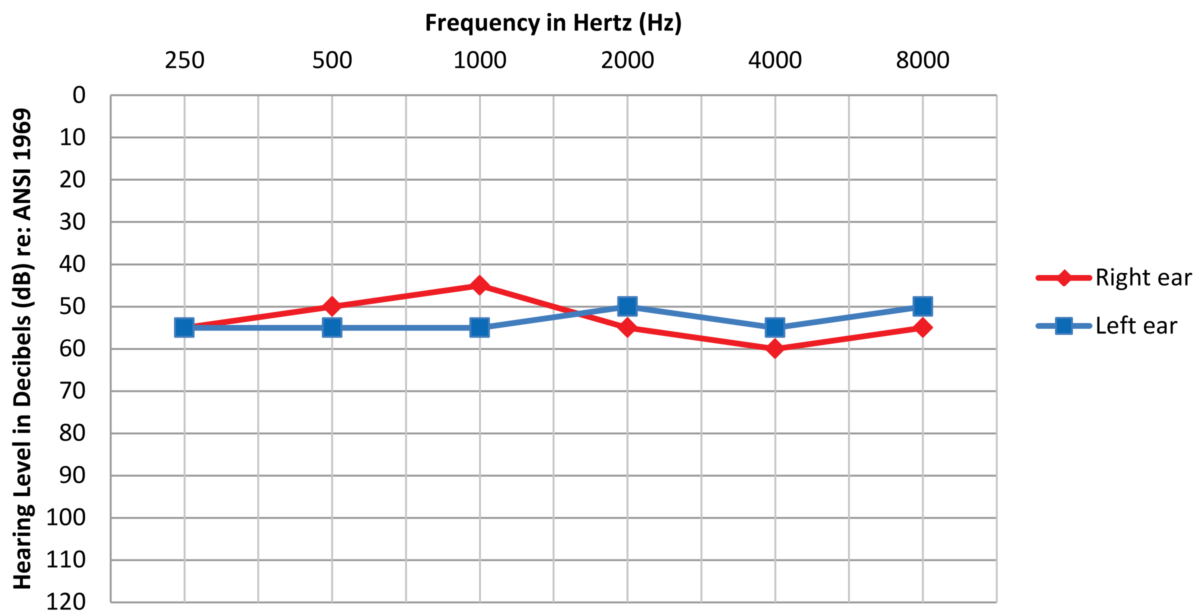

Figure 3. Air conduction audiometric thresholds for Participant 4 with mild-moderate bilateral hearing loss.

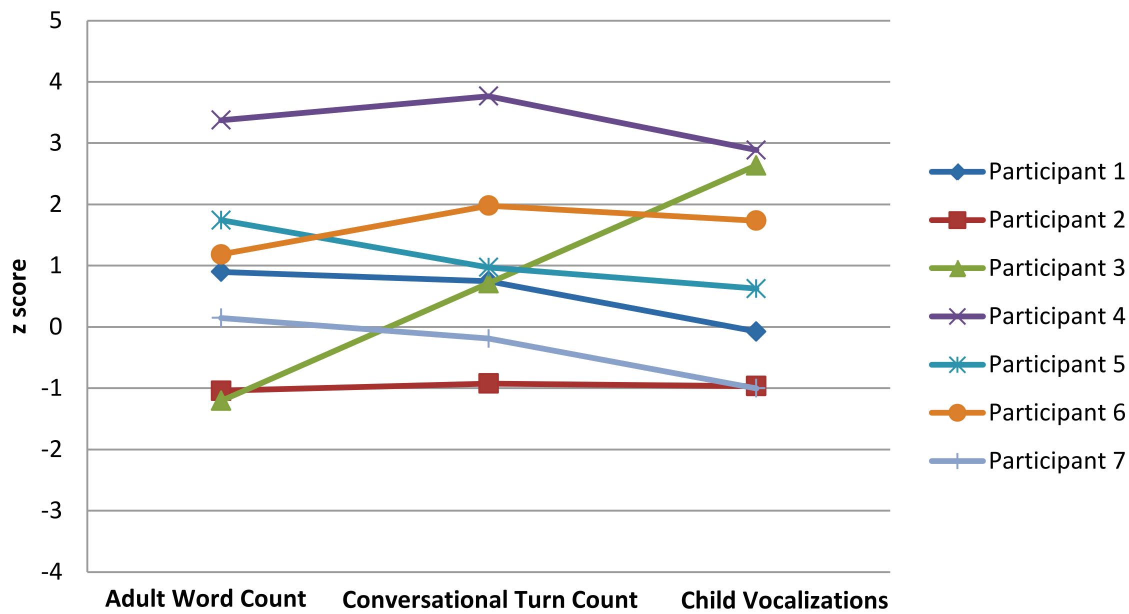

Figure 4. *z* scores for each participant of Adult Word Count, Conversational Turn Count, and Child Vocalizations of the baseline recording in reference to the LENA normative sample. *z* scores between +1 to -1 indicate scores within the average range, with a *z* score of zero indicating results at the average of the normative sample.

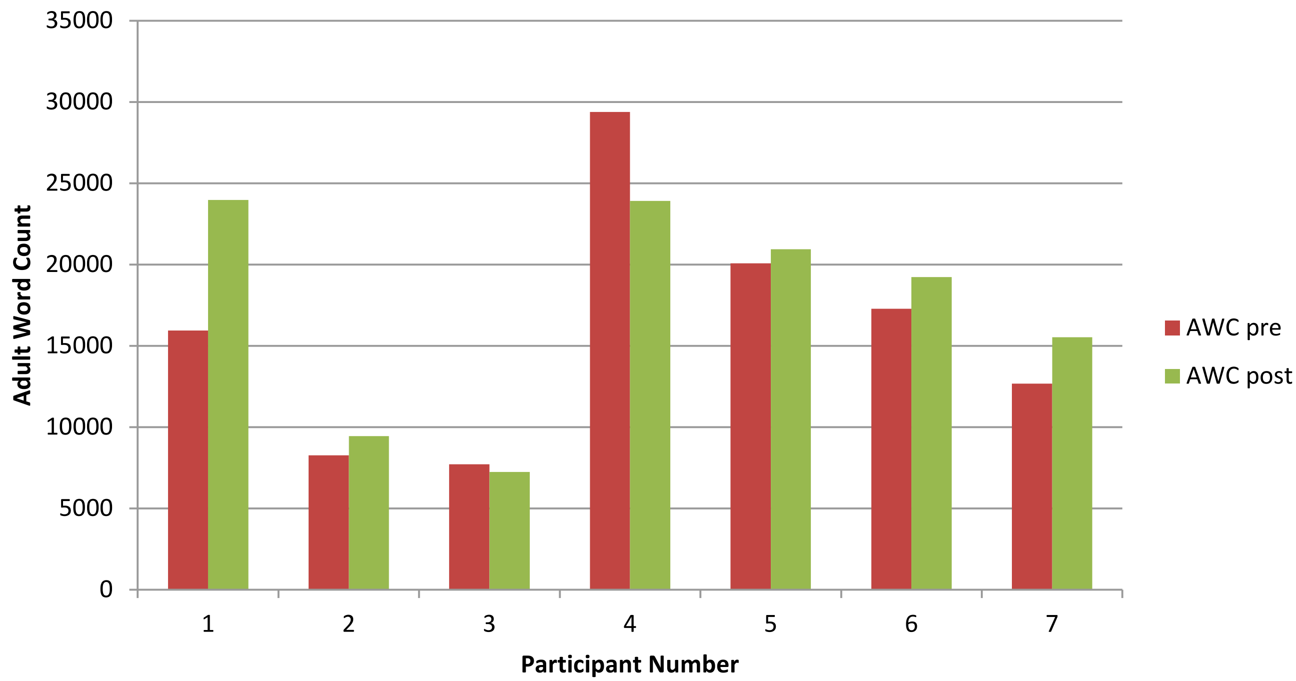

Figure 5. Individual adult word count (AWC) results for each participant pre-educational session and post-educational session.

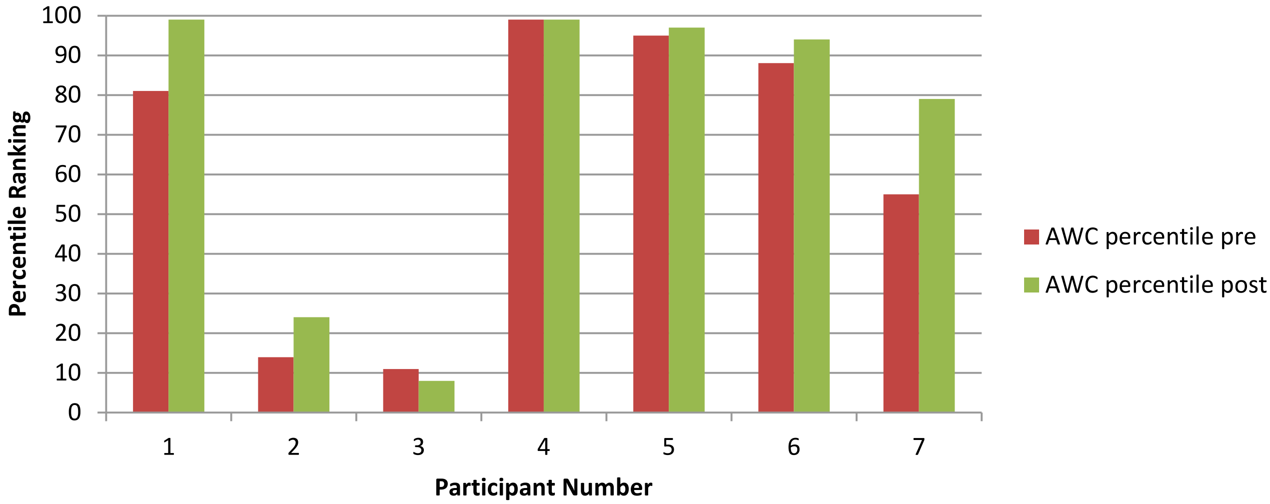

Figure 6. Individual adult word count (AWC) percentile results for each participant pre-educational session and post-educational session. Percentile rankings compare the participant's data to the LENA Natural Language Study normative database, made up of same-age peers who are typically developing and who have normal hearing.

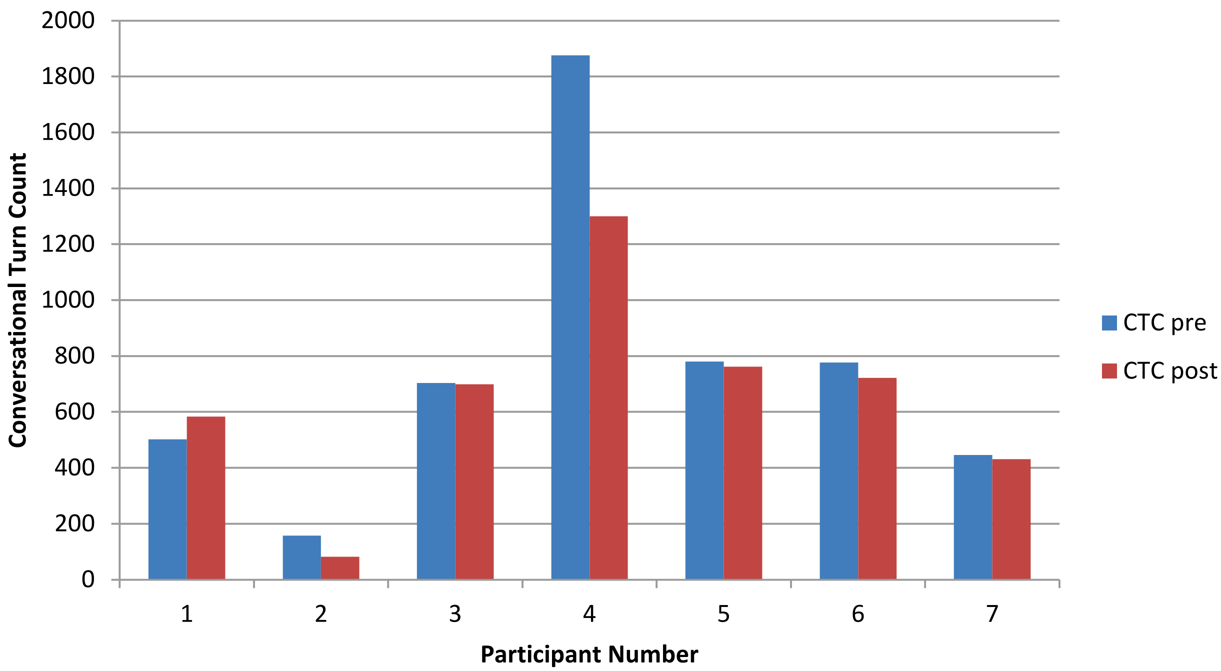

Figure 7. Individual conversational turn count (CTC) results for each participant pre-educational session and post-educational session.

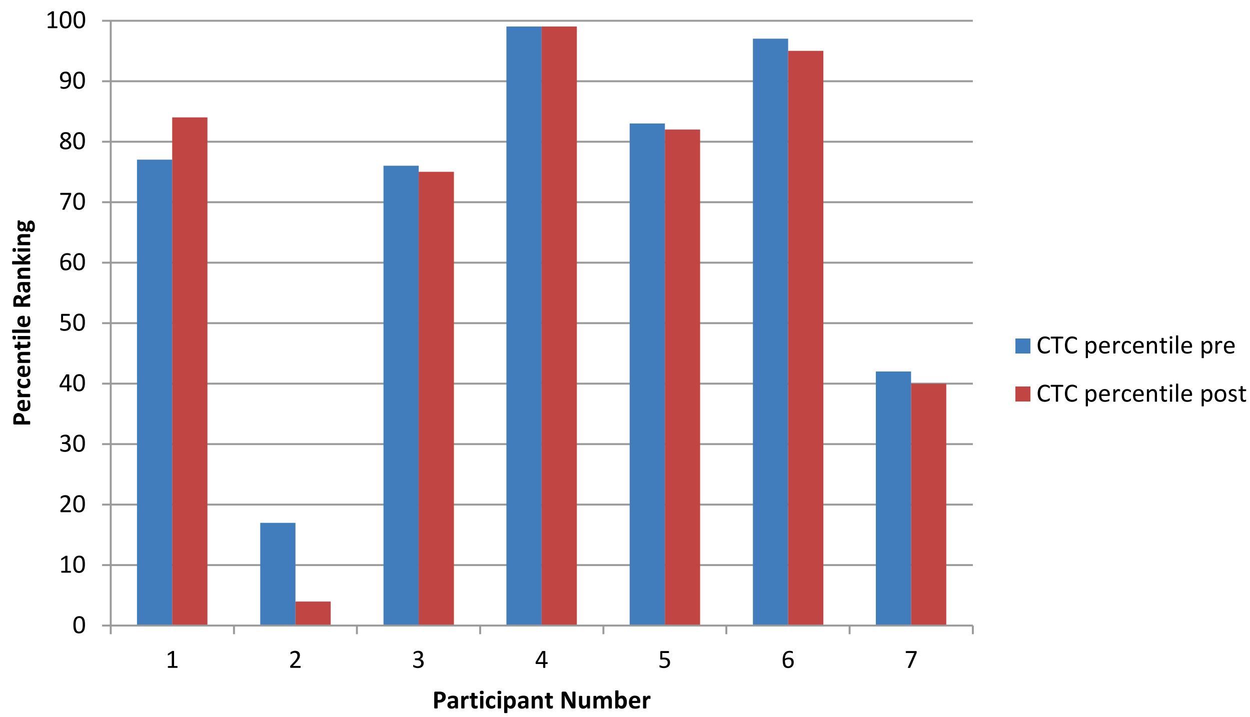

Figure 8. Individual conversational turn count (CTC) percentile results for each participant pre-educational session and post-educational session. Percentile rankings compare the participant's data to the LENA Natural Language Study normative database, made up of same-age peers who are typically developing and who have normal hearing.

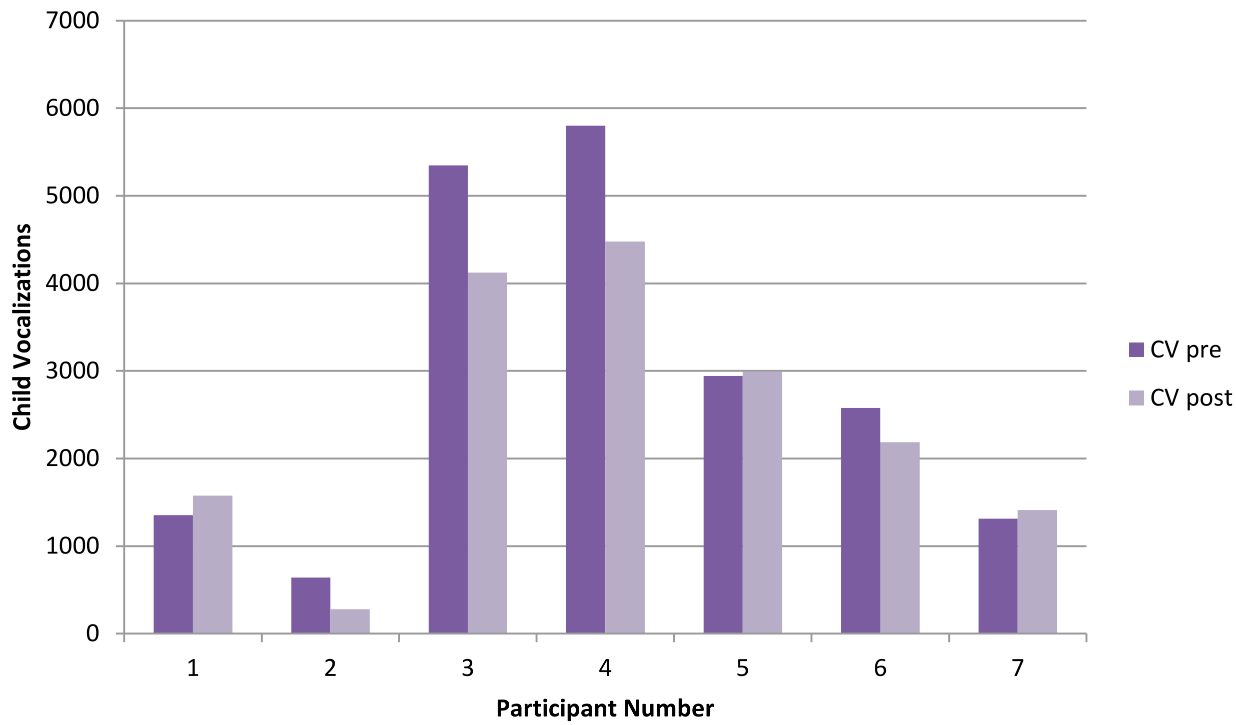

Figure 9. Individual child vocalization (CV) results for each participant pre-educational session and post-educational session.

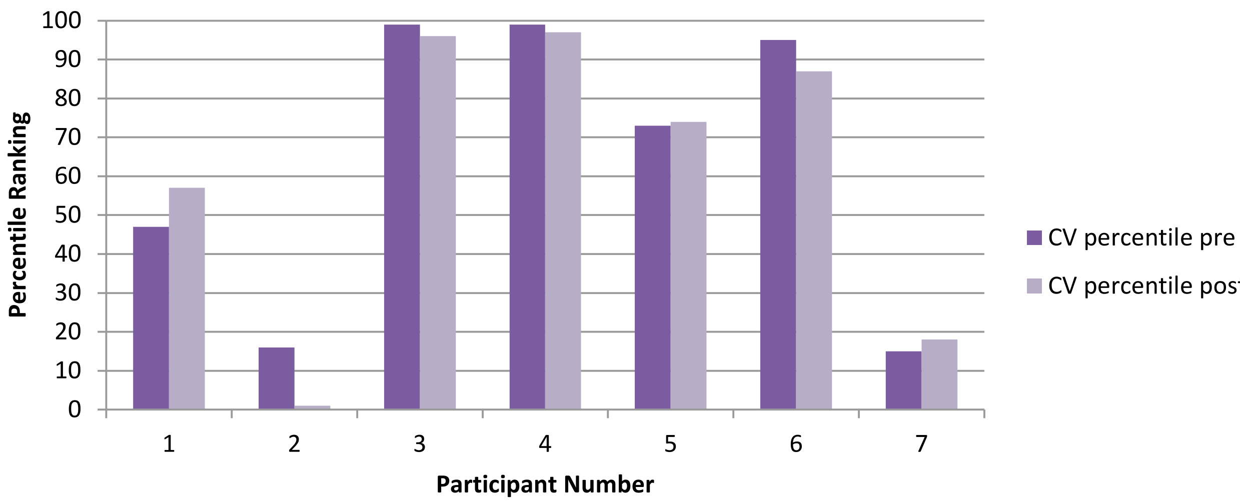

Figure 10. Individual child vocalization (CV) percentile results for each participant pre-educational session and post-educational session. Percentile rankings compare the participant's data to the LENA Natural Language Study normative database, made up of same-age peers who are typically developing and who have normal hearing.

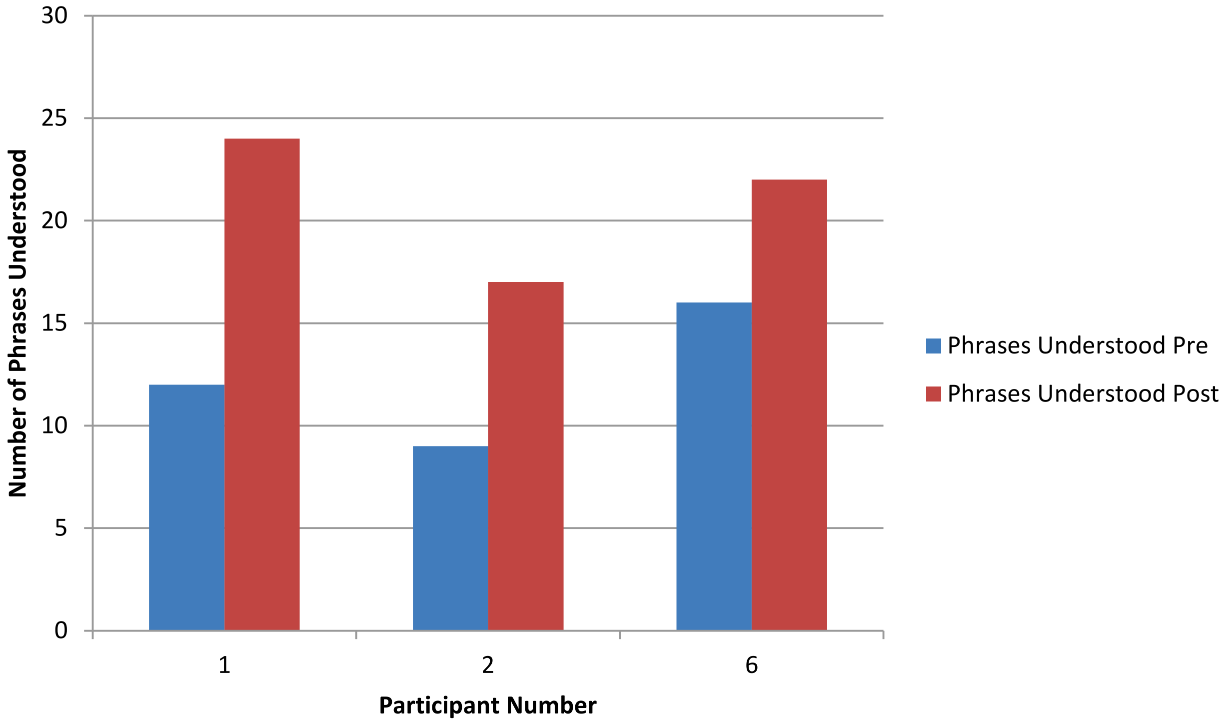

Figure 11. Number of phrases understood on the MacArthur Bates CDI Words and Gestures form for individual participants pre-educational session and post-educational session.

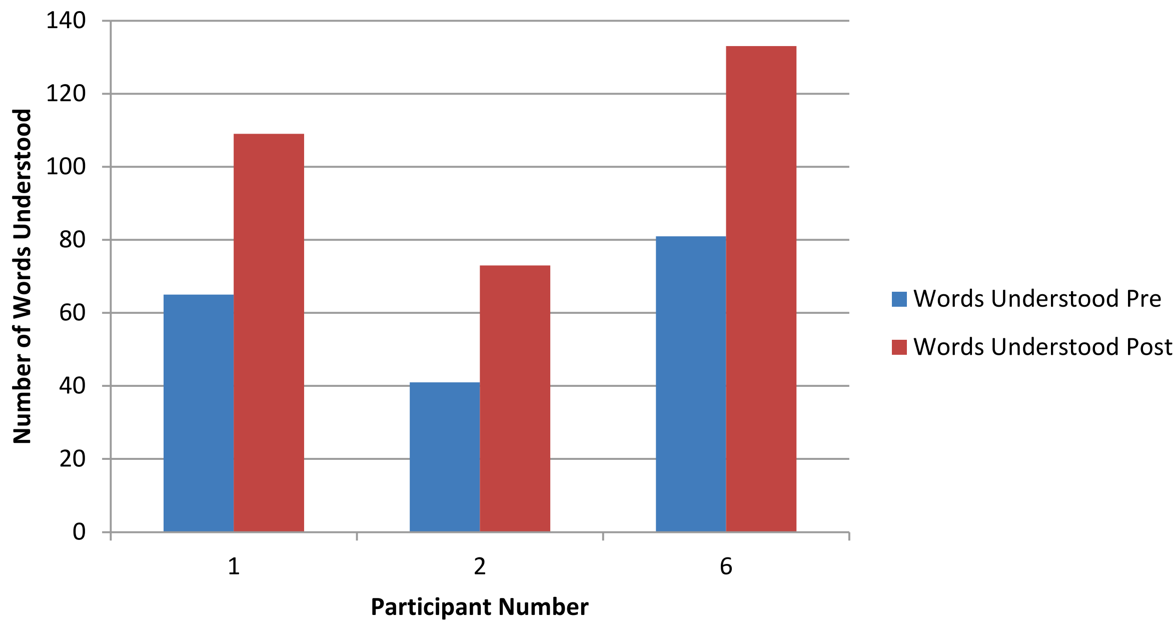

Figure 12. Number of words understood on the MacArthur Bates CDI Words and Gestures form for individual participants pre-educational session and post-educational session.

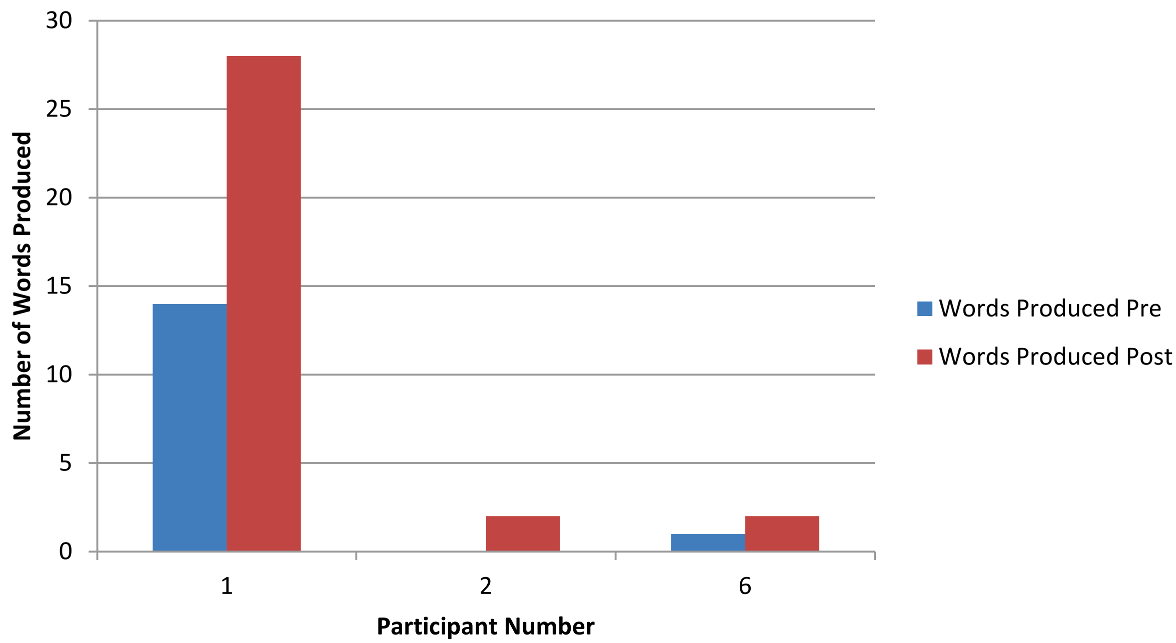

Figure 13. Number of words produced on the MacArthur Bates CDI Words and Gestures form for individual participants pre-educational session and post-educational session.

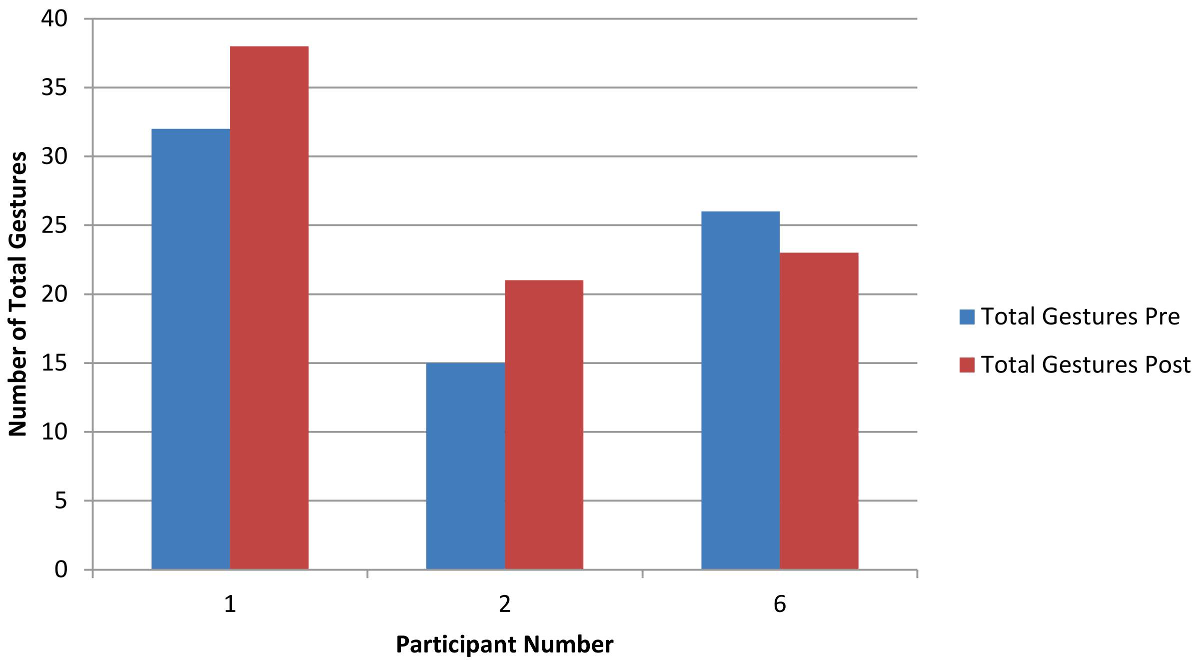

Figure 14. Number of total gestures on the MacArthur Bates CDI Words and Gestures form for individual participants' pre-educational session and post-educational session.

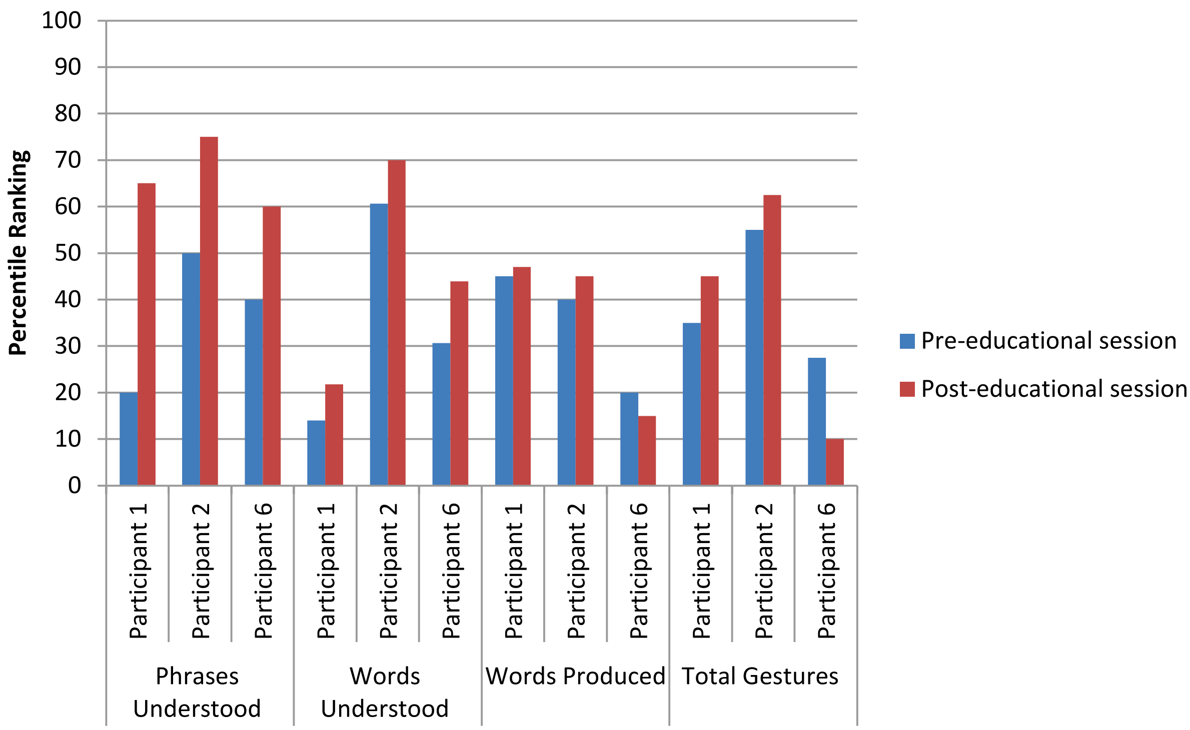

Figure 15. Individual percentile results for phrases understood, words understood, words produced, and total gestures for each participant pre-educational session and post-educational session on the MacArthur Bates CDI Words and Gestures form. Percentile rankings compare the participant's data to the MacArthur Bates CDI norms, made up of same-age peers who are typically developing and who have normal hearing.

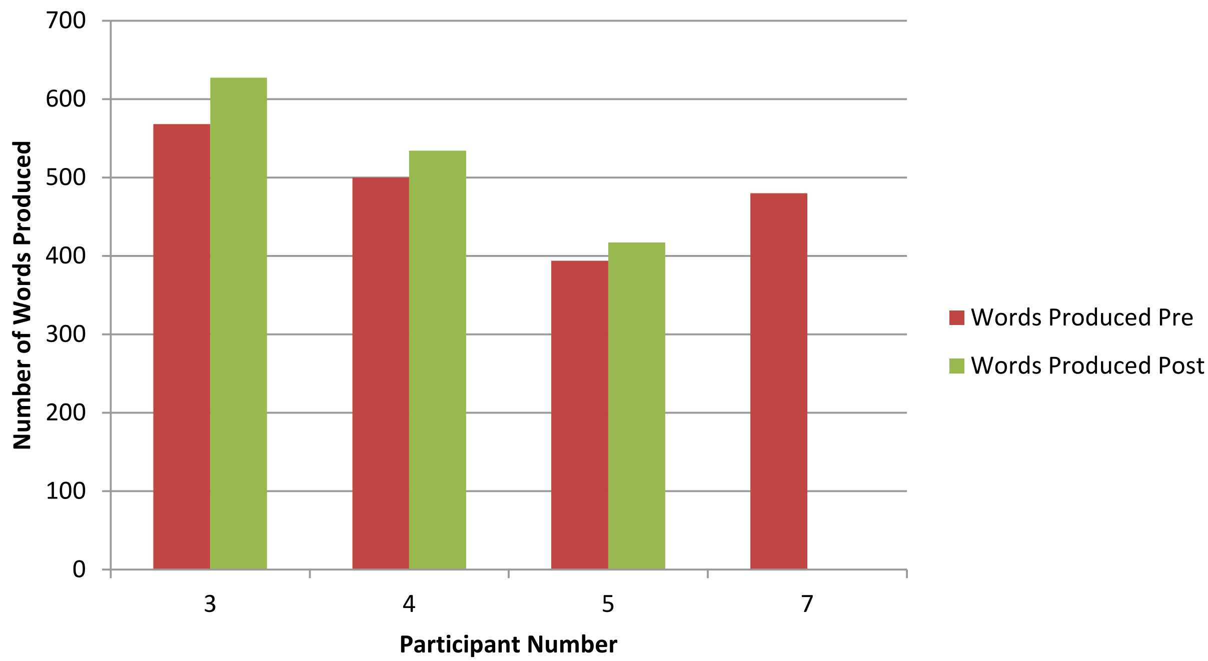

Figure 16. Number of words produced on the MacArthur Bates CDI Words and Sentences form for individual participants pre-educational session and post-educational session. Note that Participant 7 did not complete a MacArthur Bates CDI post-educational session.

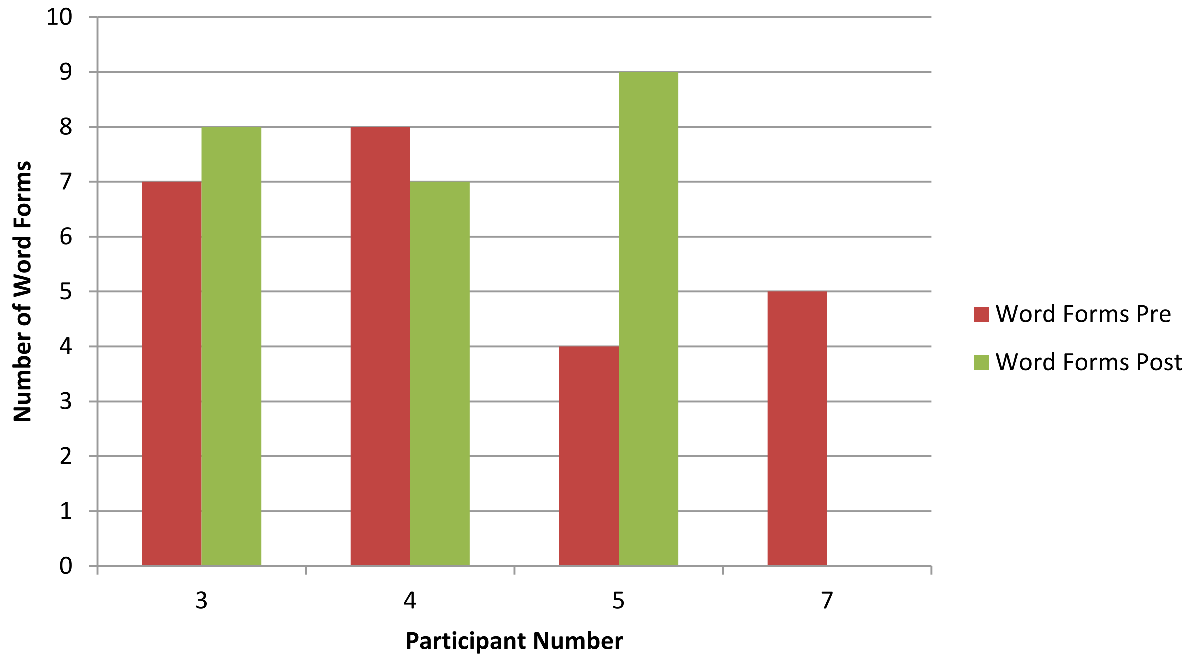

Figure 17. Number of word forms produced on the MacArthur Bates CDI Words and Sentences form for individual participants pre-educational session and post-educational session. Note that Participant 7 did not complete a MacArthur Bates CDI post-educational session.

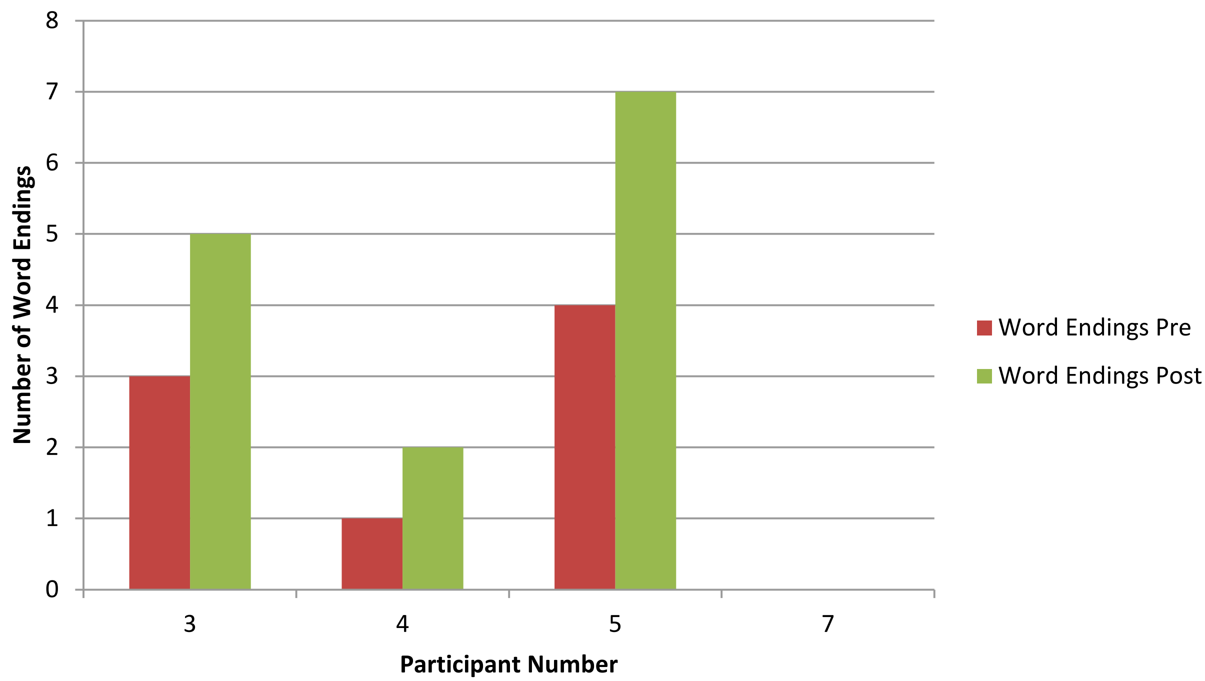

Figure 18. Number of word endings produced on the MacArthur Bates CDI Words and Sentences form for individual participants pre-educational session and post-educational session. Note that Participant 7 did not complete a MacArthur Bates CDI post-educational session.

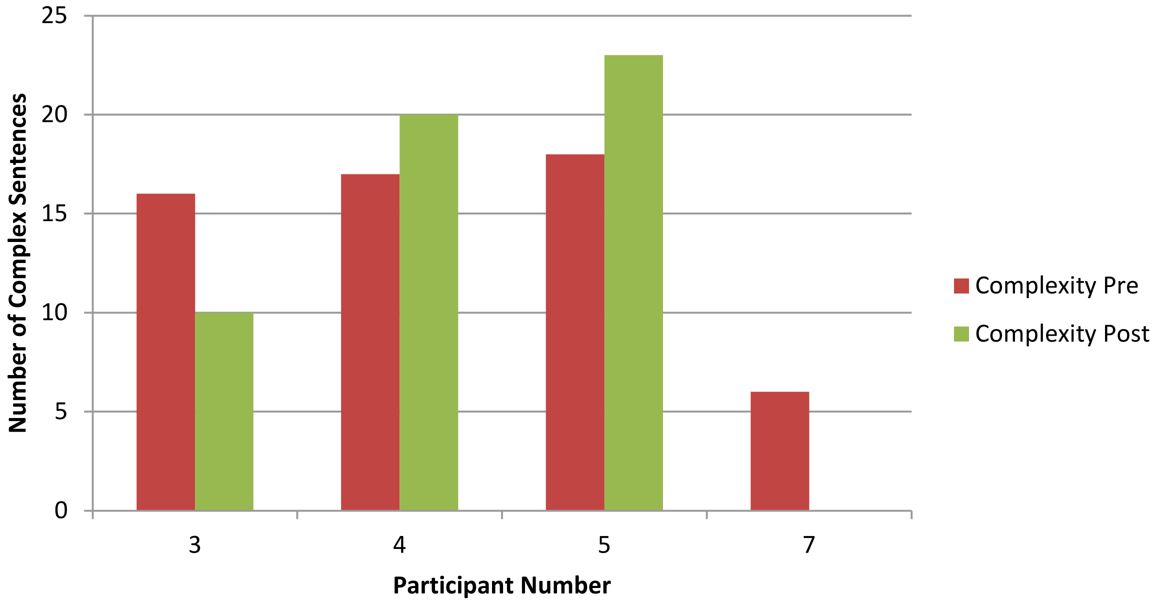

Figure 19. Number of more complex sentences selected on the MacArthur Bates CDI Words and Sentences form for individual participants' pre-educational session and post-educational session. Note that Participant 7 did not complete a MacArthur Bates CDI post-educational session.

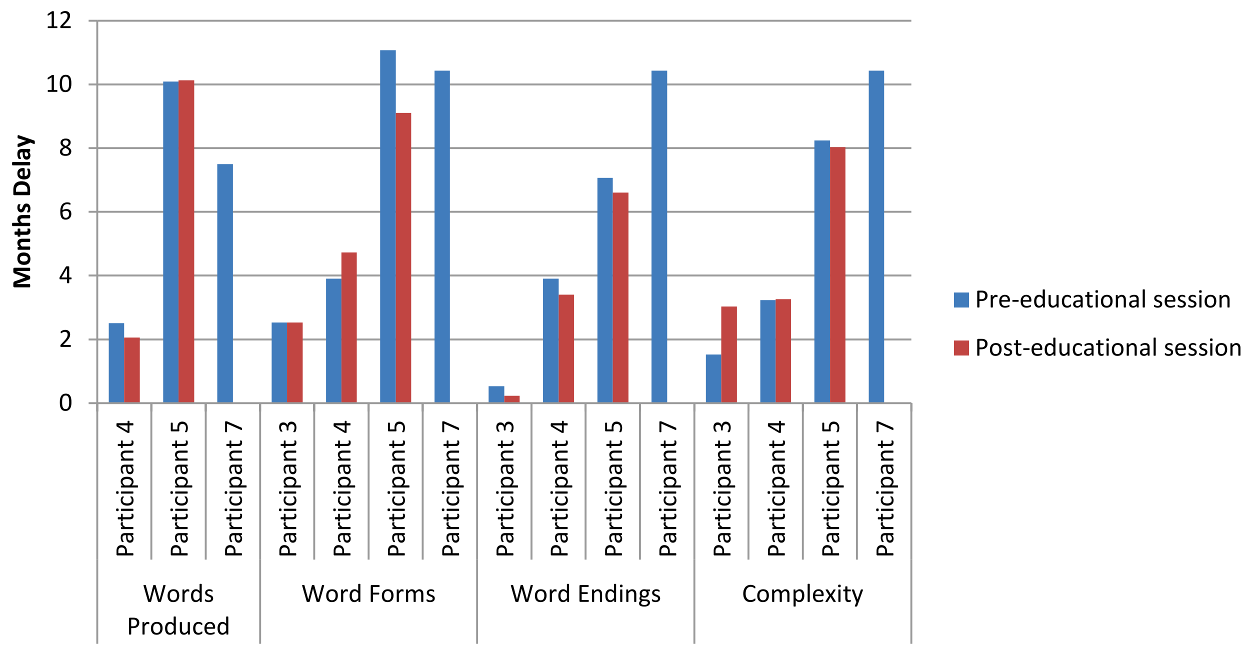

Figure 20. Number of months delayed when compared to MacArthur Bates CDI norms of peers with normal hearing and typical development for number of words produced, word forms used, word endings used, and more complex sentences selected from the MacArthur Bates CDI Words and Sentences form. Note that Participant 7 did not complete a MacArthur Bates CDI post-educational session.

APPENDIX A

Parent questionnaire

The Early Language Environment and Effect of Parental Counseling on Adult Language Exposure of Children with Unilateral and Mild Bilateral Hearing Loss

Instructions: Please answer the following questions about your child's history. Please do your best to answer every question. Thank you!

1. Date of birth of child __ __ / __ __ / __ __ __ __
M M / D D / Y Y Y Y

2. Child's Gender [ ] male [ ] female

3. Child's Race [ ] Black [ ] Native Hawaiian/Pacific Islander
[ ] White [ ] American Indian/Alaskan Native
[ ] Asian [ ] Unknown
[ ] Other/mixed____

4. Child's birth order ______ (e.g., 1st born, 2nd born, etc.)

5. Total number of children in family_______

6. Child's first language [ ] English [ ] Spanish
[ ] Other _____________________________

7. Are any other languages spoken in the home? [ ] Yes: _______________ [ ] No

8. Highest educational level or highest degree—mother/ guardian 1
[ ] 1st [ ] 2nd [ ] 3rd [ ] 4th [ ] 5th [ ] 6th [ ] 7th [ ] 8th [ ] 9th [ ] 10th [ ] 11th
[ ] 12th, no diploma [ ] High school graduate [ ] GED or eequivalent
[ ] Some college, no degree [ ] Associate degree [ ] Bachelor's degree

[ ] Master's degree [ ] Professional/ doctoral degree (MD, JD, DDS, DVM, PhD)

[ ] unknown

9. Highest educational level or highest degree—father/ guardian 2
[ ] 1st [ ] 2nd [ ] 3rd [ ] 4th [ ] 5th [ ] 6th [ ] 7th [ ] 8th [ ] 9th [ ] 10th [ ] 11th

[ ] 12th, no diploma [ ] High school graduate [ ] GED or eequivalent

[ ] Some college, no degree [ ] Associate degree [ ] Bachelor's degree

[ ] Master's degree [ ] Professional/ doctoral degree (MD, JD, DDS, DVM, PhD)

[ ] unknown

10. How many hours per week is your child cared for by someone outside the home?
____

11. Is your child currently enrolled in a Parent-Infant Program or First Steps or Child and Family Connections? [ ] No [ ] Yes

If **YES**, please state which one: ____

MEDICAL HISTORY

12. Birthweight ____ pounds, ____ ounces [ ] unknown

Was the child born full-term? [ ] Yes [ ] No

If **NO**, how many weeks gestation were they at birth? __ __ weeks (e.g., 23 to 37 weeks)

13. Did the child have any medical problems right after birth? [ ] No [ ] Yes [ ] Unknown

If **YES**, please check all that apply:

[ ] jaundice → Were blue lights used? [ ] No [ ] Yes

[ ] Was admitted to the NICU → How long? _________________ days/weeks/months

[ ] Was on the ventilator → How long? ____________ days/weeks

[ ] Received antibiotics by vein → How long? ____________ days/weeks

[ ] Needed oxygen at home → How long? ____________ weeks/months

[ ] Other problem → ____

14. Does the child have any medical or behavioral problems <u>currently</u>? [ ] No [ ] Yes

If **YES**, please check all that apply:

[ ] asthma [ ] allergies [ ] ADHD

[ ] ear infections [ ] vision problems →Wears glasses? [ ] No [ ] Yes

[ ] Other ____

15. Is the child currently taking any medications on a daily or weekly basis? [ ] No
[ ] Yes

If **YES**, please list: ____

16. Does the child have a history of any of the problems below?
[ ] head trauma → Any loss of consciousness? [ ] No [ ] Yes

[ ] skull fracture

[ ] infection at birth → What type? ____

[ ] developmental delay → What type? ____

[ ] bleeding in the brain or hydrocephalus

[ ] meningitis

[ ] kidney problem or malformation

[ ] ear or neck pits or tags

[ ] ear malformation or atresia

17. Has the child had any surgeries in the past? [ ] No [ ] Yes

If **YES**, please check all that apply:

[ ] ear tubes [ ] eye surgery

[ ] Other surgery ____

18. Has the child had any hospitalizations in the past? [ ] No [ ] Yes

If **YES**, please describe reason and age when it occurred: ____________________________

____

19. Has your child had ear infections in the past? [ ] No [ ] Yes

If **YES**, how many: ____________

20. Does your child currently have an ear infection? [ ] No [ ] Yes

21. How old was your child when hearing loss was found? __________ years old

22. Has the child <u>ever</u> tried any devices to help with hearing? [ ] No [ ] Yes

If **YES**, please check all that apply:
[ ] Hearing aid [ ] FM system
[ ] CROS hearing aid [ ] Baha implant
[ ] Other ______________________________

If **YES**, is the child still using any device? [ ] No [ ] Yes → Please check below
[ ] Hearing aid [ ] FM system
[ ] CROS hearing aid [ ] Baha implant
[ ] Other ______________________________

APPENDIX B

Communication Strategies Handout

Strategies to Increase Your Child's Language Exposure

1. Speak directly to your child within a three foot distance from him or her: Your child hears best when your voice is three feet or less away! You can imagine a yardstick, which is three feet, and stay within that distance when speaking to your child. When your voice is closer to your child, he or she is receiving a clearer signal that is not covered up by as much background noise as it would be if you were speaking further away.
2. Talk about what your child is focused on: When you are interacting with their child, talk about what your child is focused on instead of trying to talk to your child about what you are interested in. It is hard for a child to shift their attention, so they learn language best when you talk about the objects of their attention. If your child is playing with a certain toy, talk about that toy instead of trying to show your child a different one.
3. Describe every detail of what your child is doing: Your child will learn words for things by hearing you say the words while they are interacting with their environment. Talk through every detail of what your child is doing, thinking, and feeling.
4. Turn off background noise when talking to your child: Your child will have difficulty listening to you if the TV is on in the background or if the radio is playing music. Turn off any sources of background noise and then talk to your child.

5. Establish routines where language is repeated: Children learn by repetition, so create language routines you can use in your everyday life. For example, every time your child gets ready for bed, use the same language to describe every part of their bedtime routine.

APPENDIX C

LENA Analysis Results Summary

Total adult words spoken: _______

Percentile ranking (compared to average data of children with normal hearing): ____

Total interactions between an adult and your child: ____

Percentile ranking (compared to average data of children with normal hearing): ___

Percentage of time your child spends in silence: _____

Percentage of time your child listens to TV and/or radio: ____

Percentage of language that is far away from your child: _____

Percentage of language that is close by your child: ______