

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-minute 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

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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 *bi-directional* 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 elicits more complex language input from the parent (Sameroff, 2009). Considering the bi-directionality 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 the interaction.

For children with HL, the implementation of early identification and advances in hearing technology, particularly the CI, have been vital in providing early auditory access and facilitating spoken language learning (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 six 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 pre- to post-implantation. 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 Cochlear Implant Candidates

Despite recent advances in hearing technology, many children who are implanted 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) cochlear implant 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 this 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 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 pre- and post-implantation 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 pre-implantation 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 the interactions will support the delivery of effective early parent-implemented language interventions during this period.

The Impact of Hearing Loss 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 bi-directional 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 children with HL's communication can affect typical parent-child interactions can also be found in research focusing on vocal development and caregiver responsiveness. Hearing loss 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, children with HL's atypical vocalizations 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 pre-implantation, 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 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 that children with TH and children with HL heard (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. 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 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 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 the paper). 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 seconds 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, 1997; 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 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 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-minute 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 pre-implantation 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:

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 (TH vs. HL)?

Methods

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 cochlear implant 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 typical hearing (PTA 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 on 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 parent-child dyads used sign language. 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 *ps* >.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. 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 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) 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-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. 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 ten minutes 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 seconds 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 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). 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 seconds of the act were coded as temporally contingent. Based on previous mother-child interaction studies, a 3-second 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 seconds 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 don’t 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 non-lexical 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 on Table A1 in the Appendix. Additional details and the coding manual are also available upon request.

Parental Language Input Dependent Variables

Four parent-level dependent variables (Table 2) 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 since 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-Wilk's test. Results indicated that neither proportion variable violated normality ($ps > .1$). 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 (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 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 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 (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 .

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 on Table 3. On average, parents of children with TH used 179 utterances ($SD = 41$) during 10 minute 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 1), 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, $t(28) = 2.61, p = .01, d = .96$.

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 3). 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, $t(28) = 1.61, p = 0.12, d = .59$ (Figure 1, panes C 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 (all $ps > .05$). Given the lack of parent language input variables \times 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 on Table 4, 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. Though 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 index (RD; 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

2x2 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 2x2 contingency table (see Table B1 in the appendices for the 2x2 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 (all $ps < .01$, Cohen's ds 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 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 cochlear implant. 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 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 (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).

Additionally, 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 vocabulary, 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 used fewer semantically-rich and topically-contingent utterances may reflect the same underlying phenomenon that parents of children with HL are adapting and oversimplifying their language input to facilitate language intake 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 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, 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 hearing loss 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 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 in children with 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 facilitative strategies (i.e. parent utterances, temporally contingent responses, content-contingent responses,*

semantically rich responses) are impacted by 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. Additionally, due to limited resources and scope of this study, we were only able to code a 10-minute 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. Though 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 hearing loss 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.

Clinical Implications

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). Additionally, 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 is empirically effective for children with HL.

Additionally, 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 pre-implantation 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 rather to provide high-quality input that includes rich semantic content.

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