Quantity and Quality of Parental Utterances and Responses to Children With Hearing Loss Prior to Cochlear Implant

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Abstract

This study investigated the extent to which parental language input to children with hearing loss (HL) prior to cochlear implant (CI) differs from input to children with typical hearing (TH). A 20-min parent–child interaction sample was collected for 13 parent–child dyads in the HL group and 17 dyads in the TH group during free play. Ten minutes were transcribed and were coded for four variables: (a) overall utterances, (b) high-quality utterances, (c) utterances in response to child communicative acts (i.e., overall responses), and (d) high-quality utterances in response to child communicative acts (i.e., high-quality responses). Differences were detected for both quantity and quality of parental language input across the two groups. Early language skills correlated with three out of the four parental variables in both groups. Post hoc analyses suggested that the lower rate of high-quality responses in parents of children with HL could be attributed to lower intelligibility of child communication.

Keywords

hearing loss; language; communication; parent–child interactions

Introduction

The primary goal of this study was to examine the extent to which parental language input to children with hearing loss (HL) prior to cochlear implant (CI) differs from input to children with typical hearing (TH) and to explore the relationship between parental language input and early language development. From a social interactionist perspective of language development (Sameroff, 1975, 2009), children learn language through *bidirectional* and *transactional* language exchanges with caregivers. Parental language input supports language learning by providing the child with developmentally appropriate language models, which in turn results in greater child language skills that subsequently elicit more complex language input from the parent (Sameroff, 2009). Considering the bidirectionality of parent–child

interactions, the communicative behaviors of the child also influence parent behaviors. 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 an interaction.

The implementation of early identification and advances in hearing technology, particularly the CI, has been vital in providing early auditory access and facilitating spoken language learning for children with HL (Nicholas & Geers, 2007; Yoshinaga-Itano, 2004). However, the time lag between identification of HL and the age at which a child receives a CI is often at least 6 months but frequently much longer (Cole & Flexer, 2011; Kelly, 2013). This lag, during which children do not have sufficient access to auditory input, often occurs during the period of prelinguistic communication development (Sharma, Dorman, & Spahr, 2002). Past studies have consistently found that not all children with CIs develop age-appropriate spoken language skills compared to their peers with TH (Geers, Tobey, Moog, & Brenner, 2008; Holt, Beer, Kronenberger, Pisoni, & Lalonde, 2012; Nicholas & Geers, 2007). Thus, it is critical to study parent–child interactions during the prelinguistic period in children with HL who subsequently receive CIs for two primary reasons. First, the prelinguistic period can be an important time for optimizing long-term outcomes (Kaiser & Roberts, 2011), and parental language input is a malleable factor that can be adjusted to promote long-term language development (Roberts & Kaiser, 2011). Therefore, describing this population's prelinguistic learning environment is essential to understanding how early intervention may be tailored during this sensitive period. Second, understanding how parents use language with their children prior to a CI provides a baseline that allows for comparisons of parental language input preimplantation to postimplantation. This study extends the current literature by examining the quantity and quality dimensions of two types of parental language input (utterances and responses) to children with HL prior to implantation.

Unique Challenges Faced by Children Who Are CI Candidates

Despite recent advances in hearing technology, many children who receive CIs still face unique challenges in developing language skills commensurate with their peers with TH (Geers et al., 2008; Niparko et al., 2010). Children with CIs require a significantly longer time period to acquire their first 50 words (Nott, Cowan, Brown, & Wigglesworth, 2009), demonstrate lower expressive and receptive vocabulary knowledge at school entry (Lund, 2016), have difficulty with morphosyntactic development (Boons et al., 2013) and phonological awareness skills (Soleymani, Mahmoodabadi, & Nouri, 2016), and present with insufficient narrative skills (Boons et al., 2013; Crosson & Geers, 2000). Factors such as early auditory deprivation (Carlson et al., 2014), lengthy hearing aid trial periods (Morini, Golinkoff, Morlet, & Houston, 2017), insufficient hearing aid amplification (McCreery, Bentler, & Roush, 2013), and inconsistent hearing aid use (Moeller, Hoover, Peterson, & Stelmachowicz, 2009; Muñoz et al., 2015) continue to impact the amount of early linguistic exposure a child receives (Moeller & Tomblin, 2015).

Federal Drug Administration (FDA) CI candidacy guidelines stipulate a trial of hearing aid use including demonstration of limited-to-no benefit with appropriately fit aids and lack of progress in auditory skill development (Cohen, 2004; Nott et al., 2009). Due to these criteria, children with HL often experience early auditory deprivation for at least 12 months (i.e., the earliest age approved by FDA to receive CIs). The duration of the trial period usually varies depending on the degree of HL and can be a lengthy process (Morini et al., 2017). A study that examined common clinical practice related to CI candidacy revealed that the period is particularly long for children with moderate-to-severe and severe HL (Fitzpatrick et al., 2009). In these children, CIs usually only become an option when children are 18 months or older and not demonstrating any progress with hearing aids (Morini et al., 2017). A prolonged period between HL identification and CI implantation is associated with poorer spoken language outcomes (Niparko et al., 2010). More recent studies have provided convergent evidence that reduced early language experience during the first year of life increases risk for persistent language delays (Levine, Strother-Garcia, Golinkoff, & Hirsh-Pasek, 2016; Moeller & Tomblin, 2015).

Remarkably, even though language development was rated as a major concern for parents of children with CIs during both preimplantation and postimplantation periods (Incesulu, Vural, & Erkam, 2003), parents are not typically provided with evidence-based strategies for communicating with their child and facilitating their child's language development during the preimplantation period (Kelly, 2013). There are abundant investigations on children's language development following CIs, but very little is known about early language development and parent–child interactions during the period prior to implantation. Given that a lag will likely always exist between HL identification and CI implantation, it is necessary to understand parent–child interactions during this critical period of language development. Understanding these interactions will support the delivery of effective early parent-implemented language interventions during this period.

The Impact of HL on Parent–Child Interactions

From a social interactionist perspective of language development (Sameroff, 1975, 2009), a child's language is shaped not only by parent and child characteristics but also by the interactions between the parent and child. Despite the original emphasis on bidirectional transactions between parents and children, the transactional model of development has been used more often to emphasize the unidirectional effect of environmental factors on development instead of the bidirectional interaction between dynamic systems (Sameroff & MacKenzie, 2003). However, it is important to note that instead of being passive recipients of environmental input, children are actively engaged in social interactions and elicit parent communication. The presence of HL may interrupt this transactional language exchange, thereby affecting parental input. For instance, reduced audibility may lead to children being less responsive to the input their parents provide, especially in difficult listening environments such as listening from distance or in background noise (Ambrose, Walker, Unflat-Berry, Oleson, & Moeller, 2015). Consequently, parents may restrict their utterances to ideal listening environments or simplify linguistic input to ensure their child can process the language input.

Evidence that characteristics of communication by children with HL can affect typical parent– child interactions can also be found in research focusing on vocal development and caregiver responsiveness. HL impacts children's prelinguistic vocalizations by at least 8 months of age (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 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). Mothers respond differently to various types of child vocalizations (Gros-Louis, West, Goldstein, & King, 2006). Consequently, atypical vocalizations by children with HL may elicit fewer acknowledgments and responses from the parent.

Two Types of Parental Language Input: Utterances and Responses

The focus of this study is parental language input to children with HL prior to CI implantation. Due to the limited amount of research conducted on parent–child interactions in children who are preimplantation, a review of the broader population of children with HL is presented in this section. Various studies have compared parental language input for children with HL and children with TH by analyzing parental utterances during parent–child interactions (Ambrose et al., 2015; DesJardin et al., 2014; DesJardin & Eisenberg, 2007; Vandam, Ambrose, & Moeller, 2012). Studies focused on quantity have found inconsistent results about the amount of parental utterances. Vandam and colleagues (2012) used an automated technology to record and analyze natural linguistic environments of children with HL and did not find a significant difference in the number of words heard by children with TH and children with HL (Vandam et al., 2012). However, studies that coded parental utterances from parent–child interactions video samples have reported both higher (DesJardin et al., 2014) and lower totals of parental utterances across the two groups (Ambrose et al., 2015). Studies that focused on quality of parental utterances have explored the semantic content, syntactic complexity, use of facilitative language techniques, and diversity of input and have reported more convergent findings. Compared to parents of children with TH, parents of children with HL use (a) significantly less diversity of vocabulary (Ambrose et al., 2015); (b) fewer higher level facilitative language techniques, such as expansion, recast, and open-ended questions (DesJardin et al., 2014); (c) more directive interactions (Ambrose et al., 2015); and (d) less joint attention episodes (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 qualitative differences could suggest that parents tailor their linguistic input to their child's language ability rather than to their chronological age.

Another type of parental language input that has received less attention in studies of children with HL is parental utterances *in response to* child communicative acts (referred to as *parental response* when discussing the behavior and *parental responsiveness* when discussing the construct throughout the rest of this article). *Parental response* is a subset of parental language input and a type of parent interaction style that emphasizes providing contingent responses to child communication (Bornstein & Tamis-LeMonda, 1989; Landry,

Smith, Swank, Assel, & Vellet, 2001; Tamis-LeMonda, Bornstein, & Baumwell, 2001). The definition of parental response or responsiveness varies by study and can refer to emotional availability (Pressman, Pipp-Siegel, Yoshinaga-Itano, & Deas, 1999), parental sensitivity (Spencer & Meadow-Orlans, 1996, 2004), or contingent verbal responses (Landry, Smith, & Swank, 2006). In this study, it refers to *parental verbal responses that are temporally contingent to child communicative acts (i.e., a parent verbal communication that occurs within 3 s of a child communicative act)*.

Parental responses are particularly important because they help children develop expectations about events following their own behavior and help them gain a sense of control over their environment (Baumwell, Tamis-LeMonda, & Bornstein, 1997). Consistent parental responses may also facilitate early language learning by teaching children that their communicative behavior could have an effect on their linguistic environment, thereby priming their attention to the linguistic information that follows their communication. Considering the importance of parental responses and the fact that many children with HL produce fewer intentional communicative acts than children with TH (Nicholas & Geers, 2007; Vohr et al., 2008), further investigation of parent responsiveness with children with HL is warranted. Although parent responsiveness has been widely researched in children with typical development and in children with language impairment (Bornstein & Tamis-LeMonda, 1989; Girolametto, Weitzman, Wiigs, & Pearce, 1999; Yoder & Warren, 1999), only one study has investigated parental verbal responses 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 across the two groups. However, they did not analyze the content of parental responses.

The Present Study

The primary purpose of this study is to compare the quantity and quality of parental utterances and responses between children with TH and children with HL prior to cochlear implantation. We examined quantity of parental language input by analyzing the overall amount of parental utterances and responses similar to Ambrose et al. (2015) and Vandam et al. (2012). However, this study differs from the aforementioned studies in that we used observational methods and sampled parental language input in a free-play context in the child's home. Quality of parental language input was examined by coding for semantic richness and the use of language facilitation strategies in parental utterances and responses. Past studies have shown that language facilitation strategies such as diverse and rich semantic content (Rowe, 2012), linguistic mapping (Yoder & Warren, 2001), semantic expansion (Scherer & Olswang, 1984), grammatical recasts (Cleave, Becker, Curran, Van Horne, & Fey, 2015), and follow-in comments (McDuffie & Yoder, 2010) support children's early language development. We also explored the relationship between these two types of parental language input and early language development in both populations. Previous work on parental language input has indicated that the relationship between parental input and child language development may be different in typically developing (TD) children compared to children with language impairments (Proctor-Williams, Fey, & Loeb, 2001).

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 this period (Ambrose et al., 2015; Smith & McMurray, 2018). Ambrose and colleagues examined parental talk during 5-min parent–child interactions 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 the quantity and quality aspects of parental utterances and responses to children with HL during the preimplantation and prelinguistic period of language development. Understanding differences in parental language input to children with HL prior to implantation is a critical step to determining the extent to which persistent language delays in children with CIs may be remediated via early parent-implemented language intervention. Specifically, three research questions guided this study:

> **Research Question 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?
>
> **Research Question 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?
>
> **Research Question 3**: Is the relationship between the quantity and quality of parental language input and early language development conditional upon a child's hearing status (TH vs. HL)?

Method

Participants

Thirty children (13 in the HL group and 17 in the TH group) and their parents participated. Participants were recruited from 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, (c) no CI at the time of this study, (d) from a home where English was the primary language spoken, and (e) no additional medical diagnoses. Only parents who had TH (pure-tone average 30 dB HL or less) were included in the study. Children in the TH group 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 spoken, 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. Across both groups, 25 out of 30 parent–child dyads were Caucasian; only one dyad identified as Hispanic. Audiological information for children in the HL group was acquired from their audiology records. All children in the HL group presented with bilateral sensorineural HL. The mean better-ear, pure-tone average (BEPTA) was 75 dB HL (*SD*: 26 dB). While all children in the HL group were CI candidates, none of them had received an implant at the

time of the home visit and all were using bilateral hearing aids. None of the parent–child dyads used sign language. Maternal education was measured and used 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 ($p > .05$ in all cases). 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. Only spoken language was counted in the CSBS-DP scoring. Total raw score from the CSBS-DP served as our child-level-dependent variable for three reasons: (a) standard or age equivalency scores were dependent on a sample normed with children with TH 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) were 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

Participants were drawn from a longitudinal randomized controlled trial (NCT01963468) that assessed the effects of a parent-implemented communication intervention in children who were CI candidates. In the longitudinal study, children with HL prior to implantation were randomly assigned to a parent-implemented communication intervention group or a business-as-usual control group. Only parents and children assigned to the business-as-usual group were included in the current study. As part of the larger study, home visits were conducted to collect data on parent–child interactions and children's early language skills. A 20-min 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. To improve ecological validity, parents were instructed to use their own toys and materials in their home. 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 10 min of each interaction sample were 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 s 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., contained at least one meaningful content word).

Child and parental 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 a nonword vocalization, (c) a gesture that represents a specific action, item, or idea (e.g., head nod, thumbs-up, waving, proximal pointing), or a gesture that intrinsically shows coordinated attention to an object and an adult (e.g., giving, bidding to receive, showing), or (d) a conventional sign (e.g., American Sign Language). For adults, a communicative act was defined as a verbal utterance.

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

Topic contingency of parental 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 was related to what the child was communicating or doing. Examples of topic-contingent utterances include linguistic mapping, repetition, grammatical recasts, conversation repair strategies, and semantic expansions. In contrast, behavior management, redirects, or utterances that do not correspond to the presumed topic of the interactive context would not be coded as topically contingent.

Semantic richness of parental utterances.—A parental utterance was coded as semantically rich if it included at least one meaningful content vocabulary (e.g., common or proper noun, content verb, adjectives, adverbs, and prepositions referring to locations). Counterexamples include nonlexical conversation fillers (e.g., "uh-huh," "hmm"), sound effects (e.g., "vroom-vroom"), generic attention-getting and social phrases (e.g., "hey," "here," "there you go"), and interjections (e.g., "yay," "wow," "oops"). More 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 parental utterances and responses were derived from SALT transcriptions and coded variables. Quantity of overall parental utterances was measured by calculating the number of total parental utterances from the SALT transcriptions. Quality of overall parental utterances was measured by calculating the number of high-quality utterances. A parental utterance was considered high-quality if it was coded as both topic-contingent and semantically rich. Quantity of overall parental responses was measured by calculating the proportion of parental utterances coded as temporally contingent to child communicative acts. Parent responsiveness was measured using a proportion metric instead of a count metric to control for child communication rate as a parent only has the opportunity to respond after a child communicative act. Using a count metric would penalize responsive parents whose children rarely communicated. Finally, quality of parental responses was measured by calculating the proportion of high-quality parental utterances to child communicative acts. High-quality responses referred to parental utterances that were coded as temporally contingent, topically contingent, and semantically rich.

Reliability

Reliability was calculated by having a second coder independently recode 20% of the parent– child interactions 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 parental 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– Wilks's test. Results indicated that neither proportion variable violated normality ($p > .1$). Accordingly, original data were used without being arcsine transformed. Next, t tests and chi-square analyses were conducted for all demographic characteristics that are potentially associated with child- or parent-dependent variables to examine group equivalence. No significant differences were detected on child age, gender, race, or cognitive skills between groups ($p > .1$). 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 variables ($p > .05$). 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 differences in overall parental utterances, high-quality utterances, rate of overall responses, and rate of high-quality responses between the 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 (four 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.

Results

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

Overall Parental Utterances and High-Quality Utterances

For the first research question, we compared parents' overall utterances and high-quality utterances across the two groups, as shown in Table 4. On average, parents of children with TH used 179 utterances ($SD = 41$) during 10 min parent–child interactions. Parents of children with HL used 129 utterances ($SD = 43$) on average. As predicted, both overall utterances and high-quality utterances differed significantly between the groups (Figure 1a and b), with parents of children with HL using fewer overall utterances, $t(28) = 3.31$, $p < .01$, Cohen's $d = 1.19$, and fewer high-quality utterances, $t(28) = 2.61$, $p = .01$, $d = 0.96$.

Rate of Overall Parental Responses and High-Quality Responses

For the second research question, we analyzed the rate of overall parental responses and the rate of high-quality responses across the 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 response rate of 14% ($SD = 10\%$). A significant difference was found only in the rate of high-quality parental responses, $t(28) = 4.25$, $p < .01$, $d = 1.56$, but not in the rate of overall parental responses, $t(28) = 1.61$, $p = .12$, $d = 0.59$ (Figure 1c and d).

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 hearing status when the product terms were included in the regression model ($p > .05$). 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 to predict child CSBS-DP total raw score. As shown in Table 5, significant main effects were detected for three out of the four parental language input variables: overall parental utterances ($p = .01$, adjusted $R^2 = .17$), high-quality utterances ($p < .001$, adjusted $R^2 = .40$), and the rate of high-quality parental responses ($p < .001$, adjusted $R^2 = .51$). The regression model for the rate of overall parental responses was not significant ($p = .2$, adjusted $R^2 = .03$).

Post Hoc Analyses

A new question emerged as we examined the findings. Given that parents of children with HL provided their child with comparably consistent overall responses but a significantly lower rate of high-quality responses compared to parents of children with TH, we conjectured that the quality of parental responses may be driven by the intelligibility of child communication. Although all parental responses were temporally contingent to a previous child communicative act, they did not necessarily contain meaningful linguistic content. When a child produces 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 have produced more unclear communicative acts than children with TH and thus elicited more generic adult responses without semantic content.

This hypothesis was tested post hoc in two steps. First, for each participant, a new proportion variable representing the intelligibility rate was created by summing the number of intelligible communicative acts (defined as communicative acts in which all words were transcribed) and dividing this sum by the total number of communicative acts. An arcsine transformation was conducted on the value 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. A significant difference was detected, with children with HL having a higher percentage of unintelligible communicative acts than children with TH, $t(27.956) = 2.96$, $p < .01$, $d = 1.05$ ($M_{HL} = 48\%$, $SD_{HL} = 29\%$; $M_{TH} = 24\%$, $SD_{TH} = 15\%$).

Next, a sequential analysis was conducted to test whether parents were more likely to use a high-quality utterance following an intelligible child communicative act versus an 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 (RD) index (Higgins & Green, 2011), also termed as 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). 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 our analysis, the first event was an intelligible child communicative act and the second event was a parental high-quality utterance. The second event was a parental high-quality utterance instead of a high-quality response because the data have to meet the requirements of a 2×2 contingency table analysis; each behavior of interest must consist of mutually exclusive categories (child intelligible communicative act and parental high-quality utterance are either present or absent) and the two behaviors of interest must 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 2×2 contingency table (see Table 6 for the 2×2 contingency table). An 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 was 0.25 ($SD = 0.30$) for the HL group and 0.39 ($SD = 0.20$) for the TH group. 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 ($p < .01$, Cohen's d 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, $t(28) = 1.58$, $p = .13$. The positive RD indices for both groups and the pooled group indicate that parental high-quality utterances followed 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 hypothesis that parents of children with HL may have provided a lower rate of high-quality responses because their children had more unintelligible communicative acts compared to the TH group.

Discussion

This purpose of this study was to examine parental language input to children with HL prior to receiving a CI. 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 parental language input to children with HL prior to implantation during the prelinguistic period of language

development. 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 parental input variables with the exception of overall responses were positively associated with early language skills measured by CSBS-DP total raw score in the pooled group. Post hoc analyses also indicate that the intelligibility of child communication influenced parents' use of high-quality utterances.

Quantity and Quality of Parental Utterances

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 those 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-min structured task, the Art Gallery task (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, in our study, parental language input was sampled in a free-play context in the child's home. 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).

In addition, Vandam and colleagues sampled the linguistic environment of children with HL 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. One possible explanation for these divergent findings is that children with HL may be exposed to comparable quantity of 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 varies based on communication tasks and to determine the best type of communication tasks to elicit the most representative samples.

Another interesting result was that parents of children with HL provided fewer high-quality utterances compared to parents of children with TH. This finding is in line with our prediction and findings from past studies that analyzed other aspects of quality of parental language input (Ambrose et al., 2015; DesJardin et al., 2014). For example, Ambrose et al. (2015) found that parents of children with HL used shorter utterances, fewer diverse

vocabularies, fewer open-ended conversation-eliciting utterances, and more directives. Parents of children with HL also used fewer higher level language facilitation strategies, such as expansions, recasts, and open-ended questions and more lower level strategies, such as labels, directives, imitations, and closed-ended questions (DesJardin et al., 2014). It has been proposed that the differences observed in quality of parental language may indicate that parents tailor their language input to their child's communication ability rather than to chronological age (Ambrose et al., 2015; Eddy, 1997). Our findings that parents of children with HL use fewer semantically rich and topically contingent utterances may reflect the same underlying phenomenon that parents of children with HL adapt and simplify their language input to facilitate language uptake of their child with limited receptive language abilities. DesJardin and colleagues (2014) also noted that parents of children with HL may intentionally use more lower level facilitative language strategies even when their child's language skills increase. While our study provided a baseline of quality of parental utterances in children with HL prior to implantation, it remains unknown whether parents would naturally demonstrate a shift to more complex and advanced language after their child receives a CI. Future studies are needed to understand potential changes in parental language input and interaction style toward children with HL following implantation.

Quantity and Quality of Parental Responses

A significant difference was detected in the rate of high-quality responses to child communicative acts but not in the rate of overall responses. The disparity observed in the rate of 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 communicative acts (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 across both groups extends current evidence by demonstrating that the differences in the quality of parental responses were partly driven by characteristics of child communication. Specifically, parents were less likely to respond to unintelligible communicative acts with rich semantic content than to intelligible acts. For example, an unclear child communicative act such as a growl without a paired gesture would be more likely to elicit a generic noncontent 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, while our findings converge with previous findings that children with HL were exposed to parental language input of poorer quality (Ambrose et al., 2015; Spencer, 1993), they further stress the importance of viewing parent–child interactions as a transactional system (Sameroff, 1975, 2009). The competence or outcome of the child should be considered as a function of intrinsic characteristics of the child (e.g., HL), stimulations from the child to the parent (e.g., unintelligible utterances), parent interpretations of the stimulation (e.g., unclear intention, reduced linguistic ability), parent reactions to the child (e.g., reduced complexity in parental language input), and further interchanges between the parent and the child (Sameroff & MacKenzie, 2003). Accordingly, interventions should consider all parts of the dynamic system within parent–child interactions.

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 hearing status. This hypothesis was not supported by the results. No significant interaction was detected between parental language input variables and hearing status. In one previous study (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 suggested that HL may exert subtle effects on the interactions 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) but simply reflect different aspects of parent–child interactions. While Smith and McMurray showed that the coordination between children with HL and their parents may be less aligned than children with TH and their parents, our findings suggest that parental utterances and responses are positively associated with early language development regardless of hearing status.

When the two groups were pooled together to examine the relationship between parental language input and early language skills, results indicated that the number of overall parental utterances, the number of high-quality utterances, and the rate of high-quality responses were positively associated with children's early language skills. However, the rate of overall parental responses was not significantly associated with CSBS-DP scores. It is reasonable that parental responses which 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 which does not provide meaningful linguistic input was negatively associated with later language production ability in children with autism spectrum disorder (ASD; Haebig, McDuffie, & Weismer, 2013). For children with HL who have less verbal communication and attenuated access to parental language input, parental responses that are temporally contingent but do not include meaningful semantic content may be less facilitative of their language learning.

Limitations and Future Directions

The findings from this study should be considered in light 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. Considering our finding that the rate of high-quality parental responses but not the rate of overall parent responses is positively associated with early language development, future studies should investigate how these language facilitation strategies (i.e., parent utterances, temporally contingent responses, content-contingent responses, semantically rich responses) impact one another. Future work should also examine the extent to which the effects of various language facilitation strategies vary based on a child's developmental levels. In addition, due to limited resources and scope of this study, we were only able to code a 10-min parent–child interaction sample.

Another limitation was that our study did not collect data on the intensity or the type of support that parents received in early intervention. Although all children with HL included in the study engaged in a business-as-usual early intervention program, parents in the study did not receive systematic parent training that targeted aspects of parental language input examined in this study. Despite this limitation, our findings that parents of children with HL used fewer high-quality utterances and less consistent high-quality responses suggest that parents may need additional support beyond business-as-usual early intervention services to better support their child's early language development. A further limitation is that even though all children were CI candidates who were using bilateral hearing aids at the time of data collection, this study did not have a measure of hearing aid use during the day. Given that children's access to spoken language communication could potentially impact parental communicative behaviors, future studies should look at how consistency of hearing aids use, access to spoken language communication, and severity of HL impact quantity and quality of parental language input. 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. Future studies should follow language development of children with HL longitudinally to examine the extent to which differences observed in parental language input between the TD and HL groups persist following CI implantation.

Implications for Practice

What should parents do when they are uncertain of the nature of their child's intention of communication during an interaction? One adaptive strategy is to pay close attention to their child's focus of attention to be better detectives of their child's possible communicative intent. 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 a child's focus of attention also facilitate language learning in both typical and atypical populations (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). In addition, multiple intervention studies have demonstrated that parent responsiveness is a malleable factor in intervention (Girolametto, 1988; Venker, McDuffie, 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). A meta-analysis of parent-implemented language interventions also showed 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 whether parents naturally use any communication repair strategies when encountering unintelligible utterances and the extent to which follow-in comments as an adaptive strategy are empirically effective for children with HL.

In addition, professionals may want to share findings and implications from our study with families with children with HL. Quite strikingly, parents of children with HL are not typically provided with empirically based strategies for communicating with their child and facilitating their child's language development during the preimplantation period (Kelly, 2013). It is important that professionals encourage and coach parents to not simply focus on the amount of input provided to children with HL but also to provide high-quality input that includes rich semantic content.

Acknowledgments

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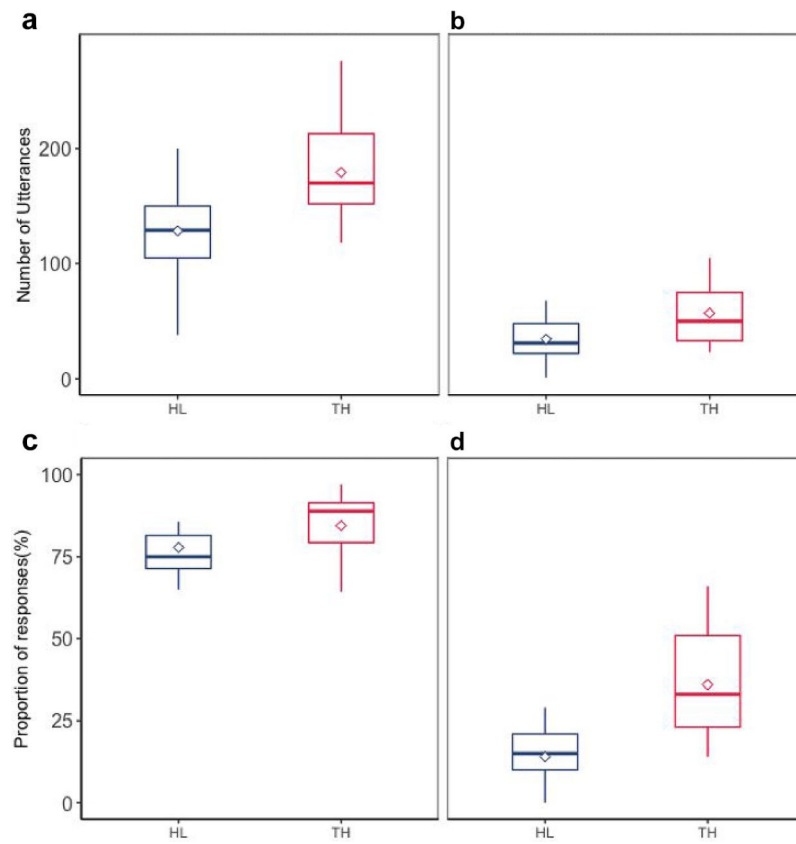
Figure 1.

Boxplots displaying the number of overall parental utterances, the number of high-quality utterances, the rate of overall responses, and the rate of high-quality responses in the TH group and the HL group: (a) Overall parental utterances, (b) high-quality parental utterances, (c) proportion of overall responses, and (d) proportion of high-quality responses.

Note. Mean values were represented by diamonds; error bars represent ±1 standard deviation. TH = typical hearing; HL = hearing loss.

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 (*M, 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%)
Other	1 (7.1%)	4 (23.5%)
Maternal education (*n, %*)		
Some college	4 (30.8%)	0 (0%)
College or higher	8 (61.5%)	17 (100%)
Not reported	1 (7.7%)	0 (0%)
Cognitive skills (*M, SD*)		
MSEL—Visual Reception Subscale	20.38 (11.98)	20.47 (3.86)
Better ear pure-tone average (dB HL; *M, SD*)	75 (26)	
Age at hearing loss identification (*M, SD*)	5.83 (7.22)	
Age at hearing aid fitting (*M, SD*)	8.08 (7.91)	
Language skills (*M, SD*)		
CSBS-DP total raw score	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. HL = hearing loss; TH = typical hearing; MSEL = Mullen Scales of Early Learning; 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 s.	Child: "Car" (1 s)
		Parent: "Yeah!"
		Child: "Car" (2 s)
		Parent: "Mm-hm."
		Child: "Car" (1 s)
		Parent: "Yes, I see a car!" (temporally and topically contingent)
Topic contingency	A parental 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."
		Child: "Ball."
		Parent: "Roll the ball!"
Semantic richness	A parental utterance that includes at least one meaningful content vocabulary word (e.g., common or proper noun, content verb, adjectives, adverbs, and prepositions referring to locations)	Child: {woof woof}.
		Parent: "I see a dog!"
		Counterexample:
		Child: {points to a dog}.
		Parent: {woof woof}.
		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 parental utterances	Number of total utterances from SALT transcriptions	Quantity of parental utterances
High-quality parental utterances	Number of parental utterances coded as topic-contingent and semantically rich	Quality of parental utterances
Rate of overall parental responses	Proportion of parental utterances coded as temporally contingent to child communicative acts	Quantity of parental responses
Rate of high-quality parental responses	Proportion of parental utterances coded as temporally contingent, topic-contingent, and semantically rich to child communicative acts	Quality of parental responses

Note. SALT = Systematic Analysis of Language Transcripts.

Table 4.

Summary Statistics and Between-Group Comparison of Parental 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*	Cohen's *d*
Overall parental utterances	129	43	38–200	179	41	118–276	3.31	.003**	1.19
High-quality utterances	35	20	1–68	57	26	23–105	2.61	.01*	0.96
Overall parental responses (%)	78	11	65–100	85	11	60–97	1.61	.12	0.59
High-quality responses (%)	14	10	0–29	36	17	14–66	4.25	<.001***	1.56

Note. HL = hearing loss; TH = typical hearing.

Obtained significance value:

*
p < .05.

***
p < .001.

Table 5.

Regression Model Results for the Relations 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	.01 [*]	.17
High-quality utterances	0.80	0.18	0.65	4.50	<.001 [***]	.40
Proportion of overall responses	66.98	50.68	0.24	1.32	.20	.03
Proportion of high-quality responses	129.70	23.12	0.73	5.61	<.001 [***]	.51

Note. B = unstandardized coefficient; β = standardized coefficient; t = obtained t values.

Obtained significance value:

[*] $p < .05$.

[***] $p < .001$.

Table 6.

The 2×2 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). RD = risk difference index.