A Comparison of Prelinguistic Learning Environment of Children with and without Hearing Loss

By

Pumpki Lei Su

Thesis

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Interdisciplinary Studies:

Communication Disorders and Neurodevelopmental Disabilities

August 10, 2018

Nashville, Tennessee

Approved:

Stephen Camarata, Ph.D., CCC-SLP

James Bodfish, Ph.D.

Paul Yoder, Ph.D.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

The primary goal of this study was to examine the extent to which parental language input to children with hearing loss (HL) differs from input to children with typical hearing (TH) and to explore the relationship between parental language input and early language development. Previous research has stressed the important role that parents play in their child's early language development (Smith, Landry, & Swank, 2000; Snow, 1977). Many different components of parental language input are associated with language development, such as amount of input (Hart & Risley, 1995), diversity and depth of vocabulary (Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2012), responsiveness (Tamis-LeMonda, Bornstein, & Baumwell, 2001; Yoder & Warren, 1999), and use of language support strategies such as asking open-ended questions using expansion (Scherer & Olswang, 1984). This study extends the current literature by examining the quantity and quality dimensions of two types of parental language input (utterances and responses) in parent-child interactions in children with HL.

From a social interactionist perspective of language development, children learn language through bi-directional transactional language exchanges with caregivers (Sameroff, 1975). Parental language input supports language learning by providing the child with developmentally appropriate language models, which in turn results in greater language skills that subsequently elicit more complex language input from the parent. Considering the reciprocal nature of parent-child interactions, the communicative behaviors of the child also influence parent-child interactions. In children with HL, auditory and communicative characteristics such as reduced audibility (McCreery et al., 2015), low rate of communication (Vohr et al., 2008), difficulty establishing joint attention (Prezbindowski, Adamson, & Lederberg, 1998), and atypical babbling patterns (Levitt, McGarr, & Geffner, 1987; Von Hapsburg & Davis, 2006), may make it challenging for parents to establish or maintain the interaction. Given the facilitative role parents play in early language development, it is critical to examine the extent to which parents of children with HL use different patterns of input as compared to parents of children with TH. Describing the prelinguistic learning environment of children with HL is also essential to understanding how early intervention may be tailored for children with HL given that caregiver language input is a malleable factor that may be addressed to promote long-term language outcomes in children with HL (Moeller, Tomblin, & OCHL Collaboration, 2015).

The Impact of Hearing Loss on Children's Early Language Environment

Despite recent advances in hearing technology, many children with HL still face unique challenges in developing language skills commensurable with their peers with typical hearing (Geers, Tobey, Moog, & Brenner, 2008; Niparko et al., 2010). In children with mild-to-profound HL, factors such as insufficient hearing aids amplification (McCreery, Bentler, & Roush, 2013), inconsistent hearing aids use (Moeller, Hoover, Peterson, & Stelmachowicz, 2009; Muñoz et al., 2015), and early auditory deprivation before 12 months of age (earliest Food and Drug Administration approved age to receive cochlear implants) continue to impact the amount of early linguistic exposure a child receives (Carlson et al., 2015; Tomblin et al., 2015). More than half of children's hearing aids were not fitted sufficiently (McCreery et al., 2013). Furthermore, even in children who have been wearing HAs for a prolonged period, only one-third used hearing aids consistently based on parent report (Muñoz et al., 2015). A recent longitudinal study further confirmed that children with HL are more susceptible to reduced early language experience, which puts them more at risk for persisting language delays (Moeller et al., 2015).

In addition to reducing children's access to linguistic input available in the environment (Cole & Flexer, 2015), HL can also impact the early language environment by altering typical parent-child interaction. Based on the transactional model of parent-child interaction (Sameroff, 1975), there is an ongoing reciprocal exchange between child communications and parent language. Instead of being passive recipients of environmental input, children are actively involved in social interactions and eliciting different parent communications. Considering the bi-directionality of parent-child interaction, auditory and communicative characteristics of children with HL may interrupt the transactional flow of language exchange and affect parental input. For instance, reduced audibility in children with HL may lead to children being less responsive to the input their parents provide, especially in difficult listening environment such as when listening from distance or when background noise is present (Ambrose, Walker, Unflat-Berry, Oleson, & Moeller, 2015). Consequently, parents may restrict their utterances to ideal listening environments or simplify linguistic input to ensure that their child can process the language input.

Evidence that communication characteristics of children with HL can affect typical parent-child interactions can also be found in research focusing on vocal development and caregiver responsiveness. Hearing loss affects children's prelinguistic vocalizations by 8 months of age and possibly earlier (Kishon-Rabin, Taitelbaum-Swead, & Segal, 2009; Stoel-Gammon & Otomo, 1986). Many children with HL display both delayed onset of canonical babbling and restricted consonant inventories (Moeller et al., 2007; von Hapsburg & Davis, 2006). Specifically, children with HL were found to produce fewer alveolar consonants (Ambrose, Thomas, & Moeller, 2016), more glides and glottal stops (Vihman & Greenlee, 1987), less complex syllable shapes, and reduced range of consonant-vowel (CV) forms (Moeller et al., 2007). In addition, mothers respond differently to different types of these vocalizations from their child (Gros-Louis, West, Goldstein, & King, 2006). Consequently, atypical vocalizations that children with HL produce may elicit fewer acknowledgments and responses from the parent.

Two Types of Parental Language Input

A few studies have compared the quantity or quality of parental language input across the HL and the TH groups by analyzing parental utterances during parent-child interactions. Recent studies that have focused on quantity of parental utterances have provided inconsistent results. Vandam and colleagues used an automated technology to record and analyze natural linguistic environment of children with HL and did not find a significant difference in the number of words that children with TH and children with HL are exposed to in their linguistic environment (Vandam, Ambrose, & Moeller, 2012). However, other studies that coded parental utterances from parent-child interaction video samples have reported both higher (DesJardin et al., 2014) and lower number of total parental utterances (Ambrose et al., 2015). Studies that focused on quality of parental utterances have reported more convergent findings. Parents of children with HL used: (a) significantly less diversity of vocabulary (Ambrose et al., 2015), (b) fewer facilitative language strategies (DesJardin et al., 2014), (c) more directive interactions (Ambrose et al., 2015; Bhat & Nagaraja, 2012), and (d) less joint attention episodes compared to parents of children with TH (Depowski, Abaya, Oghalai, & Bortfeld, 2015; Gale & Schick, 2009). Given that most of these studies used age-matched peers with TH as the control group instead of language-matched peers, these differences in quality of parental language input could suggest that parents tailor their linguistic input to child's language ability rather than to their chronological age.

Compared to parental utterances, another type parental language input that has received less attention in studies regarding children with HL is parental utterances in response to child communicative acts (referred to as parental responses throughout the rest of the paper). Parental responsiveness is a subset of parental language input and a type of parent interaction style that emphasizes providing contingent responses to child communications (Bornstein & Tamis-LeMonda, 1989; Landry, Smith, Swank, Assel, & Vellet, 2001; Tamis-LeMonda et al., 2001). The definition of parental responsiveness varies by study and can refer to emotional availability, parental sensitivity, or contingent responses (Landry, Smith, & Swank, 2006; Pressman, Pipp-Siegel, Yoshinaga-Itano, & Deas, 1999). In this study, it refers to parental verbal responses that are temporally contingent to child communicative acts (i.e., parent communication that occurs within 3 seconds of a child communicative act). Considering that many children with HL produce fewer intentional communicative acts (Nicholas & Geers, 1997; Vohr et al., 2008), parent responsiveness may be particularly important because they help children develop expectations about events following their own behavior and help them gain a sense of control over the environment (Baumwell, Tamis-LeMonda, & Bornstein, 1997). Consistent parent responses may also facilitate early language learning by teaching children that their communicative behavior could have an effect on their linguistic environment and priming their attention to the linguistic information following their communication. Taken together, these theories suggest that further investigations of parent responsiveness are warranted in children with HL. Even though the construct of parent responsiveness has been widely researched in children with typical development and language impairment (Bornstein & Tamis-LeMonda, 1989; Girolametto, Weitzman, Wiigs, & Pearce, 1999; Yoder & Warren, 1999), only one study has investigated parental responsiveness in children with HL. Smith and McMurray (2018) analyzed the temporal properties of maternal responses to children with and without HL and did not find a significant difference in latency or variability of maternal responses across the two groups. However, the content of responses was not examined in this study.

The Present Study

The purpose of this study is to compare the quantity and quality of parental utterances and responses to children with and without HL and to explore the relationship between these two types of parental language input and early language development. The prelinguistic period is a critical time for maximizing long-term learning outcomes for children with HL (Moeller, 2000). Yet only two studies to date have investigated parental language input to young children with HL during the prelinguistic period (Ambrose et al., 2015; Smith & McMurray, 2018). Ambrose and colleagues examined parental talk during a 5-minute parent-child interaction and reported differences in the quality of parental language input between the HL group and TH group at 18 months and 3 years. Smith and McMurray (2018) focused on the latency and variability of maternal responses but did not address the quantity or quality of responses. This study expands upon previous literature by examining both the quantity and quality aspects of parental utterances and responses during parent-child interactions across the HL and TH groups during the prelinguistic period of language development. Understanding differences in the prelinguistic environment of children with HL and the relationship between parental language input and early language development may offer a new perspective on the development of early intervention strategies tailored for children with HL and their parents. Specifically, three research questions guided this study:

1. Do parents of children with HL provide fewer utterances and fewer high-quality utterances than parents of children with TH during parent-child interactions?
2. Do parents of children with HL provide a lower rate of overall responses and a lower rate of high-quality responses than parents of children with TH during parent-child interactions?

3. Is the relationship between the quantity and quality of parental language input and early language development conditional upon a child's hearing status (hearing loss versus typical hearing)?

CHAPTER 2: METHODS

Participants

Thirty children (13 in the HL group and 17 in the TH group) and their parents participated. Participants were recruited from Nashville, Tennessee, and the larger Chicago area in Illinois. Inclusion criteria for children with HL were as follows: (a) chronological age between 9 and 30 months at the time of recruitment; (b) bilateral sensorineural HL greater than 25 dB; (c) no cochlear implant at the time that the home visit was conducted; (d) from a home where English was the primary language; and (e) no additional medical diagnoses. Children in the TH group were evaluated to determine whether they met the following criteria: (a) chronological age between 9 and 30 months at the time of recruitment; (b) from a home where English was the primary language; and (c) no HL or other medical condition based on parent report.

After the initial screening, eligible children and their parent were enrolled in the study. Baseline and demographic information for participants is provided in Table 1. Audiological information for children in the HL group was acquired from their audiology records. Children with HL in this study presented with varying degrees of hearing loss, ranging from mild to profound. All children with HL were using bilateral hearing aids. Maternal education was measured as a proxy for socioeconomic status (Ensminger & Fothergill, 2003; Hoff, 2006). Results from independent *t*-tests and chi-square tests indicated that children in the two groups did not differ significantly on age, gender, race, or cognitive skills (all *p*s > .05). However, a significant difference was detected in maternal education: mothers in the TH group had higher levels of education than mothers in the HL group ($p < .01$). This difference was accordingly tested and addressed in the following statistical analyses.

Measures

Early language development measure. Children's early language skills were assessed by trained research staff using the Communication and Symbolic Behavioral Scale Developmental Profile (CSBS-DP; Wetherby & Prizant, 2002). The CSBS-DP is a standardized tool to evaluate communication and language abilities of children whose functional communication age is between 6 and 24 months. Three composite scores (Social, Speech, and Symbolic composites) combine to form a total score. Total raw scores from the CSBS-DP served as dependent variables for three reasons: (a) standard or age equivalency scores were dependent on a sample normed with children with typical hearing and thus would be uninterpretable for children with HL; (b) this instrument has only been normed in children between the ages of 12 and 24 months, and our sample included children up to 30 months; and (c) we were interested in children's individual communication competency instead of their relative standing within a population.

Cognitive skills measure. Raw scores from the Visual Reception Subscale of the Mullen Scales of Early Learning (Mullen, 1995) was used to assess participants' nonverbal cognitive skills. The Mullen is a norm-referenced developmental test for children from birth to 68 months. The Visual Reception Subscale tests children's visual processing, visual-spatial, and memory abilities and was used to control for nonverbal cognitive level across groups.

Procedure and Coding Definitions

As part of a larger longitudinal study (R03DC012639), home visits were conducted to collect data on parent-child interaction and children's early language development skills. A 20-minute parent-child play session was collected in each participant's home. The parents were instructed to play as they normally would until the timer beeped. Sessions were recorded by a hand-held digital video recorder and later transcribed using Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 1985) conventions and coded by trained research staff.

The middle ten minutes of each interaction sample was coded using a timed-event, frequency-based behavior sampling procedure (Yoder & Symons, 2010) with Mangold InterACT, a software that allows frame-by-frame coding of observational data from digital media (video and audio). The following child and parent variables were coded: child communicative acts, temporal contingency of parental utterances (i.e. within 3 secs from a child communicative act), topic contingency of parental utterances (i.e. related to child's focus of attention or communication), and semantic richness of parental utterances (i.e. contain at least one meaningful content word).

Child communicative acts. A child communicative act was defined as a production of (a) a real word that contains at least one consonant and one vowel and has a consistent referent; (b) a vocal communication that consists of non-word vocalization; (c) a gesture that represents a specific action, item, or idea (e.g. head nod, thumbs-up, waving, proximal pointing, etc.), or a gesture that intrinsically shows coordinated attention to an object and an adult (e.g. giving, bidding to receive, showing, etc.); or (d) a conventional sign (e.g. American Sign Language).

Temporal contingency of parent utterances. Temporal contingency measures how quickly a parent responds to a child's communicative act. After child communicative acts were identified, parent utterances that occurred within 3 seconds of child communicative acts were coded as temporally contingent. Based on previous mother-child interaction studies, a 3-second time window best captures temporal contingencies (Van Egeren, Barratt, & Roach, 2001). Data from Smith and McMurray (2018) also suggest that most contingent responses occurred within 3 seconds for parents in the TH and HL groups.

Topic contingency of parent utterances. Topic contingency captures how well a parent takes the child's lead and models language based on the child's focus of attention or communication. An utterance was coded as topic-contingent if it is related to what the child was communicating or doing. Linguistic mapping, repetition, grammatical recasts, and semantic expansions are some examples of topic-contingent utterances. In contrast, behavior management, redirects, or utterances that don't correspond to the presumed topic of the interactive context are counterexamples of topic contingency.

Semantic richness of parent utterances. A parent utterance was coded as semantically rich if it includes at least one meaningful content vocabulary (e.g. common or proper noun, content verb, adjectives, adverbs, and prepositions referring to locations). Counterexamples include non-lexical conversation fillers (e.g., "uh-huh", "hmm"), sound effects (e.g. "whee", "vroom-vroom"), generic attention-getting and social phrases (e.g. "hey", "here", "there you go"), and interjections (e.g. "yay", "wow", "oops"). Examples of coded variables are included in Table 2. Additional details and the coding manual are also available upon request.

Parental Language Input Dependent Variables

Four parent-level dependent variables (Table 3) representing quantity and quality of overall parent utterances and parent responses were derived from SALT transcriptions and coded variables. Quantity of overall parent utterances was measured by calculating the total number of parent utterances from the SALT transcriptions. Quality of overall parent utterances was measured by calculating the total number of high-quality utterances. A parent utterance was considered high-quality if it was coded as both topic contingent and semantically rich. Quantity of overall parent responses was measured by dividing the number of parent utterances coded as temporally contingent to child communicative acts by the total number of child communicative acts. Parent responsiveness was measured using a proportion metric instead of a count metric to control for child communication rate because a parent only had the opportunity to respond after a child communicative act. Using a count metric would penalize responsive parents whose children rarely communicated. Finally, quality of parent responses was measured by dividing the number of high-quality responses by the total number of child communicative acts. Similar to high-quality utterances, high-quality responses referred to parent responses that were coded as temporally contingent, topic contingent, and semantically rich.

Reliability

Reliability was calculated by having a second coder independently recode 20% of parent-child interaction video recordings for each group. Interobserver reliability was computed using intraclass correlation coefficients (ICCs), which reflects the proportion of the variability in the reliability sample that is due to among-participant variance in true score estimates of the behavior of interest (Shavelson & Webb, 1991; Yoder & Symons, 2010). ICC values were above .93 for all dependent variables except for rate of parent high-quality responses (ICC = .64). Based on Suen and Ary (1989), ICC values above .6 are considered acceptable.

Data Analysis

Preliminary analyses were conducted to rule out potential threats to internal validity. First, proportion variables were tested for violations of normality assumption using the Shapiro-Wilk's W test. Results indicate that neither proportion variable violated normality (ps > .1). Accordingly, original data were used without being arc sin transformed. Next, *t*-tests and chi-square analyses were conducted for all demographic characteristics that potentially associate with child or parent dependent variables to examine group equivalence. No significant difference was detected on child age, gender, race, or cognitive skills between groups (all ps > .1).

However, though all mothers were high-school educated, a significant difference was detected in maternal education across the two groups: mothers in the TH group had higher levels of education than mothers in the HL group, $\chi^2(2) = 10.3$, $p = .006$. One-way analysis of variance (ANOVA) was then conducted to examine whether maternal education was independent of the dependent variables. No significant association was detected between maternal education and child CSBS-DP score or parental language input dependent variables (all ps > .05). Due to the lack of association between maternal education and the dependent variables of interest, maternal education was not controlled for in the following analyses.

For the first two research questions, two-tailed independent *t*-tests were conducted to test for potential differences in overall parent utterances, high-quality utterances, rate of overall responses, and rate of high-quality responses between two groups. For the third research question that investigated the relationship between parental language input and early language skills and the extent to which this relationship was conditional upon child's hearing status, linear regression models were constructed for each parent-level dependent variable to predict child CSBS-DP total raw scores (4 regression models in total). Due to the limited sample size, separate linear regression models were used for each parental language input variable to preserve statistical power. For each model, the parent variable was entered first, the hearing group status was entered second as a dummy-coded variable, and the product term that represents the interaction between the parent variable and the group was entered last. Effect sizes were reported as Cohen's *d*.

CHAPTER 3: RESULTS

We predicted that significant differences will be detected in all four parental language input variables across the TH and the HL group, favoring parents of children with TH. We further predicted that the relationship between parental language input and early language development will be conditional upon the hearing status. In children with TH, early language development will be significantly predicted by parental language input, and this significant relationship between parental language input and early language development will be attenuated in the HL group.

Overall Parent Utterances and High-Quality Utterances

For the first research question, we compared parents' overall utterances and high-quality utterances across two groups, as shown in Table 4. On average, parents of children with TH used 179 utterances (SD = 41) during 10 minutes of parent-child interaction. Parents of children with HL on average used 129 utterances (SD = 43). As predicted, both overall utterances and high-quality utterances differed significantly between the groups (Figure 1AB), with children with HL being exposed to significantly fewer overall utterances, $t(28) = 3.31$, $p < .01$, Cohen's $d = 1.19$, and fewer high-quality utterances, $t(28) = 2.61$, $p = .01$, $d = .96$.

Rate of Overall Parent Responses and High-Quality Responses

For the second research question, we analyzed the rate of overall parent responses and the rate of high-quality responses across two groups (Table 4). On average, parents of children with TH had an overall response rate of 85% (SD = 11%) and a high-quality response rate of 36% (SD = 17%). Parents of children with HL had an average overall response rate of 78% (SD = 11%) and a high-quality of response rate of 14% (SD = 10%). A significant difference was found only in the rate of high-quality parent responses, $t(28) = 4.25$, $p < .01$, $d = 1.56$, but not in the rate of overall parent responses, $t(28) = 1.61$, $p = 0.12$, $d = .59$ (Figure 1CD).

Relationship between Parent Language Input and Early Language Development

For the third research question, we explored the relationship between parental language input and early language development and the extent to which this relationship was conditional upon the hearing status of the child. No statistically significant interaction effect was detected between any parental language variables and the hearing status when the product terms were entered into the regression model (all *p*s >.05). Given the lack of parent language input variables × hearing status interaction, the two hearing groups were pooled for the next set of analyses.

Four parental language input variables were then respectively entered into separate regression models as independent variables to predict child CSBS-DP total raw score. As shown in Table 5, significant main effects were detected for three out of four parental language input variables: overall parent utterances, $B = 0.29$, $SE = 0.11$, $\beta = .44$, $p = .01$, adjusted $R^2 = .17$, high-quality utterances, $B = 0.80$, $SE = 0.18$, $\beta = .65$, $p < .001$, adjusted $R^2 = .40$, and the rate of high-quality parent responses, $B = 129.70$, $SE = 23.12$, $\beta = .73$, $p < .001$, adjusted $R^2 = .51$. The regression model for the rate of overall parent responses was not significant, $B = 66.98$, $SE = 50.68$, $\beta = .10$, $p = .2$, adjusted $R^2 = .03$.

Post-hoc Analyses

A new question emerged as we consolidated the findings. Given that parents of children with HL provided their child with comparably consistent overall responses but significantly lower rate of high-quality responses compared to parents of children with TH, we conjectured that the quality of parent responses may be driven by the intelligibility of child communications. Though all parent responses were temporally contingent to a child's previous communicative act, they might not carry meaningful linguistic content. When a child produces an unintelligible utterance or an ambiguous communicative act, it is more likely that the parent responds to such unclear utterances with conversation fillers or generic social phrases (e.g. “uh-huh”, “okay then”, “there you go!”) to acknowledge the child’s communication without fully understanding the child’s intended meaning. Children with HL may produce more unclear communicative acts than children with TH do and thus elicit more generic adult responses that contain less semantic content.

This hypothesis was tested post-hoc in two steps. First, for each participant, a new percentage variable representing intelligibility rate was created by summing the number of intelligible communicative acts (defined as communicative acts in which all words were transcribed) and dividing by the total number of communicative acts. An arc sin transformation was conducted on the values of this percentage variable because it violated the normality assumption. A between-group independent *t*-test was then conducted to examine whether children with HL produced a higher percentage of unintelligible communicative acts compared to children with TH. Significant differences was detected, with children with HL having a higher percentage of unintelligible communicative acts than children with TH, $t(27.956) = 2.96$, $p < .01$, $d = 1.05$ ($M_{HL} = 24\%$, $SD_{HL} = 15\%$; $M_{TH} = 48\%$, $SD_{TH} = 29\%$).

Next, a sequential analysis was conducted to test whether parents were more likely to use a high-quality utterance following a child intelligible communicative act versus a child unintelligible communicative act. A sequential metric of association was selected over nonsequential metrics of association, such as Pearson’s *r*, because the latter ignores the temporal sequence of two behaviors and can only indicate the extent to which two behaviors co-occur. To quantify the sequential associations, we used the risk difference index (RD; Higgins & Green, 2011), also termed operant contingency value (OCV; Martens, Gertz, Werder, Rymanowski, &

Shankar, 2014). This index is defined as the difference between two conditional probabilities: the probability of a second event given the presence of a first event minus the probability of a second event given the absence of a first event. This sequential metric was selected because it has been shown to quantify contingencies between two behaviors while controlling for each behavior's base occurrence rate (Lloyd, Kennedy, & Yoder, 2013; Yoder & Symons, 2010). Risk differences range from -1 to 1, with positive values indicating that a second behavior is more likely to occur given the presence of a first behavior and negative values indicating that a second behavior is less likely to occur given the presence of a first behavior.

In this analysis, the first event was child intelligible communicative act and the second event was parental high-quality utterance. The second event was parental high-quality utterance instead of high-quality response because the data have to meet the requirements of a 2x2 contingency table analysis that each behavior of interest consists of mutually exclusive categories (child intelligible communicative act and parental high-quality utterances are either present or absent) and the two behaviors of interest can be coded independently of each other (Lloyd et al., 2013). Behavior pairs that represent the presence or absence of the first and the second behavior (four pairs in total) were tallied into the four cells of a 2x2 contingency table (See Table 6 in the appendices for the 2x2 contingency table). A RD index was computed for each participant. A mean RD was then calculated for each group and the pooled group.

Results confirmed our post-hoc hypothesis. The mean RD for the HL group was 0.25 (*SD* = 0.30) and for the TH group is 0.39 (*SD* = 0.20). The mean RD for the pooled group was 0.33 (*SD* = 0.25). One-sample *t*-tests with each RD as the dependent variable revealed that all three means significantly differed from zero (*p*s <.01, Cohen's *d*s range from 0.93 to 1.95). An independent *t*-test was conducted to test whether the positive sequence of parental high-quality utterances following intelligible communicative acts was stronger in the TH group compared to the HL group. No significant difference was detected between the two groups, $t(28) = 1.58$, $p = 0.13$. The positive RD indices for both groups and the pooled group indicate that parental high-quality utterances follow intelligible communicative acts more than expected by chance. The positive sequential association did not differ by group. In other words, our findings suggest that for both children with HL and children with TH, intelligible communicative acts were more likely to elicit high-quality utterances. Taken together, these results were consistent with our conjecture that parents of children with HL may have provided lower rate of high-quality responses because their children had more unintelligible communicative acts compared to the TH group.

CHAPTER 4: Discussion

This purpose of this study was to examine parental language input to children with HL in comparison to input to children with TH. The first and second research questions assessed the extent to which the quantity and quality of parental utterances and responses directed to children with HL differed from those directed to children with TH. The third research question explored the relationship between parental language input and early language development in both groups. This study is unique in that it is the first study to examine parent utterances in response to child's communicative acts in this population. Results indicate that children with HL were exposed to fewer overall utterances, fewer high-quality utterances, and a lower rate of high-quality responses. No interaction was detected between parental language input and hearing status. All but the rate of overall responses positively associated with early language skills measured by CSBS-DP total raw score in the pooled group. Post-hoc analyses also reveal that the intelligibility of child communications influenced parents' use of high-quality utterances.

Between-Group Differences in Parental Language Input

Findings from this study support our hypothesis for the first research question. Parents of children with HL used significantly fewer overall utterances and fewer high-quality utterances compared to parents of children with TH. Interestingly, our findings on overall parental utterances contradicted findings from two previous studies (Ambrose et al., 2015; Vandam et al., 2012). Both of these studies examined the quantity of parental language input (as measured by the number of adult utterances and the number of adult words) and did not find significant differences between the HL group and the TH group. It is likely that the difference in findings was driven by methodological differences. Ambrose and colleagues (2015) used a 5-minute structured task, the Art Gallery task (Adamson, Bakeman, & Deckner, 2004; Quittner, Leibach,

& Marciel, 2004) to elicit parental language input. In this task, five art pictures were mounted on the walls of the lab and parents were instructed to show the pictures to the child, talk about the pictures, and determine which picture the child likes the best and the least. In contrast, parental language input was sampled in a free-play context in the child's home in our study. The differences in the level of structure of the task (structured vs. unstructured) and the location (lab vs. home) might explain the inconsistent evidence between this study and Ambrose et al. (2015). Additionally, Vandam and colleagues sampled the linguistic environment of children with HL by using an automated technology, the Language Environment Analysis system (LENA™; Ford, Baer, Xu, Yapanel, & Gray, 2008). Full-day recordings of children's natural linguistic environment were automatically processed to yield the number of adult words. However, this automated software did not differentiate adult language directed to the child versus adult language directed to other communication partners in the context. One possible explanation for these divergent findings is that children with HL may be exposed to comparable quantity of adult language input in their overall linguistic environment but significantly less quantity of adult language input directed to them. Taken together, these inconsistent results across studies highlight the impact that behavioral sampling context may have on dependent measures. Future research is needed to determine the extent to which parental language input vary based on communication tasks and the type of communication tasks that elicit most representative samples.

With regard to parent responses to child communicative acts, a significant difference was detected in the rate of parent high-quality responses to child communicative acts but not in the rate of overall responses. The disparity observed in the rate of parental high-quality responses between groups was particularly striking. For children with TH, parents responded to child communication in a high quality manner approximately one third of the time (36%). In contrast, for children with HL, parents only responded with high-quality language input to one in seven child communications (14%). Post-hoc analyses revealed two exploratory findings. First, the positive sequential association between intelligible communicative acts from the child and parental high-quality utterances in both the HL and the TH group extended current evidence by demonstrating that the differences in the quality of parental responses were partly driven by characteristics of child communications. Specifically, parents are less likely to respond to unintelligible communicative acts with a relevant utterance with rich semantic content than to an intelligible one. For example, an unclear child communicative act such as a growl without a paired gesture will be more likely to elicit a generic non-content response than a clear communicative act such as "ball" because it is more challenging to expand or recast a child's communication without understanding his or her intent. Taken together, these results converge with previous findings that children with HL were exposed to parental language input of poorer quality (Ambrose et al., 2015; Spencer, 1993) and further highlight the bi-directionality of parent-child interaction.

Associations with Child Early Language Skills

For the third research question, it was hypothesized that the relationship between parental language input variables and early language development would be conditional upon the hearing status. This hypothesis was not supported by the results. No significant interaction was detected between parental language input variables and the hearing status. In one previous studies (Smith & McMurray, 2018), the authors found that the influence of temporal properties of maternal responses on the child's response latency was moderated by hearing status. The authors further suggested that hearing loss may exert subtle effects on the interaction coordination between children with HL and their mothers. Even though we did not detect an interaction between hearing status and parental language input, our findings are not incompatible with findings from Smith and McMurray (2018) and simply reflect different aspects of parent-child interaction. While Smith and McMurray showed that coordination between children with HL and their parents may be less aligned than children with TH and their parents, our finding suggests that parent utterances and responses positively attribute to early language development regardless of hearing status.

When two groups were pooled together to examine the relationship between parental language input and early language skills, results indicate that the number of overall parental utterances, the number of high-quality utterances, and the rate of high-quality responses concurrently associated with children's early language skills. However, the rate of overall parental responses did not significantly associate with CSBS-DP scores. It is reasonable that parent responses that are irrelevant to child's communication or do not contain rich linguistic content may not be particularly helpful to young language learners with vulnerable linguistic systems. One previous study provided consistent evidence that parental language input that does not provide meaningful linguistic input was negatively associated with later language production ability (Haebig, McDuffie, & Ellis Weismer, 2013). For children with HL who have less verbal communications and attenuated access to parental language input, parents' responses that are temporally contingent but don't include meaningful semantic content may be less facilitative to their language learning.

Clinical Implications

What should parents do when they are uncertain of the nature of their child's intention of communication during interaction? One adaptive strategy is to pay close attention to their child's focus of attention in order to be better detectives of possible communication intents. Parental responses in this study were limited to the responses that follow a child's communicative act. However, there is mounting evidence that parental responses to the focus of attention facilitate language learning in both typical and atypical population (McDuffie & Yoder, 2010; Siller & Sigman, 2008). Parental utterances following the focus of attention have been found to account for unique variances in predicting spoken vocabulary gain in children with ASD (McDuffie & Yoder, 2010) and in children with Fragile X Syndrome (Brady, Warren, Fleming, Keller, & Sterling, 2014). Additionally, multiple intervention studies have demonstrated that parent responsiveness is a malleable factor in parent-child interaction (Girolametto, 1988; Venker, McDuffie, Ellis Weismer, & Abbeduto, 2012). Parents were able to describe their child's focus of attention and interpret their child's communicative act following a parent-mediated intervention training that incorporated both parent education and hands-on coaching (Venker et al., 2012). Findings from a meta-analysis of parent-implemented language interventions provided convergent evidence that parents of children with language impairments learned to be more responsive than parents who were not trained (Roberts & Kaiser, 2011). When receiving an unclear utterance from the child, the parent could respond to their child's focus of attention, describe an object of joint attention, or narrate an activity in which the child is engaged. Future studies may investigate further the extent to which such an adaptive strategy is empirically effective for children with HL.

Limitations and Future Directions

The findings from this study should be considered within the context of several limitations. First, considering the small sample size, parental language variables were added to multiple regression models separately to preserve statistical power. It remains unknown whether one aspect of parental language input is more effective than another. Future studies with more participants should investigate how these language support strategies statistically interact with each other or whether one specific strategy is a value-added predictor of child language growth. Additionally, due to limited resources and scope of this study, we were only able to code a 10-minute parent-child interaction sample. One may also question the internal validity of findings from this study based on the relative low ICC for the rate of high-quality responses (ICC = .64). However, low ICCs are associated with a heightened probability of Type II errors (false negative results). The finding that parents of children with HL demonstrated lower rate of high-quality responses compared to parents of children with TH and the significant correlations between the rate of high-quality responses and early language skills suggest that the relatively low ICC for this variable is not a concern of the current study.

Finally, the concurrent intact group design and concurrent correlation design were not sufficient to examine the directionality of the relationship between parental language input and early language development. This study offered important clinical implications on understanding prelinguistic language-learning environment for children with HL. Future studies should follow language development of children with HL longitudinally to understand further the predictive power of parental language input on child language development over time. Further investigation is also needed to study how parent training may influence parent-child interactions and subsequent language development.

REFERENCES

Adamson, L. B., Bakeman, R., & Deckner, D. F. (2004). The development of symbol-infused joint engagement. *Child Development*, *75*, 1171–1187.

Ambrose, S. E., Thomas, A., & Moeller, M. P. (2016). Assessing vocal development in infants and toddlers who are hard of hearing: A parent-report tool. *The Journal of Deaf Studies and Deaf Education*, *21*, 237–248.

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*, 48S-59S.

Baumwell, L., Tamis-LeMonda, C. S., & Bornstein, M. H. (1997). Maternal verbal sensitivity and child language comprehension. *Infant Behavior and Development*, *20*, 247–258.

Bhat, R. J., & Nagaraja, M. N. (2012). Maternal communicative style with children with hearing impairment – An old question revisited. *Indian Journal of Applied Linguistics*, *38*, 17–25.

Bornstein, M. H., & Tamis-LeMonda, C. S. (1989). Maternal responsiveness and cognitive development in children. *New Directions for Child and Adolescent Development*, *1989*, 49–61.

Brady, N., Warren, S. F., Fleming, K., Keller, J., & Sterling, A. (2014). Effect of sustained maternal responsivity on later vocabulary development in children with fragile X syndrome. *Journal of Speech, Language, and Hearing Research*, *57*, 212–226.

Carlson, M. L., Sladen, D. P., Haynes, D. S., Driscoll, C. L., DeJong, M. D., Erickson, H. C., … Davis, T. J. (2015). Evidence for the expansion of pediatric cochlear implant candidacy. *Otology & Neurotology*, *36*, 43–50.

Cole, E. B., & Flexer, C. (2015). *Children with hearing loss:Dveloping listening and talking, birth to six* (3rd). Plural Publishing.

Depowski, N., Abaya, H., Oghalai, J., & Bortfeld, H. (2015). Modality use in joint attention between hearing parents and deaf children. *Frontiers in Psychology*, *6,* 1-8.

DesJardin, J. L., Doll, E. R., Stika, C. J., Eisenberg, L. S., Johnson, K. J., Ganguly, D. H., … Henning, S. C. (2014). Parental Support for Language Development During Joint Book Reading for Young Children With Hearing Loss. *Communication Disorders Quarterly*, *35*, 167–181.

Ensminger, M. E., & Fothergill, K. (2003). A decade of measuring SES: What it tells us and where to go from here. *Socioeconomic Status, Parenting, and Child Development.13, 27*.

Ford, M., Baer, C. T., Xu, D., Yapanel, U., & Gray, S. (2008). The LENA™ language environment analysis system: Audio specifications of the DLP-0121. *Boulder, CO: Lena Foundation*.

Gale, E., & Schick, B. (2009). Symbol-infused joint attention and language use in mothers with deaf and hearing toddlers. *American Annals of the Deaf*, *153*, 484–503.

Geers, A., Tobey, E., Moog, J., & Brenner, C. (2008). Long-term outcomes of cochlear implantation in the preschool years: From elementary grades to high school. *International Journal of Audiology*, *47*, S21–S30.

Girolametto, L. E. (1988). Improving the social-conversational skills of developmentally delayed children: An intervention study. *Journal of Speech and Hearing Disorders*, *53*, 156–167.

Girolametto, L., Weitzman, E., Wiigs, M., & Pearce, P. S. (1999). The relationship between maternal language measures and language development in toddlers with expressive vocabulary delays. *American Journal of Speech Language Pathology; Rockville*, *8*, 364 - 374.

Gros-Louis, J., West, M. J., Goldstein, M. H., & King, A. P. (2006). Mothers provide differential feedback to infants' prelinguistic sounds. *International Journal of Behavioral Development*, *30*, 509–516.

Haebig, E., McDuffie, A., & Ellis Weismer, S. (2013). Brief report: Parent verbal responsiveness and language development in toddlers on the autism spectrum. *Journal of Autism and Developmental Disorders*, *43*, 2218–2227.

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

Higgins, J., & Green, S. (2011). *Cochrane handbook for systematic reviews of interventions. The Cochrane Collaboration*. London, UK.

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review*, *26*, 55–88.

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*, 343–365.

Kishon-Rabin, L., Taitelbaum-Swead, R., & Segal, O. (2009). Prelexical infant scale evaluation: From vocalization to audition in hearing and hearing impaired infants. *Clinical Management of Children with Cochlear Implants*, 325–368.

Landry, S. H., Smith, K. E., & Swank, P. R. (2006). Responsive parenting: Establishing early foundations for social, communication, and independent problem-solving skills. *Developmental Psychology*, *42*, 627–642.

Landry, S. H., Smith, K. E., Swank, P. R., Assel, M. A., & Vellet, S. (2001). Does early responsive parenting have a special importance for children's development or is consistency across early childhood necessary? *Developmental Psychology*, *37*, 387–403.

Levitt, H., McGarr, N., & Geffner, D. (1987). Development of language and communication skills in hearing-impaired children. Introduction. *ASHA Monographs*, 1–8.

Lloyd, B. P., Kennedy, C. H., & Yoder, P. J. (2013). Quantifying contingent relations from direct observation data: Transitional probability comparisons versus Yule's Q. *Journal of Applied Behavior Analysis*, *46*, 479–497.

Martens, B. K., Gertz, L. E., Werder, C. S., Rymanowski, J. L., & Shankar, K. H. (2014). Measures of association in contingency space analysis. *Journal of Mathematical Psychology*, *59*, 114–119.

McCreery, R. W., Bentler, R. A., & Roush, P. A. (2013). The characteristics of hearing aid fittings in infants and young children. *Ear and Hearing*, *34*.

McCreery, R. W., Walker, E. A., Spratford, M., Bentler, R., Holte, L., Roush, P., … Moeller, M. P. (2015). Longitudinal predictors of aided speech audibility in infants and children. *Ear and Hearing*, *36*, 24S-37S.

McDuffie, A., & Yoder, P. (2010). Types of parent verbal responsiveness that predict language in young children with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research*, *53*, 1026–1039.

Miller, J., & Chapman, R. (1985). Systematic analysis of language transcripts. *Madison, WI: Language Analysis Laboratory*.

Moeller, M. P. (2000). Early intervention and language development in children who are deaf and hard of hearing. *Pediatrics*, *106*, e43–e43.

Moeller, M. P., Hoover, B., Peterson, B., & Stelmachowicz, P. (2009). Consistency of hearing aid use in infants with early-identified hearing loss. *American Journal of Audiology*, *18*, 14-23.

Moeller, M. P., Hoover, B., Putman, C., Arbataitis, K., Bohnenkamp, G., Peterson, B., ... & Stelmachowicz, P. (2007). Vocalizations of infants with hearing loss compared with infants with normal hearing: Part II–Transition to words. Ear and Hearing, 28(5), 628-642.

Moeller, M. P., Tomblin, J. B., & OCHL Collaboration. (2015). Epilogue: Conclusions and implications for research and practice. *Ear and Hearing*, *36(1)*, 92S–98S.

Mullen, E. M. (1995). *Mullen scales of early learning*. AGS Circle Pines, MN.

Muñoz, K., Olson, W. A., Twohig, M. P., Preston, E., Blaiser, K., & White, K. R. (2015). Pediatric hearing aid use: Parent-reported challenges. *Ear and Hearing*, *36*, 279–287.

Niparko, J. K., Tobey, E. A., Thal, D. J., Eisenberg, L. S., Wang, N. Y., Quittner, A. L., ... & CDaCI Investigative Team. (2010). Spoken language development in children following cochlear implantation. Jama, 303(15), 1498-1506.

Pressman, L., Pipp-Siegel, S., Yoshinaga-Itano, C., & Deas, A. (1999). Maternal sensitivity predicts language gain in preschool children who are deaf and hard of hearing. *Journal of Deaf Studies and Deaf Education*, *4*, 294–304.

Prezbindowski, A. K., Adamson, L. B., & Lederberg, A. R. (1998). Joint attention in deaf and hearing 22 month-old children and their hearing mothers. *Journal of Applied Developmental Psychology*, *19*, 377–387.

Quittner, A. L., Leibach, P., & Marciel, K. (2004). The impact of cochlear implants on young deaf children: new methods to assess cognitive and behavioral development. *Archives of Otolaryngology–Head & Neck Surgery*, *130*, 547–554.

Roberts, M. Y., & Kaiser, A. P. (2011). The effectiveness of parent-implemented language interventions: A meta-analysis. *American Journal of Speech-Language Pathology*, *20*, 180–199.

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech vocabulary development. *Child Development*, *83*, 1762–1774.

Sameroff, A. (1975). Transactional models in early social relations. *Human Development*, *18*, 65-79.

Scherer, N. J., & Olswang, L. B. (1984). Role of mothers' expansions in stimulating children's language production. *Journal of Speech and Hearing Research*, *27*, 387–396.

Shavelson, R. J., & Webb, N. M. (1991). *Generalizability theory: A primer*. Sage.

Siller, M., & Sigman, M. (2008). Modeling longitudinal change in the language abilities of children with autism: parent behaviors and child characteristics as predictors of change. *Developmental Psychology*, *44*, 1691–1704.

Smith, K., Landry, S. H., & Swank, P. R. (2000). Does the Content of Mothers' Verbal Stimulation Explain Differences in Children's Development of Verbal and Nonverbal Cognitive Skills? *Journal of School Psychology*, *38*, 27–49.

Smith, N., & McMurray, B. (2018). Temporal responsiveness in mother-child dialogue: a longitudinal analysis of children with normal hearing and hearing loss. *Infancy*, 1–22.

Snow, R. E. (1977). Individual differences and instructional theory. *Educational Researcher*, *6*, 11–15.

Spencer, P. E. (1993). Communication behaviors of infants with hearing loss and their hearing mothers. *Journal of Speech, Language, and Hearing Research*, *36*, 311–321.

Stoel-Gammon, C., & Otomo, K. (1986). Babbling development of hearing-impaired and normally hearing subjects. *Journal of Speech and Hearing Disorders*, *51*, 33–41.

Suen, H. K., & Ary, D. (1989). *Analyzing quantitative observation data*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development*, *72*, 748–767.

Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language outcomes in young children with mild to severe hearing loss. *Ear and Hearing*, *36*, 76S-91S.

Van Egeren, L. A., Barratt, M. S., & Roach, M. A. (2001). Mother–infant responsiveness: Timing, mutual regulation, and interactional context. *Developmental Psychology*, *37*, 684–697.

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*, 402–420.

Venker, C. E., McDuffie, A., Ellis Weismer, S., & Abbeduto, L. (2012). Increasing verbal responsiveness in parents of children with autism: A pilot study. *Autism*, *16*, 568–585.

Vihman, M. M., & Greenlee, M. (1987). Individual differences in phonological development: Ages one and three years. *Journal of Speech and Hearing Research*, *30*, 503–521.

Vohr, B., Jodoin-Krauzyk, J., Tucker, R., Johnson, M. J., Topol, D., & Ahlgren, M. (2008). Early Language Outcomes of Early-Identified Infants With Permanent Hearing Loss at 12 to 16 Months of Age. *Pediatrics*, *122*, 535–544.

Von Hapsburg, D., & Davis, B. L. (2006). Auditory sensitivity and the prelinguistic vocalizations of early-amplified infants. *Journal of Speech, Language, and Hearing Research; Rockville*, *49*, 809–822.

Wetherby, A. M., & Prizant, B. M. (2002). *Communication and symbolic behavior scales: Developmental profile*. Paul H Brookes Publishing.

Yoder, P., & Warren, S. (1999). Maternal responsivity mediates the relationship between prelinguistic intentional communication and later language. *Journal of Early Intervention*, *22*, 126–136.

Yoder, P., & Symons, F. (2010). *Observational measurement of behavior*. Springer Publishing Company.

Appendix

Table 1.

Baseline and Demographic Information for Parents and Children in the Study.

Characteristic	HL group (n = 13)	TH group (n=17)
Age in months (mean, SD)	14.7 (4.5)	17.4 (4.3)
Age range in months	10 – 27	11 – 29
Gender (n, %)		
Male	8 (61.5%)	9 (52.9%)
Female	5 (38.5%)	8 (47.1%)
Race (n, %)		
Caucasian	12 (85.8%)	13 (76.5%)
African American	0 (0%)	0 (0%)
Asian	0 (0%)	0 (0%)
Other	1 (7.1%)	4 (23.5%)
Ethnicity (n, %)		
Hispanic	1 (7.7%)	0 (0%)
Non-Hispanic	12 (92.3%)	17 (100%)
Maternal education (n, %)		
High school	0 (0%)	0 (0%)
Some college	4 (30.8%)	0 (0%)
College or higher	8 (61.5%)	17 (100%)
Not reported	1 (7.7%)	0 (0%)
Cognitive skills (mean, SD)		
MSEL – Visual Reception Subscale [a]	20.38 (11.98)	20.47 (3.86)
Level of hearing loss in best ear when unaided		
Mild (26 – 40 dB)	3 (23%)	
Moderate (41 – 55 dB)	3 (23%)	
Severe (71 – 90 dB)	3 (23%)	
Profound (> 90 dB)	4 (31%)	
Age at hearing loss identification (month, range)	5.83 (0.6 – 24.8)	
Age at hearing aid fitting (month, range)	8.0 (1.1 – 29)	
Language skills (mean, SD)		
CSBS – DP total raw score [b]	37.46 (20.77)	76.88 (27.79)
CSBS – DP Social Composite	26 (12.64)	33.59 (6.26)
CSBS – DP Speech Composite	5.62 (6.76)	18.24 (15.55)
CSBS – DP Symbolic Composite	5.85 (5.05)	25.06 (11.51)

Note:

[a] MSEL: Mullen Scales of Early Learning.

[b] CSBS – DP: Communication and Symbolic Behavior Scales – Developmental Profile.

Table 2.

Definition and Examples of Parental Language Input Codes.

Code	**Definition**	**Example**
Temporal contingency	A parental utterance that responds to a child communicative act within 3 seconds.	Child: "Car" (1 sec) Parent: "Yeah, look at the car!"
Topic contingency	A parent utterance that relates to the child's focus of attention or communication.	Child: "Mommy?" Parent: "Yes, I'm here!" Child: "Train!" Parent: "What does your train do?" Child: "Sheep walking." Parent: "The sheep is walking."
Semantic richness	A parent utterance that includes at least one meaningful content vocabulary (e.g. common or proper noun, content verb, adjectives, adverbs, and prepositions referring to locations)	Child: "Ball." Parent: "Roll the ball!" Child: {whoof whoof}. Parent: "I see a dog!" Counterexample: Child: {points to a dog}. Parent: {whoof whoof}. Parent: "Uh-huh." Parent: "There you go."

Table 3.

Definitions and Codes of Parent-Level Dependent Variables.

Dependent variables	Definitions and codes	Construct measured
Overall parent utterances	Number of total utterances from SALT transcriptions	Quantity of parent utterances
High-quality parent utterances	Number of parent utterances coded as topic-contingent and semantically rich	Quality of parent utterances
Rate of overall parent responses	Proportion of parent utterances coded as temporally contingent to child communicative acts	Quantity of parent responses
Rate of high-quality parent responses	Proportion of parent utterances coded as temporally contingent, topic-contingent, and semantically rich to child communicative acts	Quality of parent responses

Table 4.

Summary Statistics and Between-Group Comparison of Parent Utterances and Responses.

Parental Language Input Variables	**HL group (n = 13)**			**TH group (n = 17)**			**HL vs. TH**		
	M	***SD***	**Range**	***M***	***SD***	**Range**	***t***	***p***	***d***
Overall parent utterances	129	43	38 - 200	179	41	118 - 276	3.31	0.003**	1.19
High-quality utterances	35	20	1 - 68	57	26	23 - 105	2.61	0.01*	0.96
Rate of overall parent responses (%)	78	11	65 - 100	85	11	60 - 97	1.61	0.12	0.59
Rate of high-quality responses (%)	14	10	0 - 29	36	17	14 - 66	4.25	<.001***	1.56

Note: HL = hearing loss, TH = typical hearing;

p, obtained significance value; *, $p < .05$; ** $p < .01$; ***, $p < .001$.

Table 5.

Regression Model Results for the Relationship between Parental Language Input Variables and Child CSBS Total Raw Score.

Models	***B***	***SE***	***β***	***t***	***p***	**Adjusted R^2**
Overall utterances	0.29	0.11	0.44	2.61	0.01*	0.17
High-quality utterances	0.80	0.18	0.65	4.50	<.001***	0.40
Rate of overall responses	66.98	50.68	0.24	1.32	0.20	0.03
Rate of high-quality responses	129.70	23.12	0.73	5.61	<.001***	0.51

Note: *B*, unstandardized coefficient; *SE*, standard error; β, standardized coefficient; *t*, obtained *t*-values; *p*, obtained significance value; *, $p < .05$; ** $p < .01$; ***, $p < .001$.

Table 6.

The 2x2 Contingency Table for the Calculation of Risk Difference Indices.

	Second event present (Y): Parental high-quality utterances	Second event absent (non-Y): Any coded events other than parental high-quality utterances
First event present (X): child intelligible communicative act	A X followed by Y	B: X followed by non-Y
First event absent (non-X): any coded event other than child intelligible communicative act	C Non-X followed by Y	D: Non-Y followed by non-X

Note: the risk difference index is calculated using this formula: RD = A/(A+B) – C(C+D).

Figure 1. Group Difference Summary Boxplots.

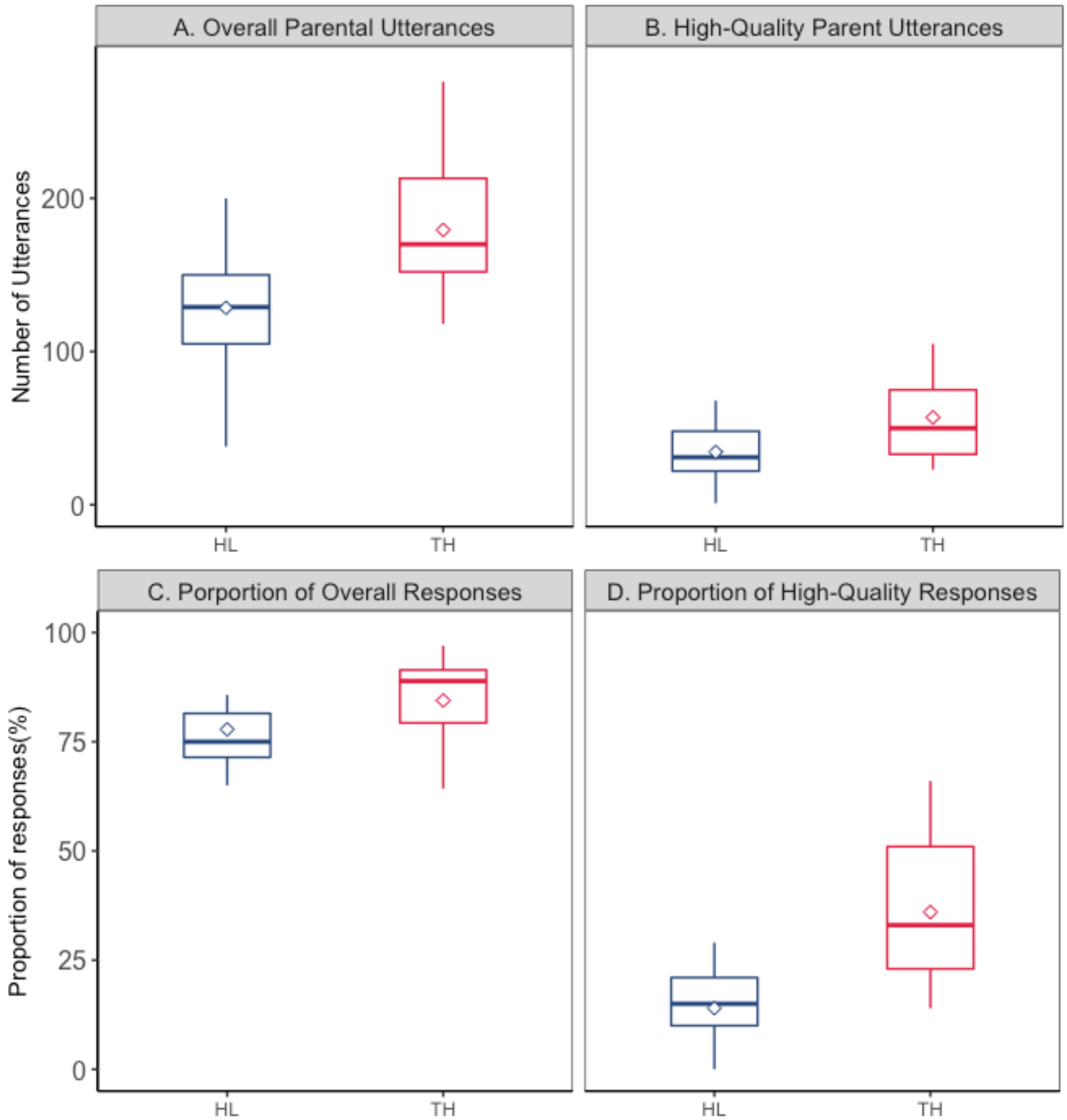

Figure 1 A-D. Boxplots displaying the number of overall parental utterances, the number of high-quality utterances, the rate of overall response, and the rate of high-quality responses in the TH group and the HL group. Mean values were represented by diamonds. Error bars represent ±1 standard deviation.