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Research Article

Parental Language Input to Children With Hearing Loss: Does It Matter in the End?

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Purpose: Parental language input (PLI) has reliably been found to influence child language development for children at risk of language delay, but previous work has generally restricted observations to the preschool years. The current study examined whether PLI during the early years explains variability in the spoken language abilities of children with hearing loss at those young ages, as well as later in childhood.
Participants: One hundred children participated: 34 with normal hearing, 24 with moderate losses who used hearing aids (HAs), and 42 with severe-to-profound losses who used cochlear implants (CIs). Mean socioeconomic status was middle class for all groups. Children with CIs generally received them early.
Method: Samples of parent–child interactions were analyzed to characterize PLI during the preschool years. Child language abilities (CLAs) were assessed at 48 months and 10 years of age.
Results: No differences were observed across groups in how parents interacted with their children. Nonetheless, strong differences across groups were observed in the effects of PLI on CLAs at 48 months of age: Children with normal hearing were largely resilient to their parents' language styles. Children with HAs were most influenced by the amount of PLI. Children with CIs were most influenced by PLI that evoked child language and modeled more complex versions. When potential influences of preschool PLI on CLAs at 10 years of age were examined, those effects at preschool were replicated. When mediation analyses were performed, however, it was found that the influences of preschool PLI on CLAs at 10 years of age were partially mediated by CLAs at preschool.
Conclusion: PLI is critical to the long-term spoken language abilities of children with hearing loss, but the style of input that is most effective varies depending on the severity of risk for delay.

Language acquisition is one of the most spectacular achievements of childhood. Mastery of the skills that permit a child to understand others when they talk, produce language oneself, read, and write facilitates the child's success in social relationships, academic pursuits, and, ultimately, career endeavors. Although most children proceed through the language-learning process seemingly without effort, a sizeable number of factors must all fall into place at just the right times for this feat to be accomplished. These factors are both genetic and epigenetic in nature. Regarding the genetic bases of language, several genes have been identified as critical to the development of language (Hamdan et al., 2010; Onnis, Truzzi, & Ma, 2018), with the most well known of these being the *FOXP2* gene (Lai, Fisher, Hurst, Vargha-Khadem, & Monaco, 2001; Nudel & Newbury, 2013; Xu et al., 2018).

However, having the proper genes is just the first step. In order for language to develop optimally, certain epigenetic factors must also come into play at specific times in the course of development. At the most basic level, that means the child must simply have the opportunity to hear the ambient language. In fact, language exposure begins to influence later language learning long before the child utters her first words. For example, DeCasper and Fifer (1980) observed that newborn infants attend longer to the speech of their mothers than to that of other women, suggesting that infants become familiar with their mothers' voices while in utero. This awareness is thought to play a role in language learning, by heightening the infant's attention to her mother's speech, the very first teacher. De Boysson-Bardies, Sagart, Halle, and Durand (1986) found that the long-term average spectra of vocalizations from 10-month-old infants resembled those of adults in their language communities, suggesting that these infants had already focused their attention

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on general patterns of the acoustic speech signal and knew how to replicate those patterns in their own productions. By understanding these relationships between acoustics and motor activities, these infants were on their way to mastering speech production. Furthermore, outcomes of categorical speech perception studies reveal that infants become attuned to the specific acoustic cues that are important in their native language over the first year of life (Kuhl et al., 2006; Werker & Tees, 1984). In an oft-cited monograph of data from 42 families (13, professional; 23, working class; and six, welfare), Hart and Risley (1995) reported that the professional parents addressed roughly 4.5 times the number of words to their preschool children as did the welfare parents. Thus, exposure to the ambient language is a requirement for children to gain an early foothold in the language-learning process. Moreover, when adequate exposure to language is not available, as in the case of the children on welfare studied by Hart and Risley or children with histories of chronic otitis media with effusion, then long-term deficits in syntactic and phonological abilities can be observed in affected children (Friel-Patti & Finitzo, 1990; Gravel & Wallace, 1992; Nittrouer, 1996; Updike & Thornburg, 1992). Overall, simply the amount of adult speech that children hear is associated with how well children acquire language skills (Hurtado, Marchman, & Fernald, 2008; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Mahr & Edwards, 2018).

Style Matters

Nonetheless, exposure to language is not all that matters. If it were, then a child could be placed in front of a television and learn language; however, television exposure has not been found to facilitate language learning (Zimmerman et al., 2009). Instead, interactions with other people of a specific nature are needed for optimal language learning. Recognition of this requirement is gathered from observational studies of young children interacting with their parents. These studies typically include children from low socioeconomic status (SES) environments, as well as mid-SES control subjects, because parental interaction styles differ across SES groups, on average. As early as 1979, Schachter studied the interaction styles of mothers in low- and mid-SES families, being careful to include Black and White mothers in both SES groups. No effect of race was observed, but more than half of the interactions of mothers from low-SES families were found to consist of directives, defined as speech behaviors that involve telling another individual what to do or what not to do. Mothers from the mid-SES families, on the other hand, were observed to use directives in only 30% of their interactions with their children, on average. Instead, these mothers tended to be responsive, following up on something the child said or tried to say. These sorts of speech acts often involve recasts, in which the adult restates something the child said using more mature language structures, or extensions, in which the adult provides a more complete statement of the child's idea.

Another kind of speech act that has been found to be facilitative of language acquisition involves open-ended inquiries. In a different study involving parents and children from low- and mid-SES households, dyads were video-recorded for 10 min while they worked together to build a Tinkertoy model from an illustration (Nittrouer, 2002). During that 10-min interaction, it was observed that children from the mid-SES environments heard an average of 12.2 open-ended inquiries, but children from the low-SES environments heard an average of only 3.6. That means that, in just those 10 min, children from the mid-SES households were encouraged to generate language roughly 3.5 times more often. That is 3.5 times the number of opportunities to practice constructing utterances and 3.5 times the number of opportunities to hear more complex syntactic structures by having those original utterances recast or expanded.

Of course, many factors differ in the environments of children living in low-SES versus mid-SES households, so care needs to be taken to trace the differences in language achievement associated with SES to parental interaction styles, rather than to any other factor that may be correlated with SES. Fortunately, several studies have explored this potential confound. In particular, several investigations have demonstrated that the effects of low-SES environments on children's language and cognitive development are similar, regardless of race or cultural background. For example, Norman-Jackson (1982) recruited low-SES preschoolers who were all African American and had siblings in the second grade, taking care to recruit some low-SES preschoolers with older siblings performing well in school, in spite of any expectations related to poverty. The preschool children were grouped according to whether the older sibling was performing within normal limits on a measure of reading or scoring below the average range for second graders on that measure. In addition, the language skills of the preschool children were examined, and it was found that children with older siblings who were good readers had an average mean length of utterance (MLU) of 3.88, compared to an average MLU of just 2.88 for children with siblings who were poor readers. Finally, the language interaction styles of the parents were examined. Overall, more verbal interactions were observed between parents and preschoolers in the group with good-reading siblings than in the group with poor-reading siblings. Thus, Norman-Jackson concluded that SES is not the factor that accounted for the observed language differences but rather the interaction styles of the parents. Unfortunately, differences in parental interaction styles depending on SES have consistently been observed across studies. Interaction styles involving frequent directives, with few open-ended inquiries or responses to children's communicative attempts, have been reliably documented for low-SES parents, regardless of race or cultural background (Hess & Shipman, 1965; Laosa, 1982; Schachter, 1979), as have fewer child-directed utterances (Hart & Risley, 1995).

However, as clear as these outcomes for group differences in parental language based on SES have been, there is another question they cannot answer, and that is whether children with risk factors for language delay are more affected by the interaction styles of their parents. To answer that question, children who are matched on SES but differ with respect to their risk for language delay need to serve as the experimental groups. One investigation that did just that involved children with autism and matched controls (Swanson et al., 2019). In this study, two measures of parental language input (PLI) were used: number of adult words addressed to the child during a 32-hr sample from the home and number of turn-taking events during those 32 hr. Both of these measures were obtained when the children were 9 and 15 months old. The dependent measure was the combined expressive and receptive scores from the Mullen Scales of Early Learning (Mullen, 1995), obtained when children were 24 months old. Although PLI and later child language scores were correlated for both groups, the slopes of the relationship were greater for the children with autism, suggesting that the nature of PLI has a stronger effect on child language outcomes if children are at risk for language delays.

PLI to Children With Hearing Loss

The robust relationship between parental language interaction style and child language outcomes has formed the basis of several investigations seeking to examine ways to improve language outcomes for children with hearing loss. For example, Quittner et al. (2013) asked if outcomes for children with cochlear implants (CIs) varied depending on three parental traits: maternal sensitivity, cognitive stimulation, and linguistic stimulation. Understanding these relationships, it was speculated, could help shape parent training. Children were all preschoolers at the time of enrollment in the study, and they were followed for 4 years after receiving their CIs. Dependent language measures consisted of the MacArthur–Bates Communicative Development Inventories (Fenson et al., 2007), the Reynell Developmental Language Scales (Reynell & Gruber, 1990), and five subscales of the Comprehensive Assessment of Spoken Language: Antonyms, Syntax, Paragraph Comprehension, Nonliteral Language, and Pragmatic Judgments (Carrow-Woolfolk, 1999). Video recordings of parent–child play interactions were coded for the three parental styles described above. Results showed that growth in language acquisition was partly explained by the combination of maternal sensitivity and cognitive stimulation, accounting for 11% of variance in growth trajectories after age of implantation and family demographics were considered. Although this study demonstrates the strong influence of parental interaction styles on language development by children with CIs, it is harder to operationally define maternal sensitivity and cognitive stimulation than the categories of parental language examined in earlier studies: number of words or utterances, inquiries, verbal responses, and directives.

Another study examined how specific features of PLI influence language growth in children after receiving CIs. Szagun and Stumper (2012) used time-lagged analysis to assess how parental MLU in their child-directed speech and number of expansions of child utterances correlated with child MLU 24 and 30 months after receiving a CI. Results were positive and significant, indicating that PLI style affects language acquisition for children with hearing loss—at least for those who receive CIs.

Language Learning Across Childhood

The studies cited above provide strong support for the suggestion that parental language interaction styles influence child language abilities (CLAs). However, there are some limitations to these studies. In particular, they focused largely on children during the preschool years or the early elementary grades at the latest. To the extent that children were followed through the early elementary grades, no measures of language growth that would explicitly be expected after school entry were included. Presumably, the language skills children develop during the preschool years serve as a foundation for language development to come later; by extension, that would suggest that PLI during the preschool years is important to later language development. However, that assumption needs examination, especially in light of the fact that the kinds of language skills being acquired change over the course of childhood; in particular, sensitivity to word-internal phonological structure is a later acquired ability.

Child phonologists have long recognized that children's initial lexicons consist of elements that are not appropriately described as phonologically structured words. Instead, those first linguistic elements are best described as holistic units that may be phonologically unstable and contextually dependent (Ferguson & Farwell, 1975; Menyuk, Menn, & Silber, 1979; Waterson, 1971). Different terms have been used for these early forms, including *articulatory routines* (Menn, 1978, 1983) and *word recipes* (Vihman & Velleman, 1989). These early lexical items are stretches of the speech signal that have a high frequency of occurrence for an individual child and carry strong meaning for that child. Examples are the child's name, names of favorite foods, pets, or toys, and routines (e.g., *all gone*). Gradually, these items acquire stability. Over the preschool and early school-age years, children discover the word-internal structures that are phonological in nature, leading to a reorganization of the lexicon (e.g., Charles-Luce & Luce, 1990; Storkel, 2002; Vihman, 1991). There is a developmental hierarchy according to which children typically gain access to these structures (Liberman, Shankweiler, Fischer, & Carter, 1974; Stanovich, Cunningham, & Cramer, 1984). First, they recognize the general constructions, at that global level, delighting in nursery rhymes that highlight that level of structure (e.g., *hickory, dickory, dock*). Next, children discover that the initial consonant or consonant cluster can be separated from the word rime (e.g., the name game). Finally, during the early elementary grades, children achieve sensitivity to the individual phonemic elements that comprise words. This level of sensitivity allows children to refine other language skills that benefit from the utilization of phonemic structure, such as verbal working memory, learning sophisticated vocabulary, and reading (Wagner & Torgesen, 1987). Thus, the nature of linguistic representation can be presumed to change dramatically from early to middle childhood, making it worthwhile to ask how PLI during the preschool years prepares young children for the language skills that become important later.

Current Study

In this report, several specific goals were addressed. First, the relationships among parental language styles and CLAs were examined during the preschool years. The major focus was on the question of how these parental language styles influence spoken language outcomes for children with hearing loss. These analyses built upon previous studies in several ways. The first way was that the relationships among PLI styles and CLAs were examined for children with normal hearing (NH), as well as for those with hearing loss, with the latter group further divided into children who have moderate hearing loss and thus wear hearing aids (HAs) and children who have severe-to-profound hearing loss and thus wear CIs. It was predicted that these relationships may vary across these groups, because of differences in the quality of the signal input: Children with poorer input signals are predicted to show stronger effects of PLI styles, because they are more dependent on carefully orchestrated interactions for language learning. From a clinical perspective, it would be helpful to understand what kinds of PLI styles best facilitate language learning for these children who are especially dependent upon carefully orchestrated interactions, so that those interactions can be fostered during the preschool years. Consequently, children with hearing loss were of primary interest in this study.

The second way in which this study differed from earlier ones examining relationships among PLI styles and CLAs, especially for children with hearing loss, was that these relationships were examined for parental language during the preschool years and child language in elementary school. Of course, a criticism of this approach that might be offered would be that PLI style during the elementary grades may influence child language learning in those years. However, the decision to focus on PLI styles during the preschool years was based on the hypothesis that, by elementary school, parents have ceased to be their children's primary teachers. By school age, children are spending much of their time outside of the home with teachers and peers. Furthermore, much of the coaching provided to parents regarding their interaction styles with their children takes place during the preschool years. By the school grades, most intervention for children with hearing loss is direct, involving only the child. Thus, the question may be asked of whether those early parental interaction styles—the ones that clinicians seek to affect through coaching—yield long-term effects.

Of course, some or all of the effects observed for early parental interaction styles on later language abilities might derive from their effects on early language abilities. Understanding what proportion of the effect of early PLI on later language skills is direct and what proportion of that effect is indirect, through its influence on early language skills, can help clinicians shape interventions and assessments. For this reason, mediation analysis was employed, using children's language abilities during the preschool years as the intermediary variable (e.g., MacKinnon, Fairchild, & Fritz, 2007).

Finally, the analyses reported here sought to examine the extent of influence of PLI style (at preschool) on syntactic and phonological language abilities separately. Because phonological sensitivity emerges largely after the start of school, this distinction is made only for analyses involving language measures obtained at school age for these children. It may be that PLI styles during preschool influence the acquisition of syntactic abilities, not phonological, precisely because these latter skills do not emerge until later.

Analysis 1: Influence of Parental Language on Child Language at Preschool

In this first analysis, PLI style was assessed for three groups of children at 48 months of age: a group with NH, a group with HAs, and a group with CIs. All these children were participants in a longitudinal study of development in children with hearing loss (Nittrouer, 2010). The children with NH whose data are included were serving as peers with NH. The parental language behaviors examined included (a) inquiries; (b) directives; (c) verbal responses; and (d) amount of talk directed to the child, with no expectation of a response (explanations). These are the language behaviors that have been found to influence children's language development in the past, in either a positive or a negative manner.

Method

Participants

Data were analyzed from 100 children who were 48 months of age at the time the dependent measures of interest were collected: 34 children with NH, 24 children who wore HAs, and 42 children who wore CIs. Although these sample sizes were the product of the numbers of children in the longitudinal study who were tested at that age, they provided adequate power for the analyses that were performed.

These children had all participated in the study since they were infants (e.g., Caldwell & Nittrouer, 2013; Nittrouer, 2010; Nittrouer, Caldwell, & Holloman, 2012; Nittrouer et al., 2013). They came from 17 cities and towns across the country, from Seattle to Boston and from Albuquerque to Orlando. For this longitudinal project, testing occurred every 6 months, within 1 month of the child's 6-month birthday. To be included in the study at the outset, children had to have unremarkable births with no medical problem other than hearing loss that could reasonably be expected to delay language acquisition on its own. English had to be the only language spoken in the home to the child.

Parents had to have NH or hearing that was readily corrected to normal levels with HAs if some hearing loss was present.

SES was indexed using a two-factor scale on which both the highest educational level and the occupational status of the primary income earner in the home are considered (Nittrouer & Burton, 2005). Scores for each of these factors range from 1 to 8, with 8 being the highest. Values for the two factors are multiplied, resulting in a range of possible scores from 1 to 64. In general, an SES score of 30 represents a household in which the primary income earner has a 4-year university degree and a job such as a mid level manager, computer programmer, nurse, or teacher. Scores below 10 represent abject poverty, usually meaning that the family is receiving government support. The lowest SES score for these groups of children was 12, so none of the children were living in extreme poverty. Mean SES (and standard deviation) was 38 (13) for children with NH, 32 (11) for children with HAs, and 34 (12) for children with CIs. These differences were not statistically significant.

Nonverbal cognitive abilities were assessed using the Leiter International Performance Scale–Revised (Roid & Miller, 2002). Standard scores (and standard deviations) on this test were 104 (15) for children with NH, 101 (16) for children with HAs, and 102 (16) for children with CIs. These differences were not significant.

All children with HAs or CIs had their hearing loss identified, HAs fit, and intervention initiated by 2 years of age: For children with HAs, the median age of identification (and standard deviation) was 5 months (10 months), the median age of receiving first HAs was 6 months (9 months), and the median age of starting intervention was 6 months (10 months). The mean better-ear, pure-tone average threshold (and standard deviation) for the three speech frequencies of 0.5, 1.0, and 2.0 kHz was 63 dB HL (9 dB HL) for these children with HAs. For children with CIs, the median age of identification (and standard deviation) was 4 months (7 months), the median age of receiving first HAs was 6 months (6 months), and the median age of starting intervention was 8 months (7 months). The median age of receiving a first CI (and standard deviation) was 14 months (7 months). The mean better-ear, pure-tone average threshold (and standard deviation) for the three speech frequencies of 0.5, 1.0, and 2.0 kHz before receiving a CI was 105 dB HL (13 dB HL). Of the 42 children with CIs at 48 months of age, 22 children had bilateral CIs, 13 children wore just one CI, and seven children wore an HA on the ear contralateral to the one with a CI. Finally, of these 42 children, 18 had worn an HA on the ear contralateral to the CI for a year or more at the time of receiving a first CI. Of those children, seven continued to do so through 48 months of age, nine received a second implant before 48 months of age, and two simply discontinued HA use.

All children with hearing loss had attended intervention programs since shortly after being identified with hearing loss. Before turning 3 years old, this intervention was provided to the parent and the child at least once per week. Starting at 3 years of age, this intervention took the form of preschool environments, with a mean attendance at preschool of 16 visits per month. Each of these visits ranged in length from 1 to 6 hr. Typically, the preschools that these children attended were affiliated with their earlier intervention programs. In all cases, intervention, including preschool services, was provided by professionals with at least a master's degree in a field associated with deafness. These fields primarily included speech-language pathology and education of the deaf.

Forty-three of the children in the study had received some instruction in a signed language during their infancy/preschool years: 18 children with NH, 11 children with HAs, and 14 children with CIs. For the children with NH, this instruction was in the form of baby signs, which were used when they were infants; they ceased using these signs as their first words emerged. For the children with HAs and CIs, this sign language was used in their early intervention and preschool programs. For children with HAs, parents reported that nine of the 11 children using sign language had been in programs that used American Sign Language; the other two children were in programs that used Signed English. The 14 children with CIs were divided evenly, with seven using American Sign Language and seven using Signed English. However, regardless of the type of sign language these children were exposed to, all children were in programs with a heavy emphasis on spoken language.

Records were obtained from parents at 6-month intervals concerning what proportion of time parents estimated their children used sign language during communication exchanges. At 48 months of age, only five children with HAs and four children with CIs were reported to still be using sign language. Of those nine children, only four were estimated to be using it in more than 20% of their communication exchanges. Likely the reason that sign language use did not continue with these children was that all parents in this study had as their goal that their children would develop spoken language well enough to function in mainstream educational environments without the aid of sign language interpreters. For these parents, sign language was viewed as a means to facilitate spoken language acquisition by their children, an approach that is frequently presented to parents of newly identified children with hearing loss (e.g., Napoli et al., 2015). In addition, as long as spoken language input is adequate, accompanying that spoken language with signs does not seem to affect the acquisition of spoken language in any long-term manner (e.g., Davidson, Lillo-Martin, & Chen Pichler, 2014). Because the focus of the current study was on spoken language acquisition and these children had largely discontinued any use of sign language by 48 months of age, this factor was not considered further in analyses. In particular, no instance of either a parent or a child using a formal sign was observed in the language samples obtained for this study at 48 months of age.

Equipment

The measures of PLI were obtained from samples of each parent–child dyad interacting for 10 min. During these interactions, they were engaged in building a structure with Tinkertoy components in order to replicate a model for which they had a picture. These interactions were recorded using a Sony DCR-TRV19 camera with audio input from an FM transmitter. A separate recording was made for each parent–child dyad in which they played together for 20 min using a set of toys that was consistent across dyads. The same video camera (and FM transmitter) that was used to record the activity with the Tinkertoy model was used to record this activity. Both recordings were used for later scoring.

Procedure

All testing was approved by the institutional review board of the authors' institution. All testing took place at early intervention centers near the homes of the children. All professionals involved in data collection had at least a master's degree in an area relevant to early intervention for deaf children, such as a teacher of the deaf, a speech-language pathologist, or an audiologist. All individuals collecting data were trained on how to do so by attending each of two training sessions at the authors' home institution. Furthermore, each tester had to test at least one child on all tasks, audio/video-record the testing, and send that recording to project staff at the authors' institution for review. Only after the staff was satisfied that an individual tester was collecting data in the prescribed manner would data collection commence.

PLI Measures

At test ages 36, 42, and 48 months, each parent–child dyad sat at a table and was given a picture of a Tinkertoy model and the components from the Tinkertoy set required to construct that model. All dyads were given the same model to complete, but the model varied across the three ages: a tricycle for children at 36 months of age, an airplane for children at 42 months of age, and a swing set for children at 48 months of age. Parents were instructed to build the model and were videotaped for 11 min. During this time, the parent wore the FM transmitter. After each test session, the examiner retrieved the recorded material, which was stored in the format of a mini tape, and mailed those materials with all paper scoring forms to the authors' home institution. Once the videotapes arrived back at the central site, 10 min of the interaction (starting after the first minute) was transferred to a DVD, and a time code was laid down. This time code consisted of 10-s observation intervals, interleaved with 2-s scoring intervals. Different tones accompanied the ends of the observation and scoring intervals to serve as auditory cues as to what state the task was in. During the observation intervals, the scorer watched the video. During the 2-s scoring interval, the scorer recorded which behaviors occurred, pausing the video if necessary. If more than one category of behavior occurred during an interval, each was recorded; however, no single behavior was recorded more than once for an interval. Two scorers independently scored each sample of the parent and child interacting in this way and recorded their responses on paper forms, which were later transferred to data files.

Although there were 16 categories of parental language behaviors that could be scored, four behaviors accounted for more than 90% of observed behaviors. Therefore, only these behaviors are considered in this report. The selection of this set of behaviors makes intuitive sense as well, because they are the ones that have mostly been considered in earlier research. These behaviors are listed and defined in Appendix A.

Occurrence agreement was used to assess reliability between scorers on an interval-by-interval basis. This method is the most stringent test of reliability that could be used: The interval-by-interval aspect of the method helps ensure that each occurrence of agreement is for the same observation. Including only agreement of behavior occurrence—rather than agreement for nonoccurrence—is preferred when there are many intervals in which a behavior may not occur, because to include nonoccurrence agreement would inflate reliability measures (Kent & Foster, 1977). The formula for occurrence reliability is

$A / (A + B + C)$,

where A is the number of intervals in which both observers recorded the behavior, B is the number of intervals in which only Observer 1 recorded the behavior, and C is the number of intervals in which only Observer 2 recorded the behavior. Observer 1 was always the more experienced staff member, so when there was a disagreement, data were retained according to the judgment of Observer 1. Mean occurrence agreement for scoring that a parental language behavior had occurred during that 10-s interval was 99%, and agreement concerning which of the 16 parental language behaviors being scored had occurred was 79%, which was considered adequate given that this method is so stringent.

These measures of PLI served as the independent variables, addressing the question of how PLI facilitates CLA. The perspective taken was that PLI has its effect on emerging language behaviors, so outcomes will largely be seen across time. Therefore, means of the numbers of each of the four PLI behaviors across testing at age groups 36, 42, and 48 months served as the variables of interest; however, comparison of mean numbers of these parental behaviors for each group across the three test ages revealed no significant differences in numbers of occurrences for any PLI for any of the three groups. These three ages comprised the 1-year period leading up to the age at which the dependent measures of CLA were collected.

CLA Measures

Five measures of children's spoken language abilities served as dependent variables. These measures were all obtained at the 48-month test session. Two measures came from unstructured samples of children's language. For these samples, parent–child dyads were recorded in the same way they had been for the samples of PLI, except that, in this case, parents and children played with a set of toys (the same set for all dyads) and children wore vests that held the FM transmitter. The set of toys made available to the dyads was as follows: a felt board with felt people and pets; a set of small, plastic people; a toy phone; a teddy bear; a toy truck; the children's book *Good Night, Gorilla* (Rathmann, 1994), which is largely wordless; a set of see-through plastic blocks with little toys in the middle; and a plastic tea set. These toys were selected on the basis that most of them should evoke conversation. When these materials were given to the parent, the instructions that accompanied them were that they (the parent and the child) should play exactly as they do at home. Each dyad was recorded for 21 min. Later, the video recording was recovered from the camera and shipped to the authors' home facility along with the samples of PLI. A time code was laid down starting 1 min after the start of the recording, and the rest of the recording was scored similarly to how the samples of PLI had been scored. Although these samples were evaluated for several categories of form and function (Nittrouer, 2010), one measure was used in the current report: the raw number of children's utterances that consisted of at least one real word. This measure was selected because it was important to have at least one indicator of general volubility. Furthermore, this particular measure was found to be a strong indicator of general language advancement over the preschool years (Nittrouer, 2010) and a significant predictor of language abilities into kindergarten (Nittrouer et al., 2012). Real-word utterance scores were not available for two children (one with NH and one with CIs) because they would not cooperate with the recording at this test time. Across all children, mean occurrence reliability for judging if an utterance consisting of at least one real word occurred was 94%, which was considered acceptable.

In addition to the interval scoring of form and function of children's language, 50 utterances from the sample were transcribed, starting at the fifth minute. Again, two staff members were involved. First, one staff member transcribed the first 50 utterances starting at the fifth minute. Next, a second staff member reviewed all transcripts by comparing them with the videotaped language samples. If there were discrepancies in how the two staff members would describe an utterance, these differences were resolved by discussion. Those transcriptions were subsequently submitted to analysis with the software package Systematic Analysis of Language Transcripts (Miller & Iglesias, 2006). Again, several measures of morphosyntactic structure were derived from this analysis, and those analyses have been reported elsewhere (Nittrouer, 2010; Nittrouer et al., 2012; Nittrouer, Sansom, Low, Rice, & Caldwell-Tarr, 2014). Only the measure of MLU in morphemes was used in this analysis because it was shown in those studies to be reliable and a good predictor of later language abilities. MLU scores were not available for seven children: the two who would not cooperate with recording and five other children with NH. During the preschool portion of this project, the decision was made to transcribe language samples from only a randomly selected subset of children with NH, because these children were homogeneous in demographic characteristics and should thus show similar and age-appropriate language. The five children with missing MLU scores were not in the randomly selected group of children with NH to have their samples transcribed.

One measure of vocabulary skill was included in the present analysis: the Expressive One-Word Picture Vocabulary Test–Third Edition (EOWPVT-3; Brownell, 2000). In this task, children provide the words that label a series of pictured items shown one at a time on separate pages. Their responses were video-recorded. Later, a laboratory staff member scored responses, and a second staff member checked all scores by watching the video recording again and confirming those scores. If any discrepancies were found, the staff members resolved them by consensus. The laboratory manager monitored all scoring procedures. Raw scores were used in the current analysis, so changes across test ages could be seen.

A measure of auditory comprehension of spoken language was included in this analysis. Specifically, the Auditory Comprehension subscale of the Preschool Language Scale–Fourth Edition (Zimmerman, Steiner, & Pond, 2002) was used. In this task, the experimenter testing the child provides a series of instructions designed to test the child's understanding of the language structures presented. For example, after presenting a teddy bear, a cup, a bowl, and a spoon, the experimenter will say, "The bear is thirsty. Give him something to drink." Again, all testing was recorded for later scoring, as was done for vocabulary testing. As with the vocabulary test, one staff member scored the test, and a second member reviewed the scoring. Raw scores were used in the current analysis.

Finally, a measure of speech intelligibility was obtained. For this purpose, the Children's Speech Intelligibility Measure (CSIM; Wilcox & Morris, 1999) was used. In this task, the child imitates 50 words, one at a time, after the examiner. The instrument consists of 200 such word lists that are constructed from a master list of 600 words. Most words are single-syllable words, but some are two-syllable words. Words were selected to be within the vocabularies of typical preschoolers, and the measure can be used with children as young as 2 years old. At 48 months of age, no measure of speech recognition was collected, so any potential effect of speech recognition abilities on speech intelligibility could not be measured. Nonetheless, because only real words were presented, those words were in the vocabularies of most children, and they were presented with clear access to lipread information, it seems fair to conclude that all children could recognize these words. Nonetheless, this concern regarding the interaction of speech recognition and intelligibility was examined further in the second analysis.

Children's productions were audio/video-recorded in the same way as the samples of parent–child interactions. The samples were recorded at a 48-kHz sampling rate with 16-bit digitization. Once the tape got to the authors' home institution, the CSIM portion was downloaded to a hard drive, and the child's word productions were separated into their own audio-only files. University students who were unfamiliar with the speech of deaf speakers listened to these samples. The task of these listeners was to select the word heard from a set of 12 phonetically similar words. Each listener heard only three lists so that no listener would become skilled at recognizing the speech of deaf children. Two naïve listeners scored the samples from each child. In this study, the mean score from the two listeners for each child was used, and these scores were reported as the percentage of words the listeners identified correctly. The correlation coefficient between the first and second listeners was computed and showed excellent agreement, $r = .94$. Recordings are missing from four children in this study: two for whom the background noise on the recording was too high to provide a good sample, one who refused to cooperate, and one for whom the batteries on the transmitter died halfway through testing without being detected. To summarize, five measures of CLA were included in this analysis: (a) number of real-word utterances, (b) MLU, (c) vocabulary, (d) auditory comprehension, and (e) speech intelligibility.

Analyses

A three-step analysis procedure was used for these data from preschool. First, one-way analysis of variance (ANOVA) was performed on the data themselves to examine potential group differences. Post hoc comparisons were included to assess where group differences did exist, if any were found. Next, Pearson product–moment correlation coefficients were computed to examine how PLI and CLA were related. Finally, potential effects of listening experience were examined using regression analyses.

Results

All data were screened for normality of distributions and homogeneity of variances. In all cases, criteria were met for these attributes. An α of .05 was established; however, recognizing that perspectives vary regarding outcomes that are nearly significant, but not over the established criterion, actual p values are given when $p < .10$. For $p > .10$, outcomes are simply reported as "not significant."

PLI

Table 1 shows the mean number of occurrences of each PLI behavior during the 10-min sample for which PLI was analyzed. ANOVA was performed on each of these measures, but none was found to differ significantly depending on the group. Thus, parents of children in all three groups provided similar kinds of language input to their children, in similar quantities, regardless of hearing status or the device used.

Table 1. Means and standard deviations for numbers of parental language behaviors of each type in a 10-min sample of interaction, averaged across three samples.

	NH		HAs		CIs	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
Inquiries	25.8	5.3	25.7	4.8	24.0	5.6
Directives	16.9	6.9	16.9	6.3	19.9	6.6
Verbal responses	19.6	5.9	16.4	5.7	17.8	6.5
Explanations	32.5	5.2	31.4	6.1	31.5	6.0

Note. NH = children with normal hearing; HAs = children with hearing aids; CIs = children with cochlear implants.

The relationship of SES and PLI was examined, for all children as a single group and for each of the groups separately. To do this, Pearson product–moment correlation coefficients were computed for SES and each of the four PLI measures. None of the correlation coefficients was significant, likely reflecting the fact that none of these children came from families who could be categorized as truly of low SES. Consequently, SES was not considered further in these analyses.

CLAs

Table 2 shows means for the five measures of CLA collected at 48 months of age. Mean raw scores are provided for the vocabulary and auditory comprehension measures: the EOWPVT-3 and the Preschool Language Scale–Fourth Edition, respectively. However, mean standard scores were also available. For the vocabulary measure, mean standard scores were 101 for children with NH, 89 for children with HAs, and 83 for children with CIs. For the measure of auditory comprehension, mean standard scores were 107 for children with NH, 90 for children with HAs, and 86 for children with CIs.

Table 3 shows outcomes of one-way ANOVA conducted on each of these measures, with group as the main effect. Post hoc comparisons were also conducted, using Bonferroni corrections for multiple comparisons because three groups were included. These results show that there was not a significant effect of group for the numbers of real-word utterances produced by children over the course of the 20-min language sample. Thus, the numbers of communicative attempts were similar for children across groups. This finding is complementary to the outcome for PLI that there were no significant differences in quantity of any of the four categories of PLI measured, especially where verbal responses are concerned. Children provided similar numbers of opportunities for parents to respond to communicative attempts, and parents responded with similar frequency.

However, significant differences were observed for all other language measures. Children with NH always differed from children with CIs, and children with NH generally differed from children with HAs, except where MLU was concerned. Children with HAs never differed from children with CIs. Thus, the quality of the language produced was poorer for children with hearing loss than for children with NH, as was the ability to comprehend language.

Correlations Between PLI and CLA

The major objective of this portion of the study was to evaluate the extent to which PLI influenced CLA, for each group of children. To this end, Pearson product–moment

Table 2. Means and standard deviations for child language ability measures at 48 months of age.

Measure	NH		HAs		CIs	
	M	*SD*	*M*	*SD*	*M*	*SD*
Real-word utterances	126	33	110	30	106	41
MLU	3.9	0.8	3.4	1.0	2.9	1.0
Vocabulary	43.4	8.9	33.7	10.7	30.2	11.1
Auditory comprehension	52.8	5.3	44.8	10.5	43.0	9.8
Speech intelligibility	78.6	12.1	56.8	20.1	57.1	18.4

Note. NH = children with normal hearing; HAs = children with hearing aids; CIs = children with cochlear implants; real-word utterances = number in a 10-min sample; MLU = mean length of utterance; vocabulary and auditory comprehension = raw scores; speech intelligibility = percent words recognized correctly.

correlation coefficients were computed between each of the four measures of PLI and each of the five measures of CLA, for each group separately.

For children with NH, only one of the 20 correlation coefficients reached significance: directives versus auditory comprehension, $r(34) = -.377$, $p = .028$. Because this relationship was inverse, the outcome means that more directive styles on the part of parents were associated with poorer auditory comprehension of language for these children.

For children with HAs, a few more correlation coefficients were significant. These are shown in Table 4. In particular, it can be seen that parental styles that included more inquiries and verbal responses were associated with more real-word utterances and better speech intelligibility. In addition, these children with HAs benefited on almost all language abilities from simply hearing their parents talk, as indicated by the several positive correlations with explanations.

A different pattern of relationship is observed between PLI and CLA for children with CIs. These correlation coefficients are shown in Table 5. For these children, it is seen that all their language abilities benefited from parental interaction styles that involved a lot of inquiries, encouraging the child to talk, and verbal responsiveness when the child communicated.

Effects of Listening Experience

The correlation coefficients described above demonstrate that PLI influenced CLA for children with HAs and CIs. However, the duration of listening experience is commonly found to influence language abilities as well. In particular, age of receiving a first CI has been observed to explain considerable variability in language abilities for children with severe-to-profound hearing loss who receive CIs. For that reason, additional analyses were performed to see if listening experience helped explain CLA for these children with hearing loss.

For children with HAs, correlation analysis was performed to see if age of receiving an HA was related to performance on any of the CLA measures. None of the resulting correlation coefficients were significant. Thus, no further analyses were performed.

For children with CIs, Pearson product–moment correlation coefficients computed for age of first CI and each of the CLA measures revealed four significant relationships: MLU, $r = -.457$, $p = .003$; vocabulary, $r = -.355$, $p = .021$; auditory comprehension, $r = -.384$, $p = .012$; and speech intelligibility, $r = -.353$, $p = .026$. Therefore, separate stepwise regression analyses were performed next, using each CLA (except real-word utterances) as a dependent measure, with age of first CI, and both the number of inquiries and number of verbal responses as independent variables. This was done to see if age of first CI explained any additional variability, when these two PLI measures were considered. Results are shown in Table 6. In all cases, one or both of the PLI measures explained more variability than age of first CI. However, age of first CI explained a significant proportion of additional variability in three of the four CLA measures.

Table 3. Statistical outcomes for child language ability measures at 48 months of age.

Measure	*F*	*df*	*p*	η^2	NH vs. HAs	NH vs. CIs	HAs vs. CIs
Real-word utterances	3.013	2, 95	.054	.060	NS	NS	NS
MLU	8.522	2, 90	< .001	.159	NS	< .001*	NS
Vocabulary	15.778	2, 97	< .001	.245	.002*	< .001*	NS
Auditory comprehension	12.564	2, 97	< .001	.206	.003*	< .001*	NS
Speech intelligibility	17.868	2, 93	< .001	.278	< .001*	< .001*	NS

Note. NH = children with normal hearing; HAs = children with hearing aids; CIs = children with cochlear implants; NS = not significant; MLU = mean length of utterance.

*Significant with Bonferroni correction.

Table 4. Correlation coefficients for children with hearing aids.

Measure	Real-word utterances		MLU		Vocabulary		Auditory comprehension		Speech intelligibility	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Inquiries	.516	.010	—	—	—	—	—	—	.425	.049
Directives	—	—	—	—	—	—	—	—	—	—
Verbal responses	.620	.001	—	—	—	—	—	—	.496	.019
Explanations	—	—	.519	.009	.580	.003	.555	.005	.545	.009

Note. MLU = mean length of utterance.

Analysis 1 Discussion

This first analysis was undertaken to examine the extent to which CLAs during preschool could be explained by parental language interaction styles. Previous studies involving children with and without hearing loss have shown that the way in which parents interact with their children influences the latter's language acquisition. The results reported here were commensurate with those earlier findings. Nonetheless, informative new trends were observed. In particular, differences across groups were found in the influence exerted by parental interaction styles on children's language acquisition.

Children with NH who were acquiring language in a typical fashion were not found to be especially influenced by the variability in their parents' interaction styles observed in these samples. Only one of the 20 correlation coefficients computed between PLI and CLA measures was found to be significant for children with NH: The more directive a parent's interaction style was, the poorer the child's auditory comprehension was. Thus, children with NH seemed to be acquiring language without a strong need for highly selective interaction styles on the part of their parents. These children showed resilience for learning language. Of course, all parents in this study were providing adequate language experiences for their children, as expected given that none of the families was of low SES.

Children with hearing loss, however, required more interactions of a particular kind to be more successful in their language learning. Children with HAs benefited from parental interaction styles consisting of inquiries and verbal responses to some extent, but they could also learn language effectively simply by hearing their parents talk. Children with CIs, on the other hand, required interactions that were highly interactive. These children benefited most from interactions in which their parents asked questions—most often open-ended questions—and then responded to the child's attempt to generate language. These outcomes demonstrate the importance of adults in the environments of children with hearing loss being trained on specific methods of interacting. Nonetheless, the major question in this study concerned the long-term effects of these parental interaction styles on child language learning, and that question served as the focus of the next analysis.

Analysis 2: Influence of Early Parental Language on Child Language at 10 Years of Age

The purpose of this second analysis was to examine the extent to which the manner in which parents interacted with their children during the preschool years influenced later language development. Once children begin school, they spend less time at home. Teachers, scout leaders, friends, and many other people begin to have stronger influences. The question asked here was whether those early influences on children's language continue to be observable.

Of course, it could be that the way in which PLI early in life influences later language development is indirect, through the manner in which it influences early CLAs. The way in which parents interact with their children was seen to affect early language development in Analysis 1, and it is likely that children with better language abilities early in life will have better language skills later in life. Alternatively, it

Table 5. Correlation coefficients for children with cochlear implants.

Measure	Real-word utterances		MLU		Vocabulary		Auditory comprehension		Speech intelligibility	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Inquiries	.357	.022	.341	.029	.570	< .001	.509	.001	.290	.070
Directives	—	—	—	—	—	—	—	—	—	—
Verbal responses	.670	< .001	.493	.001	.534	< .001	.497	.001	.464	.003
Explanations	—	—	—	—	—	—	—	—	—	—

Note. MLU = mean length of utterance.

Table 6. Outcomes for stepwise linear regression for children with cochlear implants (CIs) at 48 months of age, showing the last model derived, including independent factors that explained a significant amount of variability.

Measure	Independent variables explaining significant variance	β	*p*
MLU	Verbal responses	.437	.001
	Age of first CI	−.395	.004
Vocabulary	Inquiries	.421	.003
	Verbal responses	.359	.010
Auditory comprehension	Inquiries	.318	.025
	Verbal responses	.326	.021
	Age of first CI	−.274	.035
Speech intelligibility	Verbal responses	.438	.003
	Age of first CI	−.316	.026

Note. MLU = mean length of utterance.

is possible that the manner in which parents interact with their children early in life impacts the language learning process itself, an effect that would continue through childhood. To tease apart which (if either) of these two paths connecting early parental interactions with later child language development is valid, mediation analysis was used, which aims to separate the effect of parental interaction into these two separate effects: direct and indirect.

Method

Participants

Data from 97 children were included in this second analysis. All children had just completed fourth grade at the time of testing. All children whose data were included in the first analysis were included in this second one, with three exceptions. One child in each group did not return for testing at this time. Furthermore, six children who wore HAs at 48 months of age subsequently received a CI, so they were included in the CI group for this second analysis. These six children had similar pure-tone average thresholds to the children with HAs who were still using those HAs at 10 years of age: 69 dB HL for the newly implanted children and 63 dB HL for the children who continued with HAs. However, these six children had better pure-tone average thresholds than the children who received CIs before the age of 48 months, who had a mean of 105 dB HL. When it comes to measures of CLA, these six children did not demonstrate significantly different performance from other children with HAs at 48 months of age and from other children with CIs at 10 years of age. In fact, age of first CI did not show a significant correlation with any of the CLA measures examined at 10 years of age. That was true regardless of whether the Pearson product–moment correlation coefficients were computed with or without the six children who received their CIs after the age of 48 months. Therefore, these late-implanted children are included in the CI group for this second analysis without any special consideration, and age of first CI was not examined any further. In total, participants at 10 years of age included 33 children with NH, 17 children with HAs, and 47 children with CIs.

One additional audiologic measure was collected at this test age, namely, speech recognition, using the Central Institute for the Deaf W-22 word lists (Hirsh et al., 1952). These words are commonly used in clinical settings. All words are monosyllabic and are organized into lists of 50 words each that are phonemically balanced. The words are presented in an audio-only format. For that reason, recognition scores for these words likely serve as an underestimate of speech recognition when it is possible to see the talker. Mean correct recognition was 99% (SD = 1) for children with NH, 84% (SD = 12) for children with HAs, and 87% (SD = 8) for children with CIs. These scores were used to evaluate the extent to which speech intelligibility may have been constrained by speech recognition for these children.

Equipment

For testing at 10 years of age, children and their parents traveled to the authors' home facility for testing. All testing took place in sound-attenuated rooms. All stimuli used in testing were presented via a computer with a Creative Labs Sound Blaster sound card using a 44.1-kHz sampling rate with 16-bit digitization and a Roland MA-12C powered speaker for audio presentation. No live-voice stimuli were used. For the phonological awareness and auditory comprehension tasks, stimuli were presented in an audiovisual format using a 1,500-kbps data rate and 24-bit digitization for video presentation. This allowed children to use visual cues for speech recognition.

All test sessions were audio/video-recorded using a Sony HDR-XR550V video recorder, so scoring could be done later. Children wore Sony FM transmitters in specially designed vests. The FM receivers provided direct line input to the video cameras to ensure good sound quality for all recordings.

Procedure

All testing was done with the approval of the institutional review board of the authors' home institution. Children and their parents came to the laboratory for one full day and one half day of testing. All testing was divided into 1-hr sessions, with 1-hr breaks between each session. Seven CLA measures collected at 10 years of age were included in this second analysis.

A measure of children's oral narrative abilities was collected. For this purpose, the pictures of Fey, Catts, Proctor-Williams, Tomblin, and Zhang (2004) were used. These stimulus materials consist of four sets of three pictures each. The first picture in each set includes key characters and elements of the setting but does not explicitly illustrate any elements of a problem facing the characters. The second picture in each set shows the main character in a situation that could be identified as a problem. The final picture in each set contains the main character taking some action that could solve the problem illustrated in the second picture, without explicitly indicating what the resolution was. One set was used consistently with all children to model how to generate a narrative. Before children presented their narratives, the examiner pointed out key elements to the child in the pictures used for the model narrative as a way to encourage the child to consider all essential details in a set of pictures. Then, the examiner read the model narrative. The child was next given 10 min to generate a narrative, and then, the child was audio/video-recorded telling the narrative.

Later, two members of the laboratory team scored each narrative independently for 12 assessment categories, each having a 4-point scale ranging from 0 to 3. Thus, a child's narrative could receive between 0 and 36 points. The laboratory staff trained as a group to develop well-defined criteria for the point scale of each category. These categories were:

1. Introduction/describing the setting
2. Plot description and detail
3. Character descriptions
4. Descriptions of characters' mental states
5. Correct use of referencing
6. Remaining focused on the main story plot and elements
7. Order of narrative elements
8. Details of storytelling
9. Maintaining correct narrative tense
10. Richness of vocabulary
11. Ending
12. Cohesion of narrative elements

Criteria for scoring in each category are given in Appendix B. Once the two scorers completed their assessments, their scores were compared. Scores were considered valid if there was not more than a 2-point difference between the two scorers' total scores for the narrative. The average of the two total scores was considered the final score for the narrative. If the difference between the scorers' total scores was greater than 2 points, the scorers met and discussed why and how their scores differed. After collaboration, the scorers arrived on a final score to be given to the child. To obtain a measure of reliability for these procedures, two different members of the laboratory staff independently scored 24 narratives that had already been scored by the original scorers: 10 from children with NH, six from children with HAs, and eight from children with CIs. The second pair of scorers went through the same procedures as the original pair of scorers, and scores across the two pairs were compared for each assessment category, using the following formula:

Percent agreement = 1 – (mean absolute amount of disagreement/3),

where 3 was the maximum amount by which the two scores could be different. Using this formula, agreement across the categories was found to range from 87% to 100%, with a mean of 95.7%. This was considered acceptable agreement. Scores on this oral narrative served as the dependent measure.

Vocabulary was measured using the EOWPVT-3, as had been done at 48 months of age. Again, the raw number of words correctly provided by the child served as the dependent measure.

As a measure of auditory comprehension, a test of malapropisms was used. This task was chosen to examine auditory comprehension at this later age, because recognition of malapropisms should rely heavily on a child's sensitivity to word-internal phonological structure. The lexical restructuring model suggests that children's initial lexicons consist of global representations and that these representations acquire phonological form starting near the end of the preschool years and continuing into middle childhood (Bowey & Hirakis, 2006; Charles-Luce & Luce, 1990; Metsala & Walley, 1998; Storkel, 2002). Consequently, it was predicted that PLI in those early years might have a diminished effect on the development of sensitivity to phonological structure, and the use of a malapropism recognition task was designed to test this prediction. In this task, children sat in front of a computer monitor and were presented with a speaker saying a sentence. For each sentence, the child had to say whether the sentence was right or wrong and provide the correction if the sentence was wrong. There were a total of 47 sentences, as shown in Appendix C. Forty-one of these sentences contained malapropisms. Testing was discontinued after six incorrect answers. Responses were audio/video-recorded and scored later by a laboratory staff member. A second staff member subsequently watched the videos and confirmed all scoring. The percentage of items answered correctly served as the dependent measure.

Phonological awareness was assessed to measure the abilities of these children to consciously reflect on phonological structure. Here, a more focused procedure, the final consonant choice (FCC) task (e.g., Nittrouer & Lowenstein, 2015), was used. As with sensitivity to phonological structure in continuous speech, as assessed with malapropisms, phonological awareness is hypothesized to emerge over the years between late preschool and middle childhood. Thus, it may not be as reliant on PLI for its development. In the final consonant choice task, children sat in front of the computer monitor and were presented with stimuli in an audiovisual format. There were 48 trials, and each consisted of the talker saying a word. The child was required to repeat it. The next three words were presented, and the child had to say which of the three words ended in the same sound. Again, testing was discontinued after six incorrect answers. Responses were audio/video-recorded and scored later in the same manner as the malapropism task. Again, a second scorer checked all scoring done by the first scorer. The dependent measure obtained from this task was the percentage of trials answered correctly.

Two reading measures were used in this second analysis, both taken from the Qualitative Reading Inventory, Fourth Edition (Leslie & Caldwell, 2006). Reading is another language-related skill that generally does not emerge until the early elementary grades. For this task, children were asked to read two passages, both at the fourth-grade level. One was a narrative, and one was an expository. After a child read each passage, 10 comprehension questions were asked by the examiner. Children were audio/video-recorded reading these passages and answering the questions. The number of words read correctly was scored, along with the number of questions answered correctly. Again, a second scorer checked all scoring done by the first scorer. The two dependent measures obtained from this task were the percentage of words read correctly and the percentage of questions answered correctly.

Finally, speech intelligibility was assessed. The task used for this purpose was the same as the one used at 48 months of age and consisted of the CSIM (Wilcox & Morris, 1999).

Analyses

First, ANOVA was used to examine group differences on each of the seven dependent CLA measures obtained at 10 years of age. Next, the relationships to those CLAs at 10 years of age of both the PLI and CLA measures at 48 months of age were examined, using either regression or correlation analysis, as appropriate. Finally, mediation analyses were used to explore the nature of the relationship between those PLI measures obtained when children were in preschool and their language abilities at 10 years of age.

Results

Data screening revealed that distributions for two of the dependent measures were skewed: phonological awareness and percent words read correctly. Therefore, arcsine transformations were used in data analyses for these two measures; screening of those transformed data revealed that they were not skewed. As in the first analysis, an α of .05 was established, but actual p values are provided when $p < .10$. For $p > .10$, outcomes are simply reported as "not significant."

CLAs

Table 7 shows means and standard deviations for the seven CLA measures, and Table 8 shows the outcomes of one-way ANOVA with post hoc comparisons performed on each of these measures. A significant effect of group was observed for all measures, except reading comprehension. For this particular measure, it appears that children with hearing loss were able to bring enough of their real-world knowledge and syntactic capabilities to the task to make sense of what they were reading—to a great extent. This conclusion (that it is top-down factors that largely account for the near-typical performance of children with hearing loss) is reached because their sensitivity to phonological structure was much poorer than that of children with NH, as gauged by the auditory comprehension and phonological awareness tasks; effect sizes were largest for these two tasks. Therefore, the similarity in comprehension abilities is likely explained by the children with hearing loss using their "top-down" knowledge to make sense of what they were able to gather from the text.

In order to evaluate the extent to which these speech intelligibility scores may have been influenced by children's speech recognition abilities, correlation coefficients were computed between recognition scores for the Central Institute for the Deaf word lists and intelligibility scores for the CSIM task. For none of the groups was a significant correlation observed. That is likely due to the fact that auditory-only recognition of speech for these children was generally so good that when visual information was also provided in the form of lipreading, they had error-free recognition.

An interesting outcome of these analyses for these measures at 10 years of age is that the children with HAs appear to have developed language competencies much closer to their peers with NH than they displayed at 48 months of age and than the children with CIs were able to achieve. However, there is one notable exception: Children with HAs remained significantly below their peers with NH on the auditory comprehension task, which was designed to evaluate how well these children could apply their sensitivity to phonological structure in real-world listening conditions to comprehend precisely what was being said. Although children with HAs were able to develop phonological awareness close to that of their peers with NH (Cohen's d for phonological awareness = 0.48), they were much less skilled at applying that awareness to facilitate recognition of speech in context (Cohen's d for auditory comprehension = 1.26). Children with CIs remained significantly below children with NH in their performance on all dependent CLA measures, with the exception of reading comprehension. The question addressed in this study was how behaviors on the part of parents or children during the preschool years predicted these CLA outcomes at 10 years of age.

Influence of PLI and CLA in Preschool on CLA at 10 Years of Age

First, the PLI measures obtained in preschool were examined for their contributions to CLA measures at 10 years of age. For outcomes at 48 months of age, it was observed that PLI had minimal, if any, effects on CLA for children with NH, explanations had the largest effects for children with HAs, and inquiries and verbal responses had the largest effects for children with CIs. Because these group-related effects were found at the younger age, similar trends were anticipated at 10 years of age. Therefore, stepwise regression using the four PLI measures was conducted, rather than starting with correlational analyses. Each CLA measure at 10 years of age was used as a dependent measure in a separate stepwise regression analysis. For children with NH, none of the preschool PLI measures was found to explain any significant proportion of variability in CLA at 10 years of age. For children with HAs, the PLI measure of explanations

Table 7. Means and standard deviations for child language measures at 10 years of age.

Measure	NH		HAs		CIs	
	M	*SD*	*M*	*SD*	*M*	*SD*
Narrative score	18.3	4.5	17.6	3.9	14.8	4.4
Vocabulary	106	12	105	15	96	18
Auditory comprehension	40	4	32	8	29	10
Phonological awareness	81	15	73	18	57	24
Word reading	95	2	95	3	89	12
Reading comprehension	71	13	69	20	63	22
Speech intelligibility	96	4	92	6	90	7

Note. Narrative score, vocabulary, and auditory comprehension measures are given as raw scores; all others are percent correct scores. NH = children with normal hearing; HAs = children with hearing aids; CIs = children with cochlear implants.

accounted for a significant amount of variability in two CLA measures at 10 years of age: auditory comprehension, $\beta = .524$, $p = .031$, and speech intelligibility, $\beta = .497$, $p = .042$. However, it was for children with CIs that the greatest influence of parental language during preschool on later language abilities was found. Table 9 shows the outcomes of the stepwise regression analysis for children with CIs and reveals that verbal responsiveness on the part of parents during the preschool years explained a significant amount of variability in CLA at 10 years of age for four of the measures. Directives were negatively related to two other CLA measures at 10 years of age, and inquiries were positively related to one measure. Thus, those early interaction styles on the part of parents played an important role in the long-term language abilities of these children with CIs.

Next, the influence of CLA at 48 months of age on later language skills was examined. For this purpose, Pearson product–moment correlation coefficients were computed, between each CLA measure at 48 months of age and each CLA measure at 10 years of age, for each group separately. Tables 10, 11, and 12 show these correlation coefficients for children with NH, HAs, and CIs, respectively. These tables reveal that there are stronger relationships between early language skills and later language skills for the children with hearing loss than between those for the children with NH, with the strongest relationships found for children with CIs.

Because such strong relationships were observed between CLAs of children with CIs at 48 months of age and at 10 years of age, the question as to whether the influences of early PLI on later CLA were direct or mediated by the way early PLI affected those early language abilities became especially pertinent. To examine this question, mediation analysis was performed.

Mediated Effects

In this analysis, the effect on CLA at 10 years of age of changing a hypothetical score for a PLI measure from the first to the third quartile was estimated and termed the *total effect*. This total effect was then separated into direct and indirect effects of PLI on CLA at 10 years of age. The direct effect refers to the portion of the total effect on children's language performance at 10 years of age that is attributable solely to the PLI measure, rather than to any (additional) effect of CLA at 48 months of age. The indirect effect quantifies the change in the measure of language performance at 10 years of age that could be attributed to the effect of the PLI measure on a child's CLA at 48 months of age. In this analysis, language acquisition only of children with CIs was examined, both because this is the group that showed the strongest effects of PLI on CLA, at both 48 months of age and 10 years of age, and because they

Table 8. Statistical outcomes for child language ability measures at 10 years of age.

Measure	*F*	*df*	*p*	η^2	NH vs. HAs	NH vs. CIs	HAs vs. CIs
Narrative score	7.066	2, 94	.001	.131	NS	.002*	.069
Vocabulary	4.091	2, 94	.020	.080	NS	.026*	NS
Auditory comprehension	17.140	2, 94	< .001	.267	.006*	< .001*	NS
Phonological awareness	13.666	2, 94	< .001	.225	NS	< .001*	.026*
Word reading	7.886	2, 94	.001	.144	NS	.002*	.013*
Reading comprehension	NS	NS	NS	NS	NS	NS	NS
Speech intelligibility	8.648	2, 93	< .001	.157	NS	< .001*	NS

Note. NH = children with normal hearing; HAs = children with hearing aids; CIs = children with cochlear implants; NS = not significant.

*Significant with Bonferroni correction.

Table 9. Outcomes for stepwise linear regression for children with cochlear implants at 10 years of age, showing the last model derived, including independent parental language input factors from preschool that explained a significant amount of variability.

Measure	Independent variables explaining significant variance	β	*p*
Narrative score	Verbal responses	.340	.019
Vocabulary	Verbal responses	.317	.030
Auditory comprehension	Verbal responses	.495	< .001
Phonological awareness	Directives	−.406	.003
	Inquiries	.335	.012
Word reading	Directives	−.357	.014
Reading comprehension	NS	NS	NS
Speech intelligibility	Verbal responses	.498	< .001

Note. NS = not significant.

largely comprise the group of primary interest; the HA group was smaller. Verbal responsiveness was selected as the PLI to be investigated, because it is the one that explained significant amounts of variability in the most number of CLAs at 10 years of age. Speech intelligibility was selected as the CLA measure at 48 months of age to be included, because it explained more variability at 10 years of age than any other CLA measure collected at 48 months of age. Therefore, the direct effect in this analysis quantified the change in the outcome measure that would be expected by changing verbal responsiveness from the first to the third quartile, with the effect of speech intelligibility at 48 months of age held constant. The indirect effect quantified the change in the measure of language performance at 10 years of age that could be attributed to the effect of verbal responsiveness on a child's speech intelligibility at 48 months of age. A large direct effect and a small indirect effect would suggest that verbal responsiveness had a strong impact on the CLA measure at 10 years of age, regardless of the child's speech intelligibility at 48 months of age. Conversely, a large indirect effect and a small direct effect would indicate that any effect of verbal responsiveness on the CLA at 10 years of age was only due to the fact that verbal responsiveness facilitated better speech intelligibility during those preschool years. If both direct and indirect effects were found to be large, then it could be concluded that verbal responsiveness during the preschool years affects later language abilities both because it leads to changes in speech intelligibility early in life that then influence language development and because a parent's verbal responsiveness during those early years continues on its own to affect development through later childhood.

Table 13 shows the results of the mediation analysis, with outcomes divided into total, direct, and indirect effects. The scales differ, depending on whether integers were used, as was the case for the first three measures, or percent scores were used, as was the case for the last four measures. It can be seen that, in all cases, effects were positive, meaning that verbal responsiveness during the preschool years facilitated CLA at 10 years of age. The confidence intervals suggest whether the effects were significant or not, with the *p* value decreasing as the confidence interval moves away from zero. Looking at total effects first, it is seen that four of the seven CLA measures were clearly significant: narratives, vocabulary, auditory comprehension, and speech intelligibility; confidence intervals do not cross zero at all for these measures. Two other CLA measures were nearly significant: phonological awareness and word reading; although confidence intervals are at or cross zero by a small amount, they are largely positive. The CLA that shows the weakest total effect of verbal responsiveness is reading comprehension; the confidence interval is not clearly positive. Next, these total effects were considered as separate direct and indirect effects, for each CLA.

Narrative Score

Both the direct and indirect effects of verbal responsiveness on narrative scores were positive, but the direct effect

Table 10. Correlation coefficients for children with normal hearing at 10 years of age, for child language abilities at 48 months of age.

	Narratives		Vocabulary		Aud comp		Phon aware		Word read		Read comp		Speech intell	
Measure	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
RW utter	—	—	—	—	—	—	—	—	—	—	—	—	.383	.031
MLU	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vocabulary	.404	.020	.815	< .001	.617	< .001	—	—	—	—	.469	.006	—	—
Aud comp	—	—	.553	.001	.482	.004	—	—	—	—	.465	.006	—	—
Speech intell	—	—	—	—	—	—	.345	.049	—	—	—	—	—	—

Note. Aud comp = auditory comprehension; Phon aware = phonological awareness; Word read = word reading; Read comp = reading comprehension; Speech intell = speech intelligibility; RW utter = real-word utterances; MLU = mean length of utterance.

Table 11. Correlation coefficients for children with hearing aids at 10 years of age, for child language abilities at 48 months of age.

Measure	Narratives *r*	Narratives *p*	Vocabulary *r*	Vocabulary *p*	Aud comp *r*	Aud comp *p*	Phon aware *r*	Phon aware *p*	Word read *r*	Word read *p*	Read comp *r*	Read comp *p*	Speech intell *r*	Speech intell *p*
RW utter	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MLU	—	—	.560	.019	.668	.003	—	—	.605	.010	—	—	—	—
Vocabulary	—	—	.817	< .001	.623	.007	—	—	.590	.013	—	—	—	—
Aud comp	—	—	.748	.001	.777	< .001	—	—	.689	.002	—	—	—	—
Speech intell	—	—	.448	.082	.688	.003	—	—	.515	.041	—	—	—	—

Note. Aud comp = auditory comprehension; Phon aware = phonological awareness; Word read = word reading; Read comp = reading comprehension; Speech intell = speech intelligibility; RW utter = real-word utterances; MLU = mean length of utterance.

was stronger. Thus, verbal responsiveness during those preschool years facilitated the abilities of children with CIs to construct narratives most directly. This outcome suggests that it is experience with generating language that is most facilitative of this CLA, rather than speech production abilities.

Vocabulary

Again, both direct and indirect effects were positive, but here, these effects appear more similar in magnitude, as indicated by the greater similarity in confidence intervals. Thus, experience producing speech in general, as well as specific speech production abilities (i.e., intelligibility), contributed to vocabulary growth.

Auditory Comprehension

Both direct and indirect effects were largely positive when children's abilities to recognize malapropisms are considered. These effects seem similar in magnitude, although only the indirect effect is clearly statistically significant. These findings suggest that when it comes to auditory comprehension of language, children benefit both from opportunities to generate their own language and from the development of keen speech production abilities.

Phonological Awareness

For this measure, it is clear that the indirect effect is larger than the direct effect; the latter is centered on zero. Thus, good speech production during those early years of childhood facilitates a child's discovery of word-internal phonological structure.

Word Reading

Outcomes for this measure replicate those observed for phonological awareness, perhaps because word reading can be expected to depend on good phonological awareness.

Reading Comprehension

Outcomes were most surprising for this CLA measure, because the total effect had not appeared to be significant. However, when direct and indirect effects are separated, it becomes clear that verbal responsiveness had an indirect effect on later reading comprehension, through its effect on early speech intelligibility.

Speech Intelligibility

It is of some interest that the strongest effect found for speech intelligibility is not the indirect effect but rather the direct effect. This finding highlights how strongly a parental language style of verbal responsiveness supported the acquisition of good speech production abilities.

Analysis 2 Discussion

The major goal of this second analysis was to assess the long-term consequences to children's language acquisition of their parents' language input during the preschool years. In this analysis, relative to those used at 48 months of age, a slightly different set of child language outcome measures was included, as dependent variables. The set at 10 years of age included measures of vocabulary, auditory comprehension, and speech intelligibility, as had been

Table 12. Correlation coefficients for children with cochlear implants at 10 years of age, for child language abilities at 48 months of age.

Measure	Narratives *r*	Narratives *p*	Vocabulary *r*	Vocabulary *p*	Aud comp *r*	Aud comp *p*	Phon aware *r*	Phon aware *p*	Word read *r*	Word read *p*	Read comp *r*	Read comp *p*	Speech intell *r*	Speech intell *p*
RW utter	—	—	—	—	.434	.003	.260	.081	—	—	—	—	.390	.008
MLU	.311	.035	.529	< .001	.644	< .001	.424	.003	.503	< .001	.613	< .001	.544	< .001
Vocabulary	.331	.023	.565	< .001	.705	< .001	.414	.004	.502	< .001	.392	.006	.481	.001
Aud comp	.314	.032	.452	.001	.653	< .001	.394	.006	.531	< .001	.427	.003	.540	< .001
Speech intell	.450	.002	.535	< .001	.760	< .001	.524	< .001	.637	< .001	.552	< .001	.604	< .001

Note. Aud comp = auditory comprehension; Phon aware = phonological awareness; Word read = word reading; Read comp = reading comprehension; Speech intell = speech intelligibility; RW utter = real-word utterances; MLU = mean length of utterance.

Table 13. Results of mediation analysis of the effect of verbal responses on each outcome measured at 10 years of age and whether the effect was mediated through speech intelligibility at 48 months of age.

Outcomes	Total [95% CI]	Direct [95% CI]	Indirect [95% CI]
Narrative score	1.86 [0.3, 3.42]	1.19 [–0.7, 3.07]	0.67 [–0.58, 1.93]
Vocabulary	8.27 [0.98, 15.56]	3.55 [–2.17, 9.28]	4.71 [–0.32, 9.75]
Auditory comprehension	5.39 [2.52, 8.27]	2.31 [–0.58, 5.21]	3.08 [0.46, 5.70]
Phonological awareness	0.07 [–0.02, 0.17]	–0.01 [–0.13, 0.12]	0.08 [–0.02, 0.19]
Word reading	0.05 [0, 0.10]	0 [–0.06, 0.07]	0.05 [–0.01, 0.10]
Reading comprehension	0.04 [–0.03, 0.10]	–0.01 [–0.08, 0.06]	0.05 [–0.01, 0.11]
Speech intelligibility	0.03 [0.01, 0.06]	0.02 [0, 0.05]	0.01 [–0.01, 0.03]

collected at 48 months of age. However, the measure of auditory comprehension at this later age consisted of a measure more directly assessing children's sensitivity to phonological structure during continuous speech perception than what had been collected earlier. This selection was a deliberate effort to focus on that ability to recognize phonological structure, a language skill that emerges in large part after the preschool years. Along those lines, a measure of phonological awareness was also obtained at this later age, as were two measures of reading abilities: word reading and reading comprehension. Finally, a measure of children's abilities to construct a narrative was included.

Group differences were observed for six of the seven measures collected at 10 years of age, with the largest effects found for auditory comprehension (which depended on sensitivity to phonological structure) and phonological awareness. This trend supports the contention that children with hearing loss encounter the greatest challenges acquiring sensitivity to phonological structure, rather than acquiring skills with lexical or syntactic structures (Nittrouer, Muir, Tietgens, Moberly, & Lowenstein, 2018). At this age, the performance of children with HAs was more similar to that of children with NH than it had been at 48 months of age; that was not the case for children with CIs.

However, it is the manner in which and the extent to which early PLI influences CLAs at 10 years of age that served as the main focus of this second analysis. Here, it was discovered that several of the trends observed at 48 months of age were replicated: The strongest effects of these parental language styles were observed for the children most at risk for language delays; in this case, that meant the children with CIs. In addition, the strongest effects of parental language style were observed for parental behaviors that continued, extended, or modified children's communication acts, in other words, verbal responsiveness. This finding replicates Quittner et al.'s (2013) observation that maternal sensitivity strongly supports positive language outcomes for children with CIs: Verbal responsiveness is surely one behavioral manifestation of maternal sensitivity.

When relationships among early CLAs and later CLAs were examined, several trends emerged—some anticipated and some unanticipated. First, few significant relationships were observed between early CLAs and later CLAs for the children with NH. This lack of strong dependence among variables is a hallmark of language acquisition among children with NH and no risk factors for language delay. It is evidence of just how robust language development is for most children. As long as they have access to the ambient language, they acquire it with seemingly no effort. It is only when challenges are encountered in language acquisition that the specific details of the learning experience become pertinent. For children with HAs, a few more relationships were found, but the strongest effects of early language abilities on later language outcomes were observed for children with CIs. Moreover, for these children with CIs, speech intelligibility at 48 months of age explained the most variability in CLAs at 10 years of age for five of the seven measures obtained. The only exceptions were (a) vocabulary, where the same measure was used at both test ages and early performance was the best predictor of later performance, and (b) reading comprehension, where MLU at 48 months of age was the best predictor. This last finding supports the proposal that the lack of significant group differences for reading comprehension was due to children with hearing loss applying top-down linguistic knowledge: The better their syntactic abilities were at preschool, as indexed by MLU, the better their later reading comprehension was.

When mediation analyses were performed for outcomes from children with CIs, it became apparent that, for some CLA measures at 10 years of age, the effects of early PLI on later CLA arose due to the indirect effect that PLI—specifically, verbal responsiveness—had on early CLA—specifically, speech intelligibility. These trends conform to expectations of language learning when syntactic and phonological skills are considered as quasi-independent. The CLA at 10 years of age that is most clearly syntactic in nature was most strongly influenced directly by verbal responsiveness at younger ages. This CLA was narrative ability. The CLA measures that were more dependent on sensitivity to phonological structure showed more of an indirect effect. These measures included vocabulary development, recognizing malapropisms, phonological awareness, and word reading. Thus, for language skills that develop largely after early intervention ends, the skills that were developed during those early years are most relevant.

General Discussion

Most early intervention models are built on the premise that parents are their children's first teachers. That seems reasonable, but when it comes to children with NH, who are free from debilitating conditions and living in middle-class households, it almost seems that no teaching is required for them to develop language. These children discover lexical units in the language they hear and learn to combine those lexical units appropriately to communicate relationships among them. Later, these children go on to discover the internal constituents of those lexical units, known as phonological structure, again seemingly without effort or teaching.

Nonetheless, several kinds of evidence demonstrate the importance of PLI styles. In particular, children who are not from middle-class households exhibit delays in language acquisition that seem traceable to diminished language input, or ineffective styles of input on the part of their parents. The conclusion that the language delays exhibited by children living in poverty are due to these failures of language experience, rather than to any other consequence of poverty, is supported by evidence showing that, when these children receive adequate PLI, they learn language in a typical manner (Norman-Jackson, 1982). Thus, this SES-related difference in PLI styles can be held responsible for the language deficits of children living in poverty.

Some children face language-learning challenges for reasons unrelated to SES. In the analyses reported here, the focus was on children with hearing loss, but, presumably, many of the conclusions reached here can be generalized to other groups of children facing similar challenges, such as those associated with genetic etiologies. In this case, it was revealed that the amount and, in some cases, manner of language input from parents had significant effects on children's abilities to acquire language. For children with moderate losses who were able to benefit from HAs, effects were observed simply due to the amount of language that they heard. However, for children with more severe hearing losses who required CIs, the nature of that input mattered a great deal: The best outcomes were found for PLI styles that encouraged more generative language on the part of these children and then provided extended or modified versions of that generative language. Moreover, this was true regardless of whether child language outcomes were considered at the end of preschool or 6 years later.

A finding from the analyses reported here that was somewhat unexpected concerned the relationship of speech intelligibility to PLI, as well as to the acquisition of later language skills. In preschool, parental language styles that were responsive optimally facilitated speech production skills on the part of the children with CIs, as demonstrated by the measures of speech intelligibility. The reason for this relationship is not immediately evident. It may be that these children have sufficient recognition to use the extensions or recasts of their own speech that were provided by their parents to fine-tune their productions. When it comes to the facilitative effects of speech production abilities, this measure of intelligibility obtained at 48 months of age explained large and significant amounts of variability in the language abilities of children with CIs at 10 years of age. This relationship was observed for morphosyntactic skills, such as the telling of oral narratives and the comprehension of written text, as well as phonologically based language skills, such as auditory comprehension of malapropisms and phonological awareness. Thus, a focus of early intervention should involve how well children with hearing loss produce speech.

The role of speech production proficiency in language acquisition must be considered carefully to understand the reason for these relationships between other skills and speech intelligibility. Where skills such as oral narratives are concerned, it may be as simple as that listeners remain attentive for longer periods when it is easier to understand a child. Where phonologically based language skills are concerned, it seems likely that more refined speech production capabilities facilitate the development of sensitivity to phonological structure most effectively, a suggestion that follows from the view of the phoneme as a perceptuomotor structure (Studdert-Kennedy, 1987). According to this view, phonemic categories are defined by both the sensory and motor properties associated with those categories. Thus, learning to produce carefully coordinated speech contributes to the refinement of phonological structure for the child and, hence, sensitivity to that structure in the speech that is heard. These enhanced phonological representations and sensitivity would promote the restructuring of the lexicon, supporting better vocabulary development, as well as better auditory comprehension, phonological awareness, and word reading abilities.

Clinical Implications

Important lessons can be learned from these analyses concerning how to design early intervention programs. Coaching parents on how to interact with their children with hearing loss to maximize language learning is an important component of that intervention. Here, it can be seen that this coaching needs to focus on shaping the nature of PLI, as well as the quantity. In particular, language styles consisting of directives should be discouraged, even though a common instruction to parents is to require children to request an item or action before it is provided (e.g., *Say milk, please*). Open-ended questions, extensions, and recasts should be encouraged. These instructions are especially important for parents who have children with CIs. Moreover, these interaction styles should be encouraged among clinicians and teachers who provide intervention to children in group settings during the preschool years.

The child language skills that are evaluated during the preschool and early school-age years should also be reconsidered in light of these findings. In particular, speech intelligibility is not commonly evaluated, but as it turns out, this is a skill that is critical to the acquisition of many other language abilities. Sensitivity to phonological structure should also be assessed carefully.

Summary

PLI has long been recognized as critical for the optimal development of language abilities by children with hearing loss. However, few details have been available regarding the nature or temporal extent of these effects. This study explored whether certain types of parental language styles facilitate language outcomes better than other styles and whether any benefits obtained from PLI during a child's early years could be observed at later ages. These later language abilities were characterized according to how dependent they are on a child having sensitivity to phonological structure in the speech signal. Participants were children with NH, children with moderate losses who used HAs, and children with severe-to-profound losses who used CIs. Mean SES was middle class for all groups, and children with CIs generally received them early. Results revealed different effects of parental language on language acquisition by children as a function of risk for language delay: Children with NH were largely unaffected by the amount or nature of PLI, although all were from middle-class families and thus enjoyed reasonable parental interactions; children with HAs were affected most strongly by the sheer amount of PLI; and children with CIs, who were most at risk for language delay, benefited from parental language styles that encouraged generative language and then extended or modified the child's language. Benefits of PLI were observed for child language measures made later in childhood, although those effects were mediated by speech intelligibility for child language that was dependent on phonological sensitivity. Overall, these outcomes provide important insights for designing early intervention programs for children with hearing loss.

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Appendix A

Definitions of Parental Language Input Scored Categories

Behavior	Definition
Inquiry	The parent asks the child a question that can reasonably be expected to elicit a verbal reply or a nonverbal action. This is a question initiated by the parent, rather than a question offered in response to something the child said.
Directive	The parent verbally commands the child to pursue a given course of action. This category must include a command structure, such as *say*, *look*, *find*, *put*, *watch*, or *let's*.
Verbal response	The parent verbally responds to a question, a statement, or an action by the child clearly directed to the parent. It includes extensions, recasts, and requests for clarification. It does not include simple acknowledgments that the child said something (e.g., *uh-huh*, *okay*), imitations of what the child said, or simple reinforcement for something the child did.
Explanation	The parent provides explanation above and beyond the immediate task or outside of the immediate context. It includes the parent's acknowledgement of something the child said or did. It should be in child-directed tone and should be something the child is expected to hear and understand. Parental "self-talk," including commentaries that are self-directed, would not be scored in this category.

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Scoring Categories and Criteria for the Elicited Narrative

1. Introduction/setting	
0 points – *Unsatisfactory*	- No introduction is given - Narrative begins with an action
1 point – *Needs Improvement*	Child answers only one of the following questions: When? Who? Where?
2 points – *Satisfactory*	Child answers only two of the following questions: When? Who? Where?
3 points – *Excellent*	Child answers all three of the following questions: When? Who? Where?

2. Plot	
0 points – *Unsatisfactory*	No goal, problem, or resolution
1 point – *Needs Improvement*	Child provides only one of the following: goal, problem, resolution
2 points – *Satisfactory*	Child provides only two of the following: goal, problem, resolution
3 points – *Excellent*	Child provides all three of the following: goal, problem, resolution

3. Character descriptions/development	
0 points – *Unsatisfactory*	Child fails to describe any characters/entities, or, if he/she does, character labels are of the most basic level (e.g., *the boy, the girl, the bat*)
1 point – *Needs Improvement*	- Limited description of one character/entity (e.g., *sister, friend, the gray bat;* names) - Or the same description is attributed to more than one character/entity
2 points – *Satisfactory*	- In-depth description of one character/entity - Or limited descriptions of several characters/entities
3 points – *Excellent*	- In-depth descriptions of more than one character/entity

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Scoring Categories and Criteria for the Elicited Narrative

4. Mental states (characters' thoughts and feelings)

0 points – *Unsatisfactory*	No mental states
1 point – *Needs Improvement*	- One mental state given for one character/entity - Or the same mental state is attributed to more than one character/entity
2 points – *Satisfactory*	- Several different mental states given for one character/entity - Or one mental state for several characters/entities (cannot use same mental state for all characters)
3 points – *Excellent*	- Several mental states given for several characters/entities - One character inferring the mental state of another character - Sophisticated lexical items are used to describe mental states

5 Referencing

Does the listener know who and what the child is referring to at all times? Correct referencing involves using words such as personal pronouns (e.g., he, she, it, they), possessive pronouns (e.g., my, his, hers, your), and demonstratives (e.g., that, those, these) in place of previously introduced people, places, or things.

0 points – *Unsatisfactory*	- No correct referencing for any characters/entities, objects, or places
1 point – *Needs Improvement*	- Referencing attempts are made but significant error(s) occurs - Child mentions characters/entities, objects, places that were never introduced or established
2 points – *Satisfactory*	- Correct referencing is maintained, but the story is short and simple - Or the story is longer and more complex, but there are a few referencing errors
3 points – *Excellent*	- All characters/entities, objects, and places are referenced correctly throughout a story that is longer and more complex - **Must have a Plot score of 3 to get a 3 in this category**

Note. Boldfaced items are superordinate criteria.

6. Focus

A well-focused story has a beginning, middle, and end that tie together effortlessly to develop the plot. Well-focused stories do not stray from the plot.

0 points – *Unsatisfactory*	- No clear focus - Sounds more like a series of random events instead of a story
1 point – *Needs Improvement*	- The majority of the story lacks focus - Very few C-units relate to the plot - Series of picture descriptions - Child is rambling
2 points – *Satisfactory*	- Focus is maintained, but the story is short and simple - Or the story is longer and more complex, but the focus slips in a couple places
3 points – *Excellent*	- Longer, more complex story that maintains focus - **Must have a Plot score of 3 to get a 3 in this category**

7. Order

Do setting descriptions and events follow a logical progression?

0 points – *Unsatisfactory*	- No logical progression
1 point – *Needs Improvement*	- A few C-units are in logical order, but overall, setting descriptions and events occur in a random order
2 points – *Satisfactory*	- All C-units follow a logical progression, but the story is short and simple - Or the story is longer, more complex, and generally follows a logical progression, but a few C-units seem out of order
3 points – *Excellent*	- Longer, more complex story that follows a logical progression - **Must have a Plot score of 3 to get a 3 in this category**

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Scoring Categories and Criteria for the Elicited Narrative

8. Details	
This category assesses the child's use of elaborated phrases to describe events and provide extra information.	
0 points – *Unsatisfactory*	- Very short story with no supporting details
1 point – *Needs Improvement*	- Only a few details - The bare minimum: contains enough details for the reader to know the child is attempting to tell a story but no extra information is given
2 points – *Satisfactory*	- Interesting, descriptive details are given, but the story is relatively short - Or the story is longer and more complex with adequate details, though additional elaborated descriptions and extra information would make the story more interesting and clearer for the reader
3 points – *Excellent*	- Story is longer, more complex, and filled with explicit and interesting details, making the story both enjoyable and captivating

9. Narrative tense	
Evaluation of narrative tense across C-units; supplements the morphosyntactic analyses of SALT	
0 points – *Unsatisfactory*	- Numerous tense errors make it impossible for the reader to determine whether the story events are occurring in the past or present
1 point – *Needs Improvement*	- Correct tense is maintained for most of the story, but some errors exist - Form errors are common; for example, the child uses *was* instead of *were* or *dived* instead of *dove*
2 points – *Satisfactory*	- Maintains correct tense, no form errors, but story is short and simple - Or the story is longer, more complex, and maintains correct tense, but may have a couple form errors
3 points – *Excellent*	- Tense is used correctly (consistent throughout the story and no form errors), **and the narrative contains at least one change in tense that is appropriately implemented** (cannot be a character quote, e.g., *Sally said, "We need to go.")*

10. Vocabulary	
0 points – *Unsatisfactory*	- No use of descriptors - The same words are repeated throughout the narrative - Limited range of vocabulary
1 point – *Needs Improvement*	- A few descriptors might be used - Small range of vocabulary - Some words may be used too many times
2 points – *Satisfactory*	- Contains a variety of descriptors - Doesn't use the same word repetitively
3 points – *Excellent*	- Uses a variety of sophisticated descriptors - Language is colorful and entertaining - Impressive range of vocabulary

11. Ending	
0 points – *Unsatisfactory*	- No clear ending to the narrative - Reader is unsure of whether or not story has ended
1 point – *Needs Improvement*	- Abrupt, unexpected ending - No summarizing statement(s) - May end with a general statement (e.g., *the end*) before the story seems like it should be over
2 points – *Satisfactory*	- Child provides summarizing statement(s), final reactions of the character(s), etc. - May have a general ending statement as well, but this is not necessary
3 points – *Excellent*	- Child provides a moral

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Scoring Categories and Criteria for the Elicited Narrative

12. Cohesion	
0 points – *Unsatisfactory*	- No use of cohesive conjunctions
1 point – *Needs Improvement*	- Cohesive conjunction attempts are made, but significant error(s) exists - Story sounds choppy
2 points – *Satisfactory*	- Cohesive conjunctions are used correctly and when appropriate, but the story is short and simple - Or the story is longer and more complex, but cohesive conjunctions are used incorrectly and/or not as often as they could be
3 points – *Excellent*	- Story is longer and more complex, and cohesive conjunctions are used correctly and the narrative is easy to follow - **Must have a Plot score of 3 to get a 3 in this category**

Appendix C (p. 1 of 2)

Malapropism Task

Instructions: Say, "You are going to hear and see a man say a sentence; some of the sentences have a mistake in them and some do not. The mistake is that a wrong word has been used. For example, the man might say 'Mary had a little ham.' You know that he should have said 'Mary had a little lamb.' The man will say the sentence and you tell me if it was right or wrong. If it was wrong, tell me what word he should have said." The student does not need to state the entire sentence to receive credit. Simply stating "teeth" would be acceptable.

Practice	
1. We should brush our *feet* every morning.	teeth
2. Dad said, "There are *floor* tires on the big truck."	four
3. The large snake slithered past the tree.	*correct*
4. The baby slept best when she had a *battle* in her mouth.	bottle

Score correct answers as 1 and incorrect answers as 0. Discontinue after 6 consecutive incorrect answers.

Item	Acceptable responses	Score 1 or 0 or NR
1. Make sure you *race* your hand once you know the answer.	raise	________
2. Tyler's favorite birthday *pleasant* was a toy train.	present	________
3. The white *sheep* jumped over the fence.	*correct*	________
4. I like to use a big *soon* when I eat soup.	spoon	________
5. *Arch* is the third month of the year.	March	________
6. She ate bread and *better* with dinner.	butter	________
7. John flies all around the *word* for business.	world	________
8. My *cap* purrs whenever I come around.	cat	________
9. The *specific* ocean is the world's largest body of water.	pacific	________
10. Aunt Mary came to the holiday concert.	*correct*	________
11. The puppet show starts every day at *free* o'clock.	three	________
12. My father works at a *constriction* site building houses.	construction	________
13. I rode an *alligator* to the top of the building.	elevator	________
14. Father said, "You can't eat *desert* before your dinner."	dessert	________
15. Give the dice a good *snake* before you toss them.	shake	________
16. The rain made my hair and clothes *soaping* wet.	soaking, sopping	________
17. We climbed from the valley to the *peep* of the mountain.	peak	________
18. The *picture* won the baseball game with his fastball.	pitcher	________
19. I need a good *raisin* to do that.	reason	________
20. Look both ways before you *cross* the street.	*correct*	________
21. Chris put on his best pants and *skirt* and went to the party.	shirt	________
22. Our feet were burnt from the hot sand on the *bleach*.	beach	________
23. I *trade* to play football, but I was unable to keep a hold of the ball.	tried, trained	________
24. Cinderella wore an *elephant* dress to the ball.	elegant	________
25. The dentist said, "Open your *moth* very wide."	mouth	________

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Malapropism Task

Item	Acceptable responses	Score 1 or 0 or NR
26. Asia is the largest *consonant* in the world.	continent	________
27. The winter *buzzard* dropped 20 inches of snow in town.	blizzard	________
28. King Arthur *rules* his kingdom with his beautiful queen.	*correct*	________
29. I like to eat my *beagles* with cream cheese.	bagels	________
30. Sam *thread*, “You must rinse your plates after dinner.”	said	________
31. The horse *bugged* the cowboy right off the saddle.	bucked	________
32. You should sit over *ear*, Jake	here	________
33. I jumped into the deep end of the *slimming* pool .	swimming	________
34. Emily won the third grade *spilling* bee with the word Wednesday.	spelling	________
35. The doctor listened to my *heart* and told me it sounded strong.	*correct*	________
36. Don’t touch the flame or it will *born* your hand.	burn	________
37. Go *instead* the house to get out of the cold.	inside	________
38. The sun was so *brought* that I had to put on glasses.	bright	________
39. The detective had to *finger* out the case of the stolen lunch.	figure	________
40. By winning the fifth *gain,* our team earned the tournament trophy.	game	________
41. My mom always makes a *lift* before she goes to the grocery store.	list	________
42. I put on my socks and *tried* my shoes.	tied	________
43. Everyone was invited to the party *expect* her.	except	________
44. The teacher said, “Don’t forget to *cost* your “t’s” and dot your “i’s”	cross	________
45. Sara could not tell the *distance* between the colors red and pink.	difference	________
46. The white *spoke* billowed out from the chimney.	smoke	________
47. I *think* that the state of Hawaii is made up of more than one island.	*correct*	________