Factors Influencing Language and Reading Development in Young Children with Hearing Loss who use Listening and Spoken Language

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ABSTRACT

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This dissertation comprised three studies investigating early language and reading development of children with hearing loss who used listening and spoken language. The first study examined conversation techniques used by parents during dinnertimes at home with their preschool children with hearing loss ($N = 37$). Twenty-minute dinnertime segments were extracted from daylong, naturalistic Language ENvironment Analysis (LENA) recordings. Transcripts were coded for parents' use of open- and closed-ended language elicitation, reformulation, imitation, directives, and explicit instruction in vocabulary and grammar. Participants' receptive vocabulary and knowledge of basic concepts were also measured. Parents' use of conversation techniques varied widely, with closed-ended elicitations and directives used most frequently during dinner. Open-ended language elicitation related significantly to children's receptive vocabulary, and explicit vocabulary instruction was correlated with basic-concepts skills. Thematic analysis found common themes of concrete conversation topics and sibling speakers. In addition, parents who used many techniques often introduced abstract conversation topics; electronic media was present in all conversations with few techniques.

The second study investigated the longitudinal complexity and quantity of the language input and output of 14 preschool children with hearing loss. Participants' receptive vocabulary and understanding of basic concepts were measured and daylong recordings were collected at two time points one year apart. Twenty-minute dinnertime segments were extracted from each recording, and adults' and children's utterances were coded for syntactic and clausal complexity

and lexical diversity. The quantity and complexity of parental language input remained consistent over one year. The initial clausal complexity of the children's utterances related to their general receptive vocabulary, while the initial syntactic complexity of the children's utterances related to their understanding of basic concepts one year later.

The third study explored the reading skills achieved by 64 children with hearing loss in prekindergarten through third grade. Participants' mean scores on eight reading subtests of the Woodcock-Johnson IV Tests of Achievement were all within one standard deviation of the tests' normative means. Relative strengths were found in basic reading skills, including phonological awareness and spelling. Relative weaknesses were found in oral reading and word- and sentence-reading fluency. When 53 participants' skills were measured one year later, they had made significant gains in letter-word identification, sentence-reading fluency, and word-reading fluency, suggesting that they had made more than one year's progress in one year's time while enrolled in a specialized program.

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Chapter 1

Introduction to the Studies

When children are identified with hearing loss, the attention of their parents and the professionals supporting them often turns immediately to their language development. Without clear access to sound, how will the children understand their caregivers and peers? Will degraded exposure to the auditory environment delay their development of expressive language? Will this delay affect the children's reading skills in the early grades? For families who choose a listening and spoken language outcome for their children with hearing loss, early intervention focuses on consistent use of hearing technology and coaching families and caregivers to provide language-rich auditory environments. Such environments are thought to facilitate meaningful linguistic interactions with the children, which encourage language development and lay the foundation for reading skills (Cole & Flexer, 2016).

Poor reading outcomes have been a persistent problem in the field of deaf education, with the average reading skills of high school graduates who are deaf hovering between fourth- and sixth-grade levels across decades of research (e.g., Allen, 1986; Mitchell & Karchmer, 2012; Traxler, 2000). Some prominent theorists believe that children with hearing loss learn to read in a manner that is qualitatively similar to that used by children with typical hearing, suggesting that a strong (through-the-air) foundation in the vocabulary, phonology, and syntax of the written language is paramount if students with hearing loss are to overcome this reading gap (Trezek, Wang, & Paul, 2010). Indeed, many—but not all—children with hearing loss who learn to listen and talk develop age-appropriate receptive and expressive language skills in their early years and go on to demonstrate reading levels commensurate with those of their hearing peers (Geers, et al., 2017; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2018).

Research suggests that the quality of language input (e.g., the types of language elicitation, vocabulary exposure, and reformulation of children's utterances) from parents and caregivers varies widely among families and is closely tied to variable outcomes in children's language development both for children with hearing loss (e.g., DesJardin, 2006; Duncan & Lederberg, 2018) and for those with typical hearing (e.g., Hoff-Ginsberg, 1986; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). Greater quantities of adult speech, particularly as they encourage conversational turns, also appear to relate positively to better language outcomes for children with hearing loss (Ambrose, VanDam, & Moeller, 2014; VanDam, Ambrose, & Moeller, 2012; Vohr, Topol, Watson, St. Pierre, & Tucker, 2014). However, the amount of adult speech to which children with hearing loss are exposed differs with such demographic factors as degree of hearing loss, family income, maternal education level, and exposure to electronic media in the home (e.g., Ambrose et al., 2014; Aragon & Yoshinago-Itano, 2012). Although both the quality and quantity of language input separately appear to influence language development, and thus foundational reading skills, for children with hearing loss, less is known about the interaction of these factors, particularly over time (Arora et al., in preparation; DesJardin & Eisenberg, 2007). The present dissertation aims to explore these issues within the context of early education for children with hearing loss who use listening and spoken language.

The dissertation comprises three studies, which follow the language development of young children who are deaf and hard of hearing and investigate factors that contribute to successful communication and literacy outcomes. Using a mixed-methods approach, the first study closely examines the quality of language input experienced by preschoolers with hearing loss in their home environments and identifies the relations between parents' use of evidence-informed language-learning strategies and children's vocabulary knowledge. Using Language ENvironment Analysis (LENA) technology, the second study takes a longitudinal view and investigates the relations among the complexity and quantity of language input experienced by young children with hearing loss and their receptive vocabulary development over one year. Finally, the third study explores the reading achievement of preschool and early-elementary students with hearing loss and analyzes their progress over one year in a specialized listening and spoken language school.

Background

In the United States, two to three out of every 1,000 children born are diagnosed with a permanent hearing loss each year (Centers for Disease Control and Prevention, 2019). Ninety-five percent of children diagnosed with hearing loss have parents with typical hearing, and these parents overwhelmingly choose listening and spoken language, rather than sign language, as their child's mode of communication and instruction in school (Mitchell & Karchmer, 2004). Individuals who use American Sign Language and consider themselves a part of the Deaf community often identify as Deaf with a capital D, which emphasizes the cultural importance of their Deaf identity. Those who use listening and spoken language generally identify as having hearing loss or as being deaf or hard of hearing (with lowercase letters). The studies in this dissertation focus on children who are learning to listen and talk, so the term "children with hearing loss" will be used throughout the text.

Developing spoken language requires access to adequate auditory input. Hearing technology is thus a crucial component of listening and spoken language-based intervention. Children with mild to moderately severe sensorineural hearing loss, which occurs in the inner ear or auditory nerve, generally benefit from hearing aids. This digital technology is programmed for the wearer's specific configuration of hearing loss and amplifies sounds at the frequencies at which he or she does not otherwise have adequate access (National Institute on Deafness and Other Communication Disorders [NIDCD], 2017). Cochlear implants comprise surgically implanted internal electrode arrays and externally worn speech processors. The devices have historically been indicated for children with profound sensorineural hearing loss, but candidacy has recently expanded to include those with severe hearing loss, high-frequency loss, and single-sided deafness (Carlson et al., 2018). Although an increasing number of young infants have begun to receive cochlear implants, the Food and Drug Administration has approved the devices only for babies aged 12 months and older (Gifford, 2016). Because most children who require cochlear implants cannot access speech through even the most powerful hearing aids, many thus experience an additional 12-month delay in listening and language development in comparison to their peers with more mild hearing loss.

Auditory-verbal intervention focuses on "training the brain[s]" of children with hearing loss to make sense of the auditory signals delivered by their hearing technology and understand speech (Cole & Flexer, 2016). In contrast with older "auditory-oral" methods that emphasized speechreading and highly structured remedial practice, auditory-verbal practice follows a developmental approach that stresses the importance of rich language interactions in the child's natural environment. Family involvement in therapy is paramount, with early interventionists coaching parents in implementing evidence-informed listening and language strategies throughout their home routines (Simser & Estabrooks, 2012). Preschool and elementary programs for children with hearing loss, while center based, continue to emphasize family engagement and the use of developmentally appropriate curricula and activities (Bradham, Fonnesbeck, Toll, & Hecht, 2018).

Some children with hearing loss who undergo highly specialized intervention in listening and spoken language can develop speech and language commensurate with their typically hearing peers and participate in mainstream education programs as early as age 3. Others struggle with certain aspects of spoken language and may need targeted intervention in these areas (i.e., the form, content, or use of spoken English) (Dornan, Hickson, Murdoch, Houston, & Constantinescu, 2010). Research suggests that one reason for language delays may be delays in identification and intervention for some children with hearing loss. The Joint Commission on Infant Hearing (JCIH; 2007) recommended that infants be screened for hearing loss by 1 month of age, have their hearing loss officially identified by 3 months of age, and be fit with hearing technology and enrolled in appropriate intervention by 6 months of age. While this emphasis on early identification and intervention is widely accepted within the field of auditory-verbal practice, many families experience challenges in accessing technology and services within the recommended timeframe. These challenges, which often relate to demographic factors, may impact the language environments experienced by children with hearing loss, as well as their listening, language, and literacy outcomes (JCIH, 2007; Spivak, Sokol, Auerbach, & Gershkovich, 2009).

Significance of the Studies

Theoretical Framework

Vygotsky (1978) emphasized the importance of social interaction in the linguistic and cognitive development of young children. This work heavily informs the three studies on language and reading acquisition presented in this dissertation. To Vygotsky, children learn to create meaning through meaningful interactions with more knowledgeable others, or adults who can engage them in experiencing the world around them through language, movement, and play.

In order to be comprehensible, these interactions with the environment must take place in the child's Zone of Proximal Development, or a level just above that, which he or she could accomplish independently. Vygotsky's theories highlight the interactive nature of development and the influence of adult input on outcomes demonstrated by young children.

Research on language environments and the development of early language has found empirical evidence for Vygotsky's (1978) theories, highlighting differences in vocabulary and academic achievement relative to the quality and quantity of language input provided by parents and other caregivers (e.g., Hart & Risley, 1995; Hoff-Ginsberg, 1991; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). This work provided the theoretical underpinnings for auditory-verbal therapy's emphasis on family-centered intervention designed to increase language-rich interactions (Cole & Flexer, 2016). This listening and spoken language-based intervention emphasizes the quality of adult input, but little research has focused on the longitudinal connection between the complexity of such input and language development in children with hearing loss (Ambrose et al., 2014; Ambrose, Walker, Unflat-Berry, Oleson, & Mueller, 2015; Cruz, Quittner, Marker, DesJardin, & CDaCI Investigative Team, 2013; Vohr et al., 2014).

Vygotsky's work suggests that the "zone of proximal development" presents a useful proxy for evaluating the quality of the language environment. Adult input that is slightly more diverse and complex than the language a child understands independently should theoretically lead to more language growth than input that is too simple or far too advanced. Adults might also use the zone of proximal development when they explicitly or implicitly connect new vocabulary to familiar concepts, particularly if they pair this exposure with semantically rich experiences (Lund, Douglas, & Schuele, 2015). This dissertation will explore the quality and quantity of language exposure for children with hearing loss both at a single point and over time, highlighting the effects of children's interactions with "more knowledgeable others" on their vocabulary and reading development.

Vocabulary and Children with Hearing Loss

While outcomes for children with hearing loss who use listening and spoken language have improved markedly with the advent of such advanced technology as cochlear implants and digital hearing aids, vocabulary knowledge remains an area of delay for many children who use such technology. When compared to their age-matched peers with typical hearing, young children with cochlear implants, for example, demonstrate fewer words in their receptive and expressive vocabularies (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006). Children with congenital hearing loss are born with delays with respect to time listening in utero, and late amplification compounds these delays (Bobzien et al., 2015). Children whose families choose listening and spoken language must make rapid progress—more than one month's vocabulary growth in one month's time—to achieve age-appropriate word knowledge (Cole & Flexer, 2016). A comparative study by Nott, Cohen, Brown, and Wigglesworth (2009), however, suggests that preschoolers with cochlear implants add to their lexicons at a slower rate than do their age-matched peers with typical hearing.

The vocabulary size and level of semantic understanding in children who are deaf and hard of hearing may be related to a variety of factors, including speech perception abilities, auditory memory capacity, and listening age (Houston, Stewart, Moberly, Hollich, & Miyamoto, 2012). Access to a clear speech signal through the use of appropriate technology is particularly critical for vocabulary development. Pittman (2008) found that decreased auditory access negatively affects the ability of children with hearing loss to learn the phonological features of new words. This difficulty may limit the creation of phonological representations of the word in a child's memory and affect the development of reading skills. While children with typical hearing learn new vocabulary words through incidental exposure, hearing loss may limit a child's ability to learn new words, as well as new meanings for familiar words (Davidson, Geers, & Nicholas, 2013). This lack of incidental access to what Lund, Douglas, and Schuele (2015) term "semantically rich input" (p. 164) can lead to a decreased ability to categorize words by their semantic and phonological features.

Language Input and Acquisition

Research in the development of both children with typical hearing and children with hearing loss has examined how spoken language develops and the factors related to the rate of vocabulary acquisition. Studies involving children with typical hearing have tied the quantity and quality of adult language input to children's language output and school readiness. The number of adult words to which infants as young as 9 months of age are exposed has been shown to predict future vocabulary scores, with caregiver comments focused on objects of joint attention particularly predictive of lexical development (Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Rollins, 2003). Children whose caregivers use more varied and complex language, especially diverse clauses, lexicon, and syntax, have been shown to develop more complex expressive language as they approach school age (Huttenlocher et al., 2010). Without intervention, the quantity and quality of adult language input appear to vary with socioeconomic status; professional parents with advanced degrees provide significantly more words combined in more complex ways than do working-class parents without college degrees (Hart & Risley, 1995; Hoff-Ginsberg, 1994). The decreased adult language input for children from lower socioeconomic backgrounds then relates to slower vocabulary growth for these children (Hoff, 2003).

Research on children with hearing loss who use listening and spoken language has found a similar link between children's language environments and their language development (DesJardin & Eisenberg, 2007). This connection may be reciprocal, with both children's current language level influencing their caregivers' speech and the caregivers' speech affecting children's language development (Huttenlocher et al., 2010; Lederberg & Everhart, 1998). Several studies have used LENA technology to record and automatically analyze the quantity of language input experienced by children with hearing loss. VanDam and colleagues (2012), for example, analyzed LENA recordings of 2- and 3-year-olds and found a significant relation between the children's degree of hearing loss and the number of conversational turns in which they took part, suggesting that caregivers engaged children with mild hearing loss in more linguistic interactions than did parents of children with more severe losses. These LENA studies have largely extended the link between language input and language development found in typically hearing children to those with hearing loss (Ambrose et al., 2014; Vohr, Topol, Watson, St. Pierre, & Tucker, 2014), though Rufsvold and colleagues (2018) found no significant correlation between the quantity of input and children's vocabulary scores.

Longitudinal Reading Outcomes

Research on reading development in children with hearing loss has often focused on the role of phonology, with investigators debating Paul's (2003) qualitative similarity hypothesis. While some authors argue that, like children with typical hearing, children with hearing loss must develop phonological representations of written language in order to learn to read (Wang, Trezek, Luckner, & Paul, 2008), others posit that the phonological channel can be bypassed by a strong foundation in a visual (signed) language (Allen et al., 2008). Within the field of listening and spoken language, however, this debate is largely moot; because children are expected to develop spoken language through the auditory channel, reading instruction follows a developmental framework emphasizing phonological awareness (Robertson, 2013).

Investigations of factors affecting longitudinal reading outcomes for children with hearing loss have pointed to the importance of expressive vocabulary (Kyle & Harris, 2006), phonological processing (Johnson & Goswami, 2010), syntax (Geers & Moog, 1989), narrative discourse (Schopmeyer, 2009), and spelling skills (Harris & Moreno, 2004). Despite advances in hearing technology and the wider availability of auditory-based intervention, reading outcomes for students remain variable. Young children with hearing loss often begin acquiring preliteracy skills with delays relative to their typically hearing peers and do not make sufficient progress to narrow the gap over their school career (Werfel, 2017). Geers and Hayes (2011), for example, found that about half of the high school students in their study had achieved grade-level reading skills after at least ten years of cochlear implant use. Phonological processing skills were the most significant predictor of reading achievement. In the seven years since Geers and Hayes' study, advances in policy and technology have allowed infants and their families access to quality intervention at earlier and earlier ages, but little research has been conducted on the current state of reading development for these children with hearing loss who use listening and spoken language as they advance through preschool and the early elementary grades. This dissertation will begin to fill this research gap.

Purpose of the Studies

The three studies in this dissertation follow the trajectory of vocabulary and reading development for young children with hearing loss, beginning with an examination of the quality of adult language input to which preschoolers are exposed, moving to an investigation of the longitudinal effects of the quantity and complexity of this language input, and ending with an analysis of reading achievement for early-elementary students.

The purpose of the first study is to analyze the quality of the home language environment experienced by preschool children with hearing loss who use listening and spoken language and examine the relation between parents' use of evidence-based conversation strategies and children's vocabulary development. Previous research with this population has focused on the quantities of adult words and conversational turns (Rufsvold et al., 2018) and the diversity of clauses, syntax, and lexicon used by children and their caregivers (Arora et al., in preparation). This study extends the research to a deep analysis of language quality using a mixed-methods approach employing both quantitative and qualitative analyses. LENA technology is used to record a full day of the auditory environment experienced by 37 English-speaking children with hearing loss who attend specialized listening and spoken language preschools. The average number of adult words, conversational turns, and child vocalizations are estimated for each day's recording. A 20-minute dinnertime segment is transcribed for further analysis. Using a coding scheme adapted from Duncan and Lederberg (2018), instances of parents' use of reformulation (i.e., expansion of the child's utterance), closed-ended language elicitation (i.e., prompts eliciting simple language), open-ended language elicitation (i.e., prompts requiring response with more than one word), and explicit vocabulary and grammar instruction during the mealtime are coded. The frequency of use of each strategy is related to the quantity of language input, as measured by LENA's Automatic Vocalization Assessment (Richards et al., 2017). Strategy usage is also assessed in relation to the child's receptive language level, as measured by the Peabody Picture Vocabulary Test-4 (PPVT-4; L. Dunn & D. Dunn, 2007), and their development of basic concepts, as measured by the Boehm-3 Preschool Test of Basic Concepts 3 (BTBC-3; Boehm, 2001). Finally, a qualitative thematic analysis is conducted on the subset of dinnertime transcripts with the greatest and least use of conversation techniques to identify themes in parent-child mealtime interactions in relation to Duncan and Lederberg's (2018) evidence-based strategies.

The second study continues to focus on the role of language input in language development, this time through a longitudinal lens. It investigates the relations among the quantity and complexity of the language environment and children's vocabulary growth over one year. In this group-design study, 14 of the preschool participants from the first study contribute full-day LENA recordings from timepoints about one year apart. The children's receptive vocabulary and basic-concepts knowledge are assessed using the PPVT-4 and BTBC-3 at each timepoint, allowing analysis of their change in vocabulary skills over one year of specialized intervention in a listening and spoken language school. Quantitative aspects (i.e., adult word count, conversational turn count, and child vocalization count) of the language environments experienced by the participants at the initial recording and upon follow-up one year later are estimated using the LENA Pro Software.

Twenty minutes of a dinnertime from each timepoint are transcribed and coded for linguistic complexity using a coding scheme adapted from Huttenlocher and colleagues (2010). Both the children's and their parents'/caregivers' utterances are coded for lexical diversity, or the number of unique words uttered during the meal; syntactic complexity, or the number of various parts of speech included in an utterance; and clausal complexity, or the ways in which clauses are combined to form more complex sentences. The data are analyzed to identify demographic variables and aspects of the language environment that predict children's change in vocabulary and basic-concepts skills over one year. Whether the language environment experienced by a child with hearing loss changes significantly in regard to the quantity and complexity of adult input over the same time period is also explored. Although previous research has investigated the longitudinal effects of either the quantity of adult language input (e.g., Ambrose et al., 2014) or the quality of this input (e.g., Lederberg & Everhart, 2000), no studies have used naturalistic daylong recordings to explore the longitudinal effects of the quality and quantity of the language environments experienced by children with hearing loss. Combining LENA technology and hand coding, this study endeavors to fill this gap in the literature specifically as it pertains to children who use listening and spoken language and their families.

Finally, the third study concerns what, for many parents and professionals, is an ultimate goal of their work on optimizing the language environment and developing children's spoken vocabulary in preschool: age-appropriate reading skills in the early elementary grades. Given the low reported reading levels of children with hearing loss overall, the purpose of this group-design study is to describe the reading skills achieved by today's children who listen and speak and to investigate whether they make significant progress over one year. The students in prekindergarten through third grade ($N = 64$) in a diverse listening and spoken language school are assessed using eight subtests of the Woodcock Johnson IV Tests of Achievement (WJ IV; Schrank, Mather, & McGrew, 2014). Strengths and challenges in the areas of overall reading ability, reading fluency, reading rate, and phonemic awareness are identified in the school population. Fifty-three participants are assessed again one year later, and changes in their standard scores are analyzed to investigate whether they made significant progress toward closing the reading gap with their peers with typical hearing. Given recent advances in early identification and intervention, the results of this study have significant implications for children who use listening and spoken language, as the vast majority of children with hearing loss do.

Organization

This dissertation includes three separate studies, all investigating factors related to the development of language and reading skills in young children with hearing loss who use listening and spoken language. Each of the three chapters following this introduction comprises a separate manuscript, with the order representing the trajectory of spoken language development. Each manuscript includes its own abstract, introduction, method, results, discussion, and conclusion sections, as well as references and tables. Chapter 2 details the first study, which analyzes the quality of adult language input for preschool children. The manuscript for the second study composes Chapter 3 and reports the results of a longitudinal investigation of the quantity and complexity of language input in relation to preschool children's development of vocabulary and basic-concepts skills. Chapter 4 comprises the manuscript for the third study, which presents the results and clinical implications from a two-year study of reading achievement for prekindergarten and elementary children with hearing loss attending a specialized listening and spoken language school. Chapter 5 represents a summary of the results of the three studies with a cohesive discussion of their collective implications for the field and directions for future research.

References

Allen, T. (1986). Patterns of academic achievement among hearing impaired students: 1974 and 1983. In A. Schildroth & M. Karchmer (Eds.), *Deaf children in America* (pp. 161-206). San Diego, CA: Little, Brown.

Allen, T., Clark, M. D., Giudice, A. D., Koo, D., Lieberman, A., Mayberry, R., & Miller, P. (2009). Phonology and reading: A response to Wang, Trezek, Luckner, and Paul. *American Annals of the Deaf*, *154*(4), 338- 345.

Ambrose, S., VanDam, M., & Moeller, M. P. (2014). Linguistic input, electronic media, and communication outcomes of toddlers with hearing loss**.** *Ear and Hearing, 35*(2)*,* 139–147.

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 48S.

Aragon, M., & Yoshinaga-Itano, C. (2012). Using Language ENvironment Analysis to improve outcomes for children who are deaf or hard of hearing. *Seminars in Speech and Language, 33(4),* 340-353.

Bradham, T. S., Fonnesbeck, C., Toll, A., & Hecht, B. F. (2018). The Listening and Spoken Language Data Repository: Design and project overview. *Language, Speech, and Hearing Services in Schools*, *49*(1), 108-120.

Bobzien, J. L., Richels, C., Schwartz, K., Raver, S. A., Hester, P., Morin, L. (2015). Using repeated reading and explicit instruction to teach vocabulary to preschoolers with hearing loss. *Infants & Young Children, 28*(3), 262-280.

Boehm, A. (2001). *Boehm test of basic concepts, 3rd ed.–preschool*. San Antonio, TX: Pearson.

Carlson, M. L., Sladen, D. P., Gurgel, R. K., Tombers, N. M., Lohse, C. M., & Driscoll, C. L. (2018). Survey of the American Neurotology Society on Cochlear Implantation: Part 1, candidacy assessment and expanding indications. *Otology & Neurotology*, *39*(1), e12-e19.

Centers for Disease Control and Prevention (CDC). (2019). Data and statistics about hearing loss in children. Retrieved from https://www.cdc.gov/ncbddd/hearingloss/data.html

Cole, E., & Flexer, C. (2016). Children with hearing loss: Developing listening and talking birth to six (3rd ed.). San Diego, CA: Plural Publishing.

Connor, C. M., Craig, H. K., Raudenbush, S. W., Heavner, K., & Zwolan, T. A. (2006). The age at which young deaf children receive cochlear implants and their vocabulary and speech-production growth: Is there an added value for early implantation? *Ear and Hearing*, *27*, 628–644.

Cruz, I., Quittner, A. L., Marker, C., DesJardin, J. L., & CDaCI Investigative Team (2013). Identification of effective strategies to promote language in deaf children with cochlear implants. *Child Development, 84*(2), 543-559. https://doi.org/10.1111/j.1467-8624.2012.01863.x

Davidson, L.S., Geers, A.E., & Nicholas, J.G. 2013. The effects of audibility and novel word learning ability on vocabulary level in children with cochlear implants. *Cochlear Implants International, 15*, 211–21.

Dornan, D., Hickson, L., Murdoch, B., Houston, T., & Constantinescu, G. (2010). Is auditory-verbal therapy effective for children with hearing loss? *Volta Review*, *110*(3), 361-387.

Duncan, M. K., & Lederberg, A. R. (2017). Relations between teacher talk characteristics and child language in spoken-language deaf and hard-of-hearing classrooms. Manuscript in preparation.

Dunn, L., & Dunn, D. (2007). *Peabody picture vocabulary test* (4th ed.). Bloomington, MN: PsychCorp.

Geers, A. E., & Hayes, H. (2011). Reading, writing, and phonological processing skills of adolescents with 10 or more years of cochlear implant experience. *Ear and Hearing*, *32*(1), 49S-59S.

Geers, A. E., Mitchell, C. M., Warner-Czyz, A., Wang, N. Y., Eisenberg, L. S., & the CDaCI Investigative Team. (2017). Early sign language exposure and cochlear implantation benefits. *Pediatrics*, *140*(1), e20163489.

Geers, A., & Moog, J. (1989). Factors predictive of the development of literacy in profoundly hearing-impaired adolescents. *The Volta Review, 91*(2), 69-86.

Gifford, R. H. (2016). Expansion of pediatric cochlear implant indications. *The Hearing Journal*, *69*(12), 8-10.

Harris, M., & Moreno, C. (2004). Deaf children's use of phonological coding: Evidence from reading, spelling, and working memory. *Journal of Deaf Studies and Deaf Education*, *9*(3), 253-268.

Hart, B., & Risley, T. (1995). *Meaningful differences in the everyday experiences of young American children*. Baltimore, MD: Brookes.

Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child development*, *74*(5), 1368-1378.

Hoff-Ginsberg, E. (1994). Influences of mother and child on maternal talkativeness. *Discourse Processes*, *18*(1), 105–117.

Houston, D.M., Stewart, J., Moberly, A., Hollich, G., & Miyamoto, R.T. (2012). Word learning in deaf children with cochlear implants: Effects of early auditory experience. *Developmental Science, 15,* 448–61.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27*(2), 236–248.

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*(4), 343–365.

Joint Commission on Infant Hearing. (2007). Year 2007 position statement: Principles and guidelines for early hearing detection and intervention programs. *Pediatrics, 120*, 898-921.

Kyle, F. E., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children. *Journal of Deaf Studies and Deaf Education, 11*(3), 273–288.

Lederberg, A. R., & Everhart, V. S. (1998). Communication between deaf children and their hearing mothers: The role of language, gesture, and vocalizations. *Journal of Speech, Language, and Hearing Research*, *41*(4), 887–899.

Lederberg, A. R., & Everhart, V. S. (2000). Conversations between deaf children and their hearing mothers: Pragmatic and dialogic characteristics. *Journal of Deaf Studies and Deaf Education, 5*(4), 303–322.

Lund, E., Douglas, W. M., & Schuele, C. M. (2015). Semantic richness and word learning in children with hearing loss who are developing spoken language: A single case design study. *Deafness & Education International, 17*(3), 163-175.

Mitchell, R. E., & Karchmer, M. A. (2004). Chasing the mythical ten percent: Parental hearing status of deaf and hard of hearing students in the United States. *Sign Language Studies, 4*(2), 138–163.

National Institute on Deafness and Other Communication Disorders. (2017). *Hearing aids.* (NIH Pub. No. 13-4340). Retrieved from https://www.nidcd.nih.gov/health/hearing-aids.

Nott, P., Cowan, R., Brown, P. M., & Wigglesworth, G. (2009). Early language development in children with profound hearing loss fitted with a device at a young age: Part I- the time period taken to acquire first words and first word combinations. *Ear and Hearing*, *30*, 526–540.

Paul, P. (2003). Processes and components of reading. In M. Marschark & P. Spencer (Eds.), *Handbook of deaf studies, language, and education* (pp. 97–109). New York: Oxford University Press.

Pittman, A.L. (2008). Short-term word-learning rate in children with normal hearing and children with hearing loss in limited and extended high-frequency bandwidths. *Journal of Speech, Language, and Hearing Research, 51*, 85–97.

Richards, J. A., Xu, D., Gilkerson, J., Yapanel, U., Gray, S., & Paul, T. (2017). Automated assessment of child vocalization development using LENA. *Journal of Speech, Language, and Hearing Research, 60*, 2047-2063.

Robertson, L. (2013). *Literacy and deafness: Listening and spoken language*. San Diego, CA: Plural Publishing.

Rollins, P. (2003). Caregivers' contingent comments to 9-month-old infants: Relationships with later language. *Applied Psycholinguistics*, *24*(2), 221–234.

Schopmeyer, B. (2009). Reading and deafness. In J. K. Niparko (Ed.), *Cochlear implants: principles and practices* (pp. 263-265). Lippincott Williams and Wilkins, Philadelphia.

Schrank, F. A., Mather, N., & McGrew, K. S. (2014). *Woodcock-Johnson IV Tests of Achievement.* Rolling Meadows, IL: Riverside.

Simser, J., & Estabrooks, W. (2012). Why are parents required to participate in auditory-verbal therapy and education? In W. Estabrooks (Ed.), *101 frequently asked questions about auditory-verbal practice* (pp. 19-22). Washington, DC: Alexander Graham Bell Association for the Deaf and Hard of Hearing.

Spivak, L., Sokol, H., Auerbach, C., & Gershkovich, S. (2009). Newborn hearing screening follow-up: Factors affecting hearing aid fitting by 6 months of age. *American Journal of Audiology*, *18*(1), 24-33.

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2018). Early literacy predictors and second-grade outcomes in children who are hard of hearing. *Child Development*, 1-19.

Traxler, C. B. (2000). Measuring up to performance standards in reading and mathematics: Achievement of selected deaf and hard-of-hearing students in the national norming of the 9th Edition Stanford Achievement Test. *Journal of Deaf Studies and Deaf Education*, *5*(4), 337-348.

Trezek, B., Wang, Y., & Paul, P. (2010). *Reading and deafness: Theory, research and practice*. Clifton Park, NY: Cengage Learning.

Vohr, B., Topol, D., Watson, V., St. Pierre, L., & Tucker, R. (2014). The importance of language in the home for school-age children with permanent hearing loss. *Acta Paediatrica*, *103*(1), 62–69.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wang, Y., Trezek, B., Luckner, J., & Paul, P. (2008). *The role of phonology and phonological-related skills in reading instruction for students who are deaf or hard of hearing*. *American Annals of the Deaf*, *153*(4), 396-407.

Chapter 2

Effects of Parents' Mealtime Conversation Techniques for Preschool Children with Hearing Loss who use Listening and Spoken Language

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Abstract

Purpose: This mixed-methods study aimed to examine the conversation techniques used by parents of young children with hearing loss (HL) during dinnertime at home. Parents' usage rates of open- and closed-ended language elicitation, reformulation, imitation, directives, and explicit instruction in vocabulary and grammar were examined in relation to children's receptive vocabulary and basic-concepts skills.

Method: Twenty-minute dinnertime segments were extracted from naturalistic, daylong recordings of 37 preschoolers with HL who used listening and spoken language. The segments were hand-coded for parents' use of conversation techniques. Automated estimates of adult words, child vocalizations, and conversational turns from the whole day were also calculated. Children's receptive vocabulary and basic concepts were assessed using standardized measures.

Results: Parents' use of conversation techniques varied widely, with closed-ended elicitation and directives used most frequently during dinner. Open-ended language elicitation related significantly to children's receptive vocabulary, while explicit vocabulary instruction was correlated with basic-concepts skills. Thematic analysis of the conversations revealed common themes, including concrete topics and sibling speakers. In addition, parents who used many techniques often introduced abstract conversation topics; electronic media was present in all conversations with few techniques.

Conclusions: Parents of children with HL may benefit from specific coaching to elicit language and introduce new vocabulary during home routines. These techniques may help develop their children's receptive language.

With early identification and technology use, many children with hearing loss (HL) have access to the sounds of spoken language from increasingly early ages (Yoshinaga-Itano, Sedey, Wiggin, & Chung, 2017). However, outcomes in developing listening and spoken language continue to vary, with many young children with HL lagging behind their peers with typical hearing in their vocabulary and knowledge of basic concepts (Bracken & Cato, 1986; Davidson, Geers, & Nicholas, 2013; Moeller & Tomblin, 2015; Nott, Cowan, Brown, & Wigglesworth, 2009). These variable outcomes have previously been linked to variations in degree of hearing loss, age at identification, appropriate fitting and use of hearing technology, maternal education level, and language input provided by parents and caregivers (Ching, Dillon, Leigh, & Cupples, 2018; Geers, Strube, Tobey, Pisoni, & Moog, 2011; Lederberg & Spencer, 2009; McCreery et al., 2015; Nittrouer & Burton, 2001).

Of particular importance to early intervention and preschool programs attempting to close this language gap is the role of language input as they coach families to provide frequent, rich language input through everyday routines at home (DesJardin, 2006; Morrison, 2017). Foundational research on children with typical hearing have related variations in the quantity of language exposure to children's receptive and expressive language growth in early childhood (e.g., Hart & Risley, 1995), while other studies have focused on the roles of conversation and specific linguistic qualities (e.g., Hirsh-Pasek, et al., 2015; Hoff-Ginsberg, 1986; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). Research on children with HL suggests that the quality and quantity of language input may differ in comparison to that provided to children with typical hearing, but this input is no less important for spoken-language development (Ambrose et al., 2015; Lederberg & Everhart, 2000; Rufsvold, Wang, Hartman, Arora, & Smolen, 2018). Adapting a coding strategy from Duncan and Lederberg (2018), this study investigates the relation between the quality of language input experienced by preschoolers with hearing loss during mealtimes in their natural home environments and their development of receptive vocabulary and basic-concepts knowledge.

Theoretical Framework

Sociocultural theory posits that children do not develop language in a vacuum solely through an innate understanding of grammatical rules; rather, learning occurs through interactions with those around them (Bruner, 1981; Vygotsky, 1978). For children birth through age five, these conversational partners are most likely parents and other caregivers. Early research into the linguistic interactions of children and their mothers found wide variation in the number of words to which children were exposed (i.e., the quantity of language input) in the preschool years, with the starkest contrasts based on the level of education attained by the mothers (Hart & Risley, 1995; Hoff-Ginsberg, 1994). *What* words mothers use and *how* they interact with their children (i.e., the quality of language input) have also been found to vary in relative levels of directing behaviors, conversational elicitation, maternal sensitivity, and syntactic complexity (Hirsh-Pasek et al., 2015; Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007; McDonald & Pien, 1982).

The quantity and quality of language input comprise the sociocultural context in which children grow up, interacting with their caregivers and gaining proficiency in their mother language(s). Frequent exposure to rich language relevant to children's personal experiences, invitations to respond, and opportunities to practice expressing the language they have heard stimulate language growth in children with typical hearing (Vygotsky, 1978). Richer language input should lead to faster and more facile receptive vocabulary growth under this theoretical framework. For children with HL who use hearing technology (hearing aids or cochlear implants) and whose families have chosen to pursue a listening and spoken-language outcome, language should similarly develop in relation to the input to which they are exposed (Pollack, Goldberg, & Caleffe-Schenck, 1997).

Vocabulary Development for Children with HL

Children with HL have historically struggled to develop *receptive vocabulary*, or the set of words to which they demonstrate comprehension, on par with their peers with typical hearing (Davidson, Geers, & Nicholas, 2013; Lund, 2016). Despite the adoption of universal newborn hearing screening programs, advances in hearing technology, and increased access to spoken-language services, many children, even those with cochlear implants, continue to develop smaller, less flexible lexicons than their age-matched peers (Connor, Craig, Raudenbush, Weavner, & Zwolan, 2006; Davidson et al., 2013; Nittrouer, Muir, Tietgens, Moberly, & Lowenstein, 2018; Nott et al., 2009). Recent research suggests that this difference may be related to delays in developing disambiguation, or assignment of novel words to unfamiliar objects, at least for children with cochlear implants (Lund, 2018).

Delays in receptive language for children with HL often include difficulty understanding *basic concepts*, words that indicate such ideas as position (*first/last*), amount (*most/least*, *empty/full*), location (*over/under*), and size (*long/short*) (Bracken, 1984). Though these are often short, unstressed words, substituting one basic-concepts word for another can change the meaning of a sentence (e.g., “Put the crayons *under* the table.” versus “Put the crayons *around* the table.”). Basic concepts are thus critical for comprehension, though they are often not as well represented in receptive-vocabulary assessments as nouns (e.g., *crayons*, *table*) and verbs (e.g., *put*). Children with HL, particularly those with cochlear implants, often have difficulty learning basic concepts, perhaps due to their unstressed position and decreased auditory salience in connected speech (Rufsvold et al., 2018).

Through the use of hearing technology (i.e., hearing aids and cochlear implants), many infants and preschoolers with HL can develop spoken language through audition, but differences in the development of vocabulary remain a serious concern (Cole & Flexer, 2015; Lund, 2016). Research attempting to explain these delays has largely focused on two aspects of children's language environment: the *quantity* of input provided by parents and other caregivers and the *quality* of such input.

Quantity of Language Input

Early research into the influences of children's language environment largely highlighted the *quantity of language input*, defined as the number of words said to or around a child in a given period. Hart and Risley (1994) famously found that children from professional families heard approximately 30 million more words by the time they entered school than did those from working-class families. The researchers argued that this "word gap" accounted for differences in their participants' vocabularies and school readiness. Other early studies have found a similar relation between maternal talkativeness and young children's language level and rate of vocabulary growth, with quantity of language input remaining relatively stable as the child aged (Hoff-Ginsberg, 1994; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Huttenlocher et al., 2007). Hoff-Ginsberg (1994) hypothesized that this relation might be bidirectional, with mothers' quantity of language both influencing and influenced by children's level of talkativeness. She also foreshadowed a future focus on the quality of language input by noting that mothers who talked more produced more utterances on one topic, which correlated to children's maintenance of the same topic. The quantity of language input may also be influenced by the conversational context. Mothers have been shown to use more words with their infants during book reading than play with toys and in structured "art gallery" tasks than in free play (Gilkerson, Richards, & Topping, 2015; Soderstrom & Wittebolle, 2013; Sosa, 2016).

Many early studies of language quantity relied upon short video or audio clips of parent-child dyads engaged in structured tasks or researcher-designed "free play" in a laboratory setting. The introduction of the Language ENvironment Analysis (LENA) system in 2006 has allowed full days of language input to be recorded in a child's natural environment (Xu, Yapanel, & Gray, 2009). Recordings are captured by a small digital language processor worn in a vest, and the LENA software then provides an automated analysis of the daylong language environment, including estimates of adult word count (AWC), child vocalization count (CVC), and conversational turn count (CTC). Several studies using LENA have replicated the relation between the quantity of language input and child outcomes, highlighting the particular importance of conversational turns (Dykstra et al., 2013; Oller, et al., 2010).

Several studies have found positive relations between the quantity of adult language input and the language development of children with HL (VanDam, Ambrose, & Moeller, 2012; Vohr, Topol, Watson, St. Pierre, & Tucker, 2014). As with children with typical hearing, however, studies on children with HL have largely found conversational turns to be the most important quantitative factor (Ambrose, VanDam, & Moeller, 2014; Arora et al., in preparation). This finding has led practitioners and parents to ask what qualities of adults' language encourage more conversational turns and what qualities of these turns foster greater language growth in children with HL.

Quality of Language Input

Arguing that the sheer number of words to which children are exposed does not fully explain variation in language outcomes, many researchers have investigated the influence of quality over quantity, or at least a combination of the two, on children's development of vocabulary, basic concepts, syntax, and other language skills. The *quality of language input* has variously been defined as parental sensitivity/responsivity, diversity of the lexicon, complexity of utterances, the use of language elicitation strategies, and directing behaviors (e.g., Ambrose, Walker, Unflat-Berry, Oleson, & Mueller, 2015; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Landry, Smith, & Swank, 2006; Naigles & Hoff-Ginsberg, 1998).

Complexity and maternal sensitivity. While the quantity of words used by mothers has been shown to be relatively stable over children's infancy and preschool years, the complexity of syntactic input appears to vary with children's ages (Huttenlocher et al., 2007). As children grow, mothers use more multi-clause sentences and a greater variety of sentence types, conjoining clauses in increasingly complex ways as children's comprehension develops. This increasing syntactic complexity relates to vocabulary development in early childhood (Hoff & Naigles, 2002; Huttenlocher et al., 2010). Greater diversity of words and parts of speech in children's language environments also relates to increased receptive and expressive vocabulary development (Cristofaro & Tamis-LeMonda, 2012; Hoff & Naigles, 2002; Naigles & Hoff-Ginsberg, 1998).

The quality of language input has also been hypothesized to relate to parenting behaviors and maternal sensitivity. Mothers' contingent responsiveness to their children's verbal and nonverbal attempts to communicate have been shown to relate to increased maternal input and to mediate the relation between responsive parenting interventions and children's receptive vocabulary (Landry et al., 2006; Landry, Smith, Swank, & Guttentag, 2008). Maintenance of joint attention and the connection of language input to items of visual interest to the child have also been related to more advanced language development (Hoff & Naigles, 2002). Language related to symbol-infused joint engagement and routines and rituals, rather than measures of maternal sensitivity unrelated to language, has similarly been shown to predict later expressive gains (Hirsh-Pasek et al., 2015).

Conversation techniques. Recent investigations using daylong audio recordings from the LENA system have highlighted the importance of frequent conversational turns, rather than increased input alone, in children's language and brain development (e.g., Romeo et al., 2018). The literature on language development in children with typical hearing suggests that strategies adults use when talking with their children can promote or hinder conversational turns and affect later language development.

***Higher-level conversation techniques*.** Higher-level conversation techniques are those that have been theorized to elicit longer, more complex responses from children with and without HL. Higher-level techniques, such as expansion, open-ended questions, and parallel talk, generally require multi-word responses or adding words to a child's utterance to make it more complex. Duncan and Lederberg (2018) termed one such conversation technique *reformulation*, or an adult response that "includes a child utterance but adds or substitutes semantic or syntactic detail, corrects syntax, or changes the voice" (p. 2978). Also referred to as expansions and recasts by other authors, reformulations occur in a child's "zone of proximal development" as parents reflect the child's communicative intent and point of interest while adding information or using syntax just above the child's independent expression (Vygotsky, 1978). Reformulations have been associated with increased maternal responsivity (Landry et al., 2012) and faster rates of expressive language growth for children with delays (Giromaletto, Weitzman, Wiigs, & Steig Pearce, 1999).

Open-ended language elicitations, or questions that require responses with more than one word or those to which several responses are possible, also "prod[] the child to produce utterances beyond the range of his or her current linguistic competence" (Hoff-Ginsberg, 1986, p. 160). In contrast to closed-ended or yes/no questions, open-ended *wh*-questions have been shown to relate to children's expressive syntax (Hoff-Ginsberg, 1986), more frequent child responses (Hoff-Ginsberg, 1990), and children's engagement in shared book reading activities (Landry et al., 2012). The number of *wh*-questions fathers used in free play predicted children's vocabulary or verbal reasoning in a recent study, while sheer quantity of language input did not (Rowe, Leech, & Cabrera, 2016). Mothers' open-ended narrative prompts, along with their lexical diversity, also appear to improve children's expressive responses and increase their school readiness (Cristofaro & Tamis-LeMonda, 2012).

Several studies have investigated the effects of higher-level conversation techniques on children with HL. DesJardin (2004; 2006) found positive relations between mothers' use of reformulation and open-ended questions during structured play and book reading and the language skills of their children with hearing aids. Similar relations have been found between these higher-level language elicitation techniques and language skills of children with cochlear implants (DesJardin & Eisenberg, 2007) and those identified as hard of hearing (Ambrose et al., 2015). Expansions and other parental behaviors that encourage and reinforce communication attempts might also show promise in increasing speech-related prelinguistic skills in infants and toddlers with HL (Roberts, 2018). Other research has more specifically defined the effects of these conversation techniques. In one study, reformulation and open-ended questions predicted expressive language growth, while the diversity of word types in adult speech predicted growth in receptive language in children with HL (Cruz, Quittner, Marker, DesJardin, & CDaCI Investigative Team, 2013). Duncan and Lederberg (2018) found positive relations between reformulation and children's development of expressive vocabulary.

Lower-level conversation techniques. In contrast to the positive effects of these higher-level techniques, *lower-level conversation techniques* are those that appear to elicit fewer, less complex responses in children with and without HL. Lower-level techniques often require only a one-word response or no verbal response at all. *Imitation*, or verbatim repetition of a child's utterance, was positively related to language development in children with typical hearing at the one-word stage in one study (Girolametto, Weitzman, Wiigs, & Pearce, 1999), but did not have a significant effect on language in several studies with children with HL (DesJardin, 2006; DesJardin & Eisenberg, 2007; Duncan & Lederberg, 2018). *Closed-ended language elicitation*, or those prompts that can be answered correctly with just one word, were also not significant predictors of language growth in those studies (DesJardin, 2006; DesJardin & Eisenberg, 2007; Duncan & Lederberg, 2018). Parents of children with HL have been shown to use more *directives*, or telling the child to perform an action, with their children than do parents of children with typical hearing (Ambrose et al., 2015; Lederberg & Everhart, 2000). This strategy has been found to relate negatively with language development in children with and without HL (DesJardin, 2006; DesJardin & Eisenberg, 2007; McDonald & Pien, 1982).

Explicit vocabulary instruction. *Explicit vocabulary instruction* occurs when adults provide a child-friendly definition of a word, explicitly label a novel object, or affirm a child's own definition. A common technique in instruction for children with typical hearing (e.g., Marulis & Newman, 2010; Weizman & Snow, 2000), explicit vocabulary instruction, has been theorized to be helpful for children with HL as it builds connections between familiar and new vocabulary words (Duncan & Lederberg, 2018). Despite the persistent gap between children with HL and their counterparts with typical hearing, relatively few intervention studies have targeted receptive vocabulary and basic concepts in young children with HL who use listening and spoken language (Luckner & Cook, 2010). Several studies have demonstrated positive effects for some form of explicit vocabulary instruction in which the definition, visual referent, or multiple meanings of a word are explicitly highlighted (Blaiser, 2015; Duncan & Lederberg, 2018; Lund & Schuele, 2014; Paatsch, Blamey, Sarant, & Bow, 2006). Vocabulary instruction that includes rich semantic information, including multiple opportunities to hear a label and information about a word's use, may be especially effective for children with HL who have language delays (Lund & Douglas, 2015). While most research on vocabulary instruction has occurred in classrooms, parents may effectively integrate word teaching in their homes through shared book reading and everyday routines (Fung, Chow, & McBride-Chang, 2005; Lund, 2018).

Explicit grammar instruction. *Explicit grammar instruction* refers to the explicit explanation of a rule of syntax in spoken English, such as correct word order or tense markers. Often a staple of second-language classes for older children and adults (e.g., Klapper & Rees, 2003), explicit grammar instruction is a somewhat controversial issue in the field of general education. Some researchers argue that such instruction is necessary for children with delays to learn syntactic structures, while others argue that it is ineffective and unnecessary (see discussion in Feng & Powers, 2005). Few recent studies have investigated the efficacy of explicit grammar instruction with children with HL who use listening and spoken language. Duncan and Lederberg (2018) found that explicit grammar instruction occurred very rarely in listening and spoken-language classrooms for learners with HL and was not predictive of children's language gains. Auditory-verbal practice for children with HL generally encourages families to immerse children with HL in examples of correct syntax, rather than formally teach grammar (Richels et al., 2015; Rhoades, Estabrooks, Lim, & MacIver-Lux, 2016). This suggests that explicit grammar instruction occurs very rarely in the homes of young children with HL who listen and talk.

Significance of the Study

This study investigates the relations between the quantity and quality of natural language input and the development of vocabulary and basic concepts in preschoolers with HL. Most previous studies with children with HL have analyzed mother-child interactions during lab-based structured tasks. Many have employed the "art gallery task," which asks the parent to try to engage the child in talking about pictures hung around the room for approximately five minutes (e.g., Ambrose et al., 2015; Cruz et al., 2013; Quittner, Leibach, & Marciel, 2004). Others have recorded several minutes of interaction with prescribed toys and/or books in the laboratory setting (e.g., DesJardin, 2006; DesJardin & Eisenberg, 2007; Lederberg & Everhart, 2000). Several studies with children with typical hearing have collected data in children's homes, but provided toys with which parents and children were instructed to play (e.g., Rowe et al. 2016; Sosa, 2016). Few studies have investigated the quality of language input during natural mealtimes (Huttenlocher et al., 2002; 2007; 2010), all of which have focused on children with typical hearing.

To our knowledge, this is the first study to explore the conversation techniques employed by caregivers (including fathers and other adult family members) of children with HL during dinnertime at home. Early intervention providers coach parents to embed language learning in everyday routines, such as mealtimes, but little is known about how modern parents elicit conversations and teach language outside of experimental and therapy settings (Moeller, Carr, Seaver, Stredler-Brown, & Holzinger, 2013). The LENA technology used in this study allows deep analysis of natural conversations as well as provides a picture of the quantity and quality of language input young children with HL experience over a full day of listening. The following research questions guided the present investigation:

1. What are the characteristics of parents' use of conversation techniques during mealtimes with their young children with hearing loss who use listening and spoken language?
2. Are there significant relations between parents' use of conversation techniques and the quantity of language children are exposed to and produce?
3. Are there significant relations between parents' use of conversation techniques and children's receptive vocabulary and basic-concepts knowledge?
4. What qualitative themes emerge from the mealtime conversations with the greatest frequencies of higher-level conversation techniques and the mealtime conversations with the lowest frequencies of higher-level conversation techniques?

Method

Participants

Thirty-seven children with HL (21 females) and their families participated in the study. Participants were recruited from six listening and spoken language preschool programs across five states: California, Missouri, New Jersey, New York, and Washington. Children were eligible to participate if (a) they were between the ages of 3 and 6 years, (b) they had an identified HL and wore hearing technology, (c) they used listening and spoken language to communicate, and (d) their families spoke English at home.

Participants had a mean age of 50.22 months (*SD* = 9.60). All had sensorineural HL in at least one ear, with most diagnosed with severe or profound loss (degree of hearing loss in the better ear: within normal limits/mild [*n* = 2], moderate [*n* = 12], moderately severe [*n* = 3], severe [*n* = 4], profound [*n* = 16]). Most participants used bilateral cochlear implants (*n* = 19) or binaural hearing aids (*n* = 15). Two participants used bimodal technology (1 hearing aid and 1 cochlear implant), and another used a unilateral hearing aid. (See Table 1 for additional details.) Five participants had an additional diagnosed disability (CHARGE syndrome [*n* = 2], Waardenburg syndrome [*n* = 2], rare chromosomal disorder [*n* = 1]). Ninety-five percent of the parents had completed at least some college. Other characteristics of the participants and their families are presented in Table 2.

Procedures

Approval for the study procedures was received from the Institutional Review Board of Teachers College, Columbia University. All adults whose voices were audio recorded provided written informed consent. Participants were recruited from listening and spoken language preschool programs around the United States, and all children and families who met the inclusion criteria were invited to participate. Thirty-five families who met the inclusion criteria provided informed consent to participate. Demographic information, including onset/degree of HL, amplification use, and family socioeconomic status, was collected via comprehensive file review and/or parent questionnaire. Data were collected over a 2- to 4-day school visit, with audio recorders sent home during or soon after that visit.

The Peabody Picture Vocabulary Test-4 (PPVT-4; L. Dunn & D. Dunn, 2007) and Boehm-3 Preschool Test of Basic Concepts (BTBC-3; Boehm, 2001) were administered to all participants. Experienced teachers of the deaf and hard of hearing administered the assessments in the child's school in a child-friendly therapy room or classroom with reduced visual and auditory distractions. Participants were given breaks between the two assessments as needed. The total administration time for the assessments was approximately 30 minutes.

The spoken-language environments of the participants were recorded and analyzed using the LENA system. Participants wore a LENA digital language processor (DLP) in a vest with an acoustically transparent chest pocket for two full days, beginning when they awoke in the morning and recording about 16 hours until the DLP automatically turned off after the children went to sleep in the evening. For this study, the first day with a clear dinnertime was used to analyze both the quality and quantity of language input. If the first day of recording contained a dinnertime that met the criteria described in the "Quality of language input" section below, that mealtime conversation was transcribed, and the AWC, CTC, and CVC from that day were used. In several cases, no clear dinnertime could be found because the child ate a quick meal in the car or because the family grazed on snacks during a party throughout the evening. In those cases, a clear dinnertime was located on the second day of recording. The quality and quantity variables for that day were used in subsequent analyses. Families were advised that they could return the DLP and request that the data be deleted if they were uncomfortable with that day's recording for any reason. None of the participating families expressed concerns, however.

Measures

Receptive vocabulary. The PPVT-4 (L. Dunn & D. Dunn, 2007) was used to measure participants' receptive vocabulary. The PPVT-4 has two parallel forms: A and B; Form B was used in the present study. Each form contains training items and then 228 test items, though only those that fall within a child's basal and ceiling levels are presented during a single administration. The number of items presented ranged from 24 to 96 for the participants in this study. Each item comprises four color illustrations as response options on a page. The child points to a picture when given the prompt "Show me ____." The test covers a range of vocabulary content areas, including everyday and specialized objects, actions, and tools, across all levels. The PPVT-4 is a norm-referenced, standardized measure that is widely used in research and educational settings. The normative mean is 100, with a standard score of 15. Internal consistency was found to be between .94 and .95, with alternate-forms reliability reported to be .89. The PPVT-4 has been widely used in receptive-vocabulary research. Although the participants generally had not previously taken the PPVT-4, the picture-pointing task it required was familiar to them. Participants' standard scores on the PPVT-4 were used as variables in this study.

Basic concepts. The BTBC-3 (Boehm, 2009) was used to measure children's knowledge of basic concepts. A norm-referenced measure validated for use with children ages 3;0 through 5;11, the BTBC-3 measures receptive understanding of such concepts as position (*in front of/behind*), amount (*empty/full*), position (*over/around*), and size (*long/short*) in connected speech. While the full test contains 78 items, only 52 items are administered at one time, depending on the age bracket (3;0-3;11 or 4;0-5;11) in which the child falls. The child is shown an easel with four pictures while the examiner reads a scripted sentence using acoustic highlighting to emphasize the basic concept being assessed (e.g., "Point to the girl who is in line *before* a boy."). The BTBC-3 was normed on a sample of 660 children between the ages of 3 and 5;11 years. Internal consistency was reported to be between .85 and .92, with test-retest reliability between .9 and .94. The BTBC-3 does not give a standard score; thus, children's percentile ranks were used as variables in this study. One participant was too old to receive a percentile rank on the BTBC-3; they were excluded for all analyses involving the test.

Quantity of language input. The quantity of language input experienced by the participants was measured using the LENA system. The system, which comprises small audio recorders called DLPs and specialized LENA Pro software, was validated by Gilkerson and Anderson (2008) in a comprehensive natural-language study. The researchers collected a large sample of full-day recordings of spontaneous speech in the homes of infants and young children selected to be representative of the U.S. population. Strong reliability was found between professional transcription of audio segments and the LENA system's estimates of the quantity of language input (Gilkerson, Coulter, & Richards, 2008).

In this study, LENA Pro was used to analyze 16-hour audio recordings and estimate three quantitative variables in the participants' language environments. The number of words spoken by caregivers and other adults in close proximity (within approximately 6 to 10 feet) throughout the daylong recording was estimated as AWC. The number of times the child vocalized using speech or speech babble was estimated as CVC. The number of times an adult responded within 5 seconds of the child's vocalization, or the child responded to an adult, was estimated as CTC. Although the LENA DLPs recorded for 16 hours, the amount of time children were awake and interacting with caregivers during that period varied among participants. In order to standardize the AWC, CVC, and CTC values across participants, each daily estimate was divided by the participant's number of waking hours (defined as beginning when the DLP was turned on and ending when child vocalizations and conversational turns ceased in the evening). The resulting proportions of AWC, CVC, and CTC were used as variables in this study.

Quality of language input. The quality of language input was measured by coding the conversation techniques and explicit instruction used by parents during dinnertime interactions with their children. LENA Pro software was used to extract a 20-minute audio clip of each participant's family dinnertime from the first day's recording with a dinnertime that met the criteria below. This same day was used to estimate the quantity of language input. The investigator or a trained research assistant listened to the audio recorded by the DLP during the approximate time of the child's evening meal. In some cases, parents provided an estimated time that dinner began; in others, the research assistant listened to most of the evening recording until dinner began. In all cases, dinnertime was considered to begin when (a) a clear announcement was made (e.g., "It's dinnertime!"), (b) the child was called to the table (e.g., "Come sit down for dinner."), (c) the child was first offered food (e.g., "Want some chicken?"), or (d) the child first requested food ("I want potatoes."). Criteria (c) and (d) were only used if neither (a) nor (b) could be found in the recording. In order to standardize the length of time for all participants, dinnertime was considered to last for 20 minutes from the time one of the above utterances was noted, regardless of whether eating continued for longer than 20 minutes. After 20 minutes of audio were extracted from the LENA Pro software, professional transcribers transcribed the conversations. The investigator or a trained research assistant checked each transcript; no major discrepancies were found.

Higher-level conversation techniques. Each transcript was coded for adults' use of several conversation techniques previously shown to elicit children's responses and facilitate vocabulary growth. Although the natural dinnertime conversations included adult-to-adult and sibling-to-sibling speech, only adults' child-directed utterances were coded. Coding was completed by the investigator using coding guidelines adapted from Duncan and Lederberg (2018).

Reformulation. Adults' child-directed utterances were coded as reformulations if they repeated what the child previously said, but corrected grammar or added information without changing the essential meaning of the utterance. A child who said, "Daddy eating egg," for example, might be answered with either type of reformulation: "Daddy *is* eating an egg" (correcting syntax) or "Yes, Daddy is eating the hard-boiled egg we made on the stove" (adding information).

Open-ended language elicitation. Open-ended language elicitations were coded when adults elicited language that required more than one word to be answered correctly. *Wh*-questions were generally considered open-ended language elictations, except when they requested a one-word label (e.g., "What is this?"). Non-question prompts to respond with more than one word (e.g., "Tell me about the movie.") were also considered open-ended language elicitations.

Lower-level conversation techniques. Lower-level techniques were also coded. Although previous research suggests that these strategies are not positively associated with vocabulary growth, it was theorized that they would be used frequently during mealtimes with young children.

Closed-ended language elicitation. Prompts were considered closed-ended if they could be answered correctly with only one word or with prescribed language. Examples included yes/no questions (e.g., "Do you like your carrots?") and requests for prescribed language ("What do you say?"). Forced-choice questions (e.g., "Do you want mashed potatoes or rice?") were coded as closed-ended, regardless of the number of words in each choice.

Imitation. Responses were coded as imitations if an adult imitated all or part of the child's utterance verbatim without changing or adding any words. A questioning intonation might have been added (e.g., Child: "I have five Goldfish." Adult: "Five Goldfish?").

Directives. Adult utterances were coded as directives if they asked the child to perform a behavior without requiring a verbal response (e.g., "Sit in your chair." or "Can you eat two bites?"). Commands requiring a verbal response (e.g., "Say, 'Thank you.'") were coded as closed-ended language elicitations.

Explicit language instruction. Adults' utterances that provided explicit instruction regarding vocabulary or grammar were also coded according to the guidelines established by Duncan and Lederberg (2018). Explicit instruction could occur on its own or as part of a parent's use of another conversation technique (e.g., reformulation).

Explicit vocabulary instruction. Explicit vocabulary instruction was coded when an adult gave a definition of a word, affirmed a child's definition (e.g., "That's right! Angry means mad."), or labeled a novel word (e.g., "This dessert is called *flan*."). Explicit vocabulary instruction did not need to be formally planned by the parent; it could occur spontaneously as a result of natural conversation.

Explicit grammar instruction. Explicit grammar instruction was coded when an adult explicitly provided information about the syntax of spoken English. Mere corrections of a child's utterance were not coded, but corrections that added explanations of why a certain construction was correct were considered explicit grammar instruction. For example, in response to "I want two cookie," an adult might provide explicit grammar instruction by responding, "You can say, 'I want two cookie*s*.' Remember, you have to add an *s* to the end if you want more than one."

Reliability. A research assistant, a master's-level special educator, underwent training as a reliability coder, which comprised guided analysis of sample coded transcripts and independent practice. After the research assistant attained 90 percent agreement with a gold-standard coded transcript, she began coding independently. Approximately 28 percent of the transcripts were independently coded by both the principal investigator and the reliability coder. Mean percent agreement for all instances of conversation strategies and explicit instruction in these transcripts was 90.6 percent. Interrater percent agreement ranged from 73.3 to 100 percent, with an outlier of 60.0 percent for one transcript with very little dialogue and an exceedingly small number of conversation strategies used. All instances of disagreement in coding were discussed by the coders until consensus was reached, and the totals reached by consensus were used in subsequent analyses.

Data Analysis

IBM SPSS Version 26 for Mac was used to conduct all statistical analyses.

Quantitative analyses. Descriptive statistics were used to answer the first research question. For the second research questions, Pearson correlations between and among each conversation technique and each quantity variable analyzed by the LENA (i.e., AWC, CVC, and CTC) were first calculated. Because no instances of explicit grammar instruction were found, this variable was dropped for all subsequent analyses. Several significant correlations were found between conversation techniques, but, because no patterns in significant correlations emerged, these variables were not regrouped into composite variables (i.e, higher-level, lower-level, and explicit instruction). Table 3 presents Pearson correlations among the technique variables. No significant correlation was found between the participants' ages and AWC, CTC, and CVC. Analyses of variance (ANOVAs) were used to determine whether differences in

AWC, CVC, and CTC existed based on children's degree of hearing loss, type of hearing technology, maternal education level, or presence of additional disability.

For the third research question, ANOVAs were used to determine whether differences in receptive vocabulary and basic-concepts knowledge existed based on children's degree of hearing loss, type of hearing technology, maternal education level, or presence of additional disability. Significant demographic variables were controlled for in subsequent analyses. Finally, stepwise regressions were performed to investigate the relations between conversation techniques and receptive vocabulary and basic-concepts knowledge, while controlling for demographic differences. The final models for PPVT-4 standard score and BTBC-3 percentile rank were constructed using the conversation techniques that explained a significant amount of variance, holding constant demographic variables.

Qualitative analysis. The four transcripts with the greatest number of open-ended elicitations and reformulations and the four transcripts with the smallest number of these techniques were selected for qualitative analysis. Following Braun and Clarke's (2006) approach to thematic analysis, the transcripts were analyzed using repeated, active reading. Using NVivo Version 12 for Mac, the transcripts were first coded using *a priori* codes the investigator anticipated might be important. Some themes related to the dinnertime environment (e.g., setting, people present, type of food served, presence of electronic media), while others related to the content of the dinnertime conversations (e.g., adult/child initiations, specific topics). Other codes emerged during close readings of the transcripts. The codes were then organized into potential themes using tables and NVivo's "mind map" feature. Themes were reviewed to ensure internal homogeneity and external heterogeneity. The final analysis discusses these themes and compares and contrasts how themes are used in the transcribed conversations with the greatest and least number of conversation techniques.

Results

Research Question 1: What are the characteristics of parents' use of conversation techniques during dinnertime with their young children with hearing loss who use listening and spoken language?

Table 4 displays the mean, standard deviation, and range for parents' use of each conversational and explicit-instruction technique: reformulation, open- and closed-ended language elicitation, imitation directives, and explicit vocabulary and grammar instruction. Closed-ended elicitations (M = 19.32, SD = 12.33) and directives (M = 10.51, SD = 8.48) were used most frequently in the 20-minute dinnertime samples. Parents' use of these two techniques, however, varied widely across participants following roughly normal distributions. While 57 percent of parents gave between 10 to 25 closed-ended elicitations, four parents gave 45 or more, or greater than two closed-ended elicitations per minute. Open-ended elicitations (M = 2.51, SD = 2.73) and reformulations (M = 1.78, SD = 2.08) were relatively rare; approximately one-quarter of parents used none at all during dinnertime recordings, though two parents used these techniques once every two minutes. No instances of explicit grammar instruction were found in any sample, and imitation (M = .84, SD = 1.21) and explicit vocabulary instruction (M = .43, SD = 1.12) were, on average, used less than once per 20-minute recording.

Research Question 2: Are there significant relations between parents' use of conversation techniques and the quantity of language children are exposed to and produce?

Only AWC was found to differ significantly based on the hearing technology used by the children, $F(2, 34) = 3.305$, $p = .049$, with hearing-aid users exposed to significantly more adult words than cochlear-implant users. A significant correlation was found between the quantity of children's language production, as measured by LENA's estimate of CVC, and parents' use of directives, $r(35) = .378$, $p = .021$.

Research Question 3: Are there significant relations between parents' use of conversation techniques and children's receptive vocabulary and basic-concepts knowledge?

A significant correlation was found between the participants' age and their PPVT-4 scores, $r(34) = .354$, $p = .032$. Children's performance on the PPVT-4 differed significantly based on their hearing technology, $F(2, 34) = 3.797$, $p = .032$. Significant differences in performance on the BTBC-3 were found based on degree of HL, $F(4, 31) = .3660$, $p = .015$, and hearing technology, $F(2, 33) = 5.345$, $p = .010$. Children with hearing aids (with mild to moderate HL) performed significantly better on both tests than children with cochlear implants (with severe to profound HL). Type of hearing technology was controlled for in subsequent analyses.

A significant correlation was found between children's receptive vocabulary, measured by PPVT-4 standard score, and the number of open-ended language elicitations their parents used during dinnertime conversation, $r(35) = .339$, $p = .040$. Regression analyses of nested models were performed to test whether open-ended language elicitation contributed a significant amount of variance to children's PPVT-4 scores, when controlling for age and hearing technology. An *F*-test for a model regressing PPVT-4 score on hearing technology (represented by dummy variables for hearing aids and bimodal technology), age, and open-ended language elicitation was significant, $F(4, 32) = 2.952$, $p = .035$. However, an individual *t*-test indicated that open-ended language elicitation did not contribute a significant amount of variance to children's PPVT-4 scores when hearing technology and age were held constant, $t(31) = 1.385$, $p = .176$ (Table 5).

A significant correlation was found between children's basic-concepts knowledge, measured by BTBC-3 percentile rank, and the number of instances of explicit vocabulary instruction used by their parents, $r(34) = .410$, $p = .013$. Regression analyses of nested models were performed to test whether explicit vocabulary instruction contributed a significant amount of variance to children's BTBC-3 scores, when controlling for hearing technology. Model 1 regressed BTBC-3 score on hearing technology (hearing aids and bimodal technology); results of a *F*-test were significant, $R^2 = .245$, $F(2, 33) = 5.345$, $p = .010$. Model 2 then added explicit vocabulary instruction as an additional independent variable. The overall regression model was significant, $R^2 = .353$, $F(3, 32) = 5.810$, $p = .003$, as was a test of change in R^2 from Model 1 to Model 2, $F(1, 32) = 5.336$, $p = .027$. Explicit vocabulary instruction contributed a significant amount of variance to children's BTBC-3 scores, controlling for hearing technology, $b = 8.837$, $t(32) = 2.310$, $p = .027$ (Table 6). Each instance of explicit vocabulary instruction during dinnertime explained an increase of 8.837 percentage points in the child's basic-concepts score.

Research Question 4: What qualitative themes emerge from the dinnertime conversations with the greatest frequencies of higher-level conversation techniques and the dinnertime conversations with the lowest frequencies of higher-level conversation techniques?

A thematic analysis of the ten dinnertime conversations with the greatest and least frequencies of higher-level conversation techniques revealed two common themes: sibling speakers and concrete conversation topics, including those related to food and mealtime behaviors. The five conversations with the greatest frequencies of open-ended language elicitations and reformulations revealed an additional theme: abstract conversation topics without immediate visual referents. These conversations included discussions about the day's events, plans for the future, and people and objects not present during the meal. The five conversations with the lowest frequencies of higher-level techniques converged around another theme, television and other electronic media, sounds from which appeared throughout all five recordings. These themes are discussed in detail in the Discussion below.

Discussion

This study found wide variation in parents' use of conversation techniques and explicit instruction with their young children with HL during mealtimes in their natural home environments. Closed-ended language elicitations and directives were used the most frequently, on average occurring once every minute or two, while instances of imitation and explicit instruction in vocabulary were rare. No parents used explicit grammar instruction during mealtime conversations with their children. Parents' use of directives was found to relate significantly to the number of vocalizations produced by their children throughout the naturalistic daylong recording. Open-ended language elicitations correlated with children's receptive vocabulary, while explicit vocabulary instruction predicted their comprehension of basic concepts, even when controlling for type of hearing technology. Thematic analysis of the dinnertime conversations with the greatest and least frequency of open-ended elicitation and reformulation, which were shown in the literature to promote language development, found two shared themes: the presence of sibling speakers and concrete conversation topics.

Conversations with low rates of higher-level techniques converged around a theme of television and electronic media use during the meal, while those with high rates included many abstract conversation topics. Conversation techniques were not related to the quantity of language to which children were exposed during the day, though one parental behavior—frequent use of directives—was related to the quantity of language children produced. Two techniques related significantly to children's receptive vocabulary. Parents' use of open-ended language elicitations was related to children's receptive vocabulary skills, with parents who provided more opportunities for children's conversational responses more likely to have children with higher receptive vocabulary scores on the PPVT-4. Parents' use of explicit vocabulary instruction during mealtimes related to children's skills in a particularly important area of receptive vocabulary, those representing basic concepts, even when controlling for the type of hearing technology used by the children. These findings highlight the pivotal role of family conversation in the development of listening and spoken language for young children with HL.

Parents in this study varied greatly in the quality and quantity of the language input they provided to their children, reflecting the findings of previous studies conducted in laboratory settings (e.g., Ambrose et al., 2015; Cruz et al., 2013; DesJardin & Eisenberg, 2007) and extending them to the home environment using naturalistic daylong recordings. Duncan and Lederberg (2018) found wide variation in the specific conversation techniques used by teachers in classrooms for children with HL. As expected, teachers in their study used conversation techniques at higher rates during Language Arts lessons, which focus on meaning in oral language and written texts, than did parents in the present investigation, who were recorded during natural mealtimes in their home. However, relative frequencies of strategy usage followed a similar trend; closed-ended language elicitations occurred most frequently in both samples, followed by open-ended elicitations, reformulations, imitation, and explicit vocabulary instruction. Family-centered practice in early intervention and preschool programs for children with HL emphasize parents as children's primary teachers, and professionals aim to equip parents with the same conversational tools that trained educators use (Moeller et al., 2013; Morrison, 2017). The results of this study suggest that the relative popularity of these tools is similar between the two groups, but parents use all techniques at lower rates, pointing to a need for greater support in eliciting rich language from their children during routine family activities, such as mealtimes.

Qualitative analysis of the conversations explored the questions of how, why, and on what topics the parent and child participants conversed. Two common themes emerged from the conversations containing many techniques and those with very few. Siblings were present and participated in most dinnertime conversations. These other children were, at times, a topic of conversation between the target child and their parents, such as when one dyad discussed a younger brother's baby-sized flatware. Parents often directed open-ended elicitations and directives to sit or eat at both the target child and their sibling(s). Some recordings also included conversations between the target child and a sibling. Because parent talk was the focus of this study, the conversation techniques used by children to elicit language from their siblings with hearing loss were not coded, though this would be a rich area for future exploration. A shared theme of concrete conversation topics also emerged from close readings of the dinnertime recordings. As expected, parents and children often discussed the dinner menu, food preferences, and items, such as clothing and toys, that were visible in the dining area. Concrete topics also frequently included children's current mealtime behavior, including washing their hands, eating, drinking, sitting properly, and cleaning up.

Abstract conversation topics formed an additional theme found mostly in the dinnertime recordings that included the greatest number of higher-level language elicitation techniques. These conversations included talk of future events (e.g., what the family planned to do the next day) or past memories (e.g., stories from a parent's childhood). They also included references to imaginary stories and to people and items not physically present. Although many of the abstract conversations included open-ended elicitations and an expectation of complex language on the part of the child, some supported children with less advanced expressive language recount the events of their day through closed-ended yes/no or forced-choice questions (e.g., "Did you go to the farm or the bookstore?").

In contrast to the convergence around abstract topics that occurred in the conversations with frequent use of higher-level conversation techniques, the conversations with rare use of these techniques converged around a theme of television and electronic media. Audio from at least one of these sources was present in each of the five recordings with the fewest instances of open-ended elicitation and reformulation. In several cases, these sounds dominated the recordings, with both children and parents silent for several minutes at a time while they ate and watched television. In others, the target child played an electronic game or watched a video silently while adults engaged in adult-directed conversation. While parents used some closed-ended questions (e.g., "Is that Peppa Pig?") and issued directives involving eating and sitting at the table, few attempts to initiate and maintain abstract topics of conversation were made. Interestingly, in one of the recordings with the greatest number of higher-level conversation techniques, the target child was also engaged in playing an electronic game throughout dinnertime. In contrast to the low-frequency recordings, however, the child's mother frequently asked questions and elicited multi-word responses as she sat beside him while he ate and played. Some conversations were concrete (e.g., directions for the game), but many used what they saw in the game as inspiration for more abstract conversations (e.g., when the aquarium seen in the game led to a discussion of the mother's childhood pets). The parent also provided two instances of explicit vocabulary instruction related to new concepts seen in the game. The parent's frequent use of higher-level techniques to elicit conversation may have related to the child's development of basic concepts and vocabulary; both scores were in or above the average range. While this conversation demonstrated that eliciting and maintaining rich conversations is possible in the context of electronic media, the general absence of higher-level techniques (and, indeed, much conversation at all) when electronic media was present during dinner supports professionals' cautioning parents to limit screen time, particularly during mealtimes (Ambrose et al., 2014; Duch et al., 2013).

No significant correlation was found between the conversation techniques and the quantity of adult language experienced by the child throughout the day. This suggests that the conversation techniques represent a construct separate from the sheer number of words said by adults, supporting the notion that both quality and quantity of input may be important. In terms of child language output, only directives were related to the number of times children vocalized during the daylong recording. Directives made frequent appearances in the dinnertime conversations experienced by the children with HL in this sample. This was not surprising given the mealtime setting, for which parents often set and enforce expectations related to eating and other behaviors. Previous research has also found a high frequency of directives used by parents in interactions with their children with HL (Ambrose et al., 2015; Lederberg & Everhart, 2000). While directives have been found in previous studies to predict poorer language outcomes for children with and without HL (DesJardin, 2006; DesJardin & Eisenberg, 2007; McDonald & Pien, 1982), surprisingly, in this study, parents' more frequent use of directives was linked to higher rates of child vocalizations over the daylong recording. The cross-sectional nature of this study precludes a conclusion regarding the direction of this relationship. It seems unlikely, given the previous literature, that parents' directing behavior led to greater quantities of child talk. What seems more probable is that great quantities of child talk prompted more adult directives during dinnertime, as parents attempted to redirect them to eat or speak more politely. Future research might explore this link further, while investigating coaching strategies that support parents in redirecting children through conversation-eliciting techniques, rather than directives.

Parents in this sample used open-ended language elicitations far less frequently than directives during mealtime conversations. While directives occurred, on average, once every two minutes, open-ended elicitations occurred only every eight minutes. Parents were far more likely to elicit one-word or rote responses through closed-ended elicitations (about one per minute) than they were to provide opportunities for multi-word responses. However, as with other techniques, there was great variation in frequency of open-ended elicitation. Nearly one-quarter of parents used no open-ended elicitations at all during their 20-minute dinnertime samples, while three parents used 8 to 11 during the same time period. Greater use of this type of elicitation by adults related to greater receptive vocabulary in children with HL in this study. While the direction of this relationship cannot be definitively stated, previous research has suggested that more opportunities to respond to open-ended questions leads to greater language growth (Ambrose et al., 2015; DesJardin, 2004, 2006; DesJardin & Eisenberg, 2007). As Hoff-Ginsburg (1994) suggested, this relationship may also be bidirectional; as children's language abilities grow, parents initiate and continue more conversations through open-ended elicitations that they believe their children have the ability to answer.

Explicit vocabulary instruction was also related to children's receptive skills in the specific area of vocabulary related to basic concepts, even when controlling for the type of hearing technology used by the children. While explicit vocabulary instruction is often emphasized in formal settings for children with HL (Blaiser, 2015; Duncan & Lederberg, 2018; Lund & Schuele, 2014), few studies have examined its use by parents during home routines beyond structured book reading (Fung, Chow, & McBride-Chang, 2005; Lund, 2018). In this study, explicit vocabulary occurred rarely during dinnertime conversations, with most conversations containing no instances of the technique. A number of parents, however, skillfully introduced new vocabulary several times throughout their dinnertime conversation. These instances of explicit instruction sometimes involved labeling and describing novel food items on the dinner table, but they also occurred naturally during abstract conversations, when parents defined NASA, staying hydrated, and other ideas in child-friendly ways. Parents' use of this explicit instruction related significantly to children' understanding of basic concepts, an area considered critical for later academic success (Boehm, 2009). Though parents did not explicitly define any relational words included on tests of basic concepts, they did use prepositions and other function words to explain nouns and verbs. Perhaps this explicit exposure, which often included the use of acoustic highlighting, led children to develop more advanced basic-concepts skills.

Limitations

While this study represents an important first step in understanding how families elicit language from young children with HL, several limitations must be noted. To allow for transcription and hand coding of conversations, only children who spoke English at home participated, limiting the generalizability of the results to families with other home languages. While the number of participants (*N* = 37) was relatively large for studies in the low-incidence field of HL, it may not have provided sufficient statistical power to detect relations between conversational strategies and children's vocabulary. Perhaps a larger sample would have allowed relations shown in previous studies to emerge. While separate statistical analyses indicated that children with additional disabilities in this sample had similar relations between vocabulary and parents' conversation techniques, further qualitative exploration of this group of children would be interesting. Similarly, the language environment and vocabulary outcomes of the participant with unilateral hearing loss might be explored in future studies. That the recordings and assessments were collected at a single time point limits the extent to which conclusions regarding the directionality of the relations that did emerge can be drawn. Future research should include longitudinal analyses that explore whether parents' use of mealtime conversation techniques leads to faster language growth, or whether children's language level influences parents' use of these techniques. Finally, dinnertime was chosen as a period during which families might theoretically have the opportunity to engage in conversation using the techniques under study. However, it is possible that other periods, perhaps playtime or other meals, would have yielded a fuller picture of parents' use of conversation techniques throughout a typical day in the child's natural environment. Future research might include these other periods, select the segments of the LENA recording with the greatest density of conversational turns, or examine several days of recording for each child.

Conclusion

This mixed-methods study is among the first to examine conversation techniques and explicit instruction used by parents during natural mealtime conversations with their children with HL in their home environments. Wide variation was found among parents, who generally favored closed-ended language elicitations and directives over open-ended elicitation and reformulation in their dinnertime interactions. Though explicit vocabulary instruction may often be associated with formal lessons in school or therapy, several parents incorporated the technique into natural conversations at home. As open-ended language elicitation and vocabulary instruction were both linked to children's receptive-language skills, professionals should coach parents in ways to incorporate these techniques into everyday routines, including mealtimes. The results of the thematic analysis of these data suggest several ways to achieve this, including discussing concrete topics, bridging to abstract ideas, and limiting electronic media. Future research might examine specific interventions that support families in implementing effective conversation techniques in their natural environments outside the clinical setting. Though the families in this study used English as their primary language, their linguistic and cultural backgrounds were diverse, with some parents and children code-switching occasionally to communicate with extended family and friends and others incorporating a variety of religious practices into dinnertime. Future research might examine the specific influences of families' cultural backgrounds on home language environments. Such research would continue to help close the gap in spoken-language development between children with and without HL from all backgrounds.

References

Ambrose, S. E., VanDam, M., & Moeller, M. P. (2014). Linguistic input, electronic media, and communication outcomes of toddlers with hearing loss. *Ear & Hearing*, *35*(2), 139-147.

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 48S.

Arora, S. B., Smolen, E.R., Wang, Y., Hartman, M. C., Rufsvold, R., & Howerton Fox, A. (2018). Quantity or diversity: Language environments and language development of children with hearing loss. Manuscript in preparation.

Boehm, A. (2001). *Boehm Test of Basic Concepts – Preschool (3rd ed.)*. San Antonio, TX: Pearson.

Boehm, A. E. (2009). Children's knowledge of basic concepts: An essential component of direction following and problem solving (pp. 269-286). In T. Gutkin & C. R. Reynolds (Eds.) *The handbook of school psychology* (4th ed.). New York: John Wiley.

Bracken, B. A. (1984). *Bracken Basic Concept Scale*. San Antonio, TX: Psychological Corporation.

Bracken, B. A., & Cato, L. A. (1986). Rate of conceptual development among deaf preschool and primary children as compared to a matched group of nonhearing impaired children. *Psychology in the Schools*, *23*(1), 95-99.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Bruner, J. S. (1981). The social context of language acquisition. *Language & Communication,* *1*(2-3), 155-178.

Cole, E., & Flexer, C. (2015). *Children with hearing loss: Developing listening and talking birth to six (3rd ed.)*. San Diego, CA: Plural Publishing.

Connor, C. M., Craig, H. K., Raudenbush, S. W., Heavner, K., & Zwolan, T. A. (2006). The age at which young deaf children receive cochlear implants and their vocabulary and speech-production growth: Is there an added value for early implantation? *Ear and Hearing*, *27*, 628–644.

Cristofaro, T. N., & Tamis-LeMonda, C. S. (2012). Mother-child conversations at 36 months and at pre-kindergarten: Relations to children's school readiness. *Journal of Early Childhood Literacy*, *12*(1), 68-97.

Cruz, I., Quittner, A. L., Marker, C., DesJardin, J. L., & CDaCI Investigative Team (2013). Identification of effective strategies to promote language in deaf children with cochlear implants. *Child Development, 84*(2), 543-559. https://doi.org/10.1111/j.1467-8624.2012.01863.x

Davidson, L.S., Geers, A.E., & Nicholas, J.G. (2013). The effects of audibility and novel word learning ability on vocabulary level in children with cochlear implants. *Cochlear Implants International, 15*, 211–21.

DesJardin, J. L. (2006). Family empowerment: Supporting language development in young children who are deaf or hard of hearing. *The Volta Review, 106*(3), 275-298.

Duch, H., Fisher, E. M., Ensari, I., Font, M., Harrington, A., Taromino, C., ... & Rodriguez, C. (2013). Association of screen time use and language development in Hispanic toddlers: a cross-sectional and longitudinal study. *Clinical Pediatrics*, *52*(9), 857-865.

Duncan, M. K., & Lederberg, A. R. (2018). Relations between teacher talk characteristics and child language in spoken-language deaf and hard-of-hearing classrooms. *Journal of Speech, Language, and Hearing Research*, *61*(12), 2977-2995.

Dunn, L., & Dunn, D., (2007). *Peabody Picture Vocabulary Test* (4th ed.). San Antonio, TX: Pearson.

Dykstra, J. R., Sabatos-DeVito, M. G., Irvin, D. W., Boyd, B. A., Hume, K. A., & Odom, S. L. (2013). Using the Language Environment Analysis (LENA) system in preschool classrooms with children with autism spectrum disorders. *Autism*, *17*(5), 582-594.

Feng, S., & Powers, K. (2005). The short-and long-term effect of explicit grammar instruction on fifth graders' writing. *Reading Improvement*, *42*(2), 67-73.

Geers, A. E., Strube, M. J., Tobey, E. A., Pisoni, D. B., & Moog, J. S. (2011). Epilogue: factors contributing to long-term outcomes of cochlear implantation in early childhood. *Ear and Hearing, 32,* 84S-92S.

Gilkerson, J., Coulter, K. K., & Richards, J. A. (2008). *Transcriptional analyses of the LENA natural language corpus.* Boulder, CO: LENA Foundation.

Gilkerson, J., Richards, J. A., & Topping, K. J. (2017). The impact of book reading in the early years on parent–child language interaction. *Journal of Early Childhood Literacy*, *17*(1), 92-110.

Girolametto, L., Weitzman, E., Wiigs, M., & Pearce, P. S. (1999). The relationship between maternal language measures and language development in toddlers with expressive vocabulary delays. *American Journal of Speech-Language Pathology*, *8*(4), 364-374.

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

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., ... & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071-1083.

Hoff, E. & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development, 73*(2), 418-433.

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive Psychology*, *45*(3), 337-374.

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

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

Klapper, J., & Rees, J. (2003). Reviewing the case for explicit grammar instruction in the university foreign language learning context. *Language Teaching Research*, *7*(3), 285-314.

Landry, S. H., Smith, K. E., & Swank, P. R. (2006). Responsive parenting: establishing early foundations for social, communication, and independent problem-solving skills. *Developmental Psychology*, *42*(4), 627.

Landry, S. H., Smith, K. E., Swank, P. R., Zucker, T., Crawford, A. D., & Solari, E. F. (2012). The effects of a responsive parenting intervention on parent–child interactions during shared book reading. *Developmental Psychology*, *48*(4), 969.

Luckner, J.L., & Cooke, C. (2010). A summary of the vocabulary research with students who are deaf or hard of hearing. *American Annals of the Deaf, 155*(1), 38–67.

Lund, E. (2018). The effects of parent training on vocabulary scores of young children with hearing loss. *American Journal of Speech-Language Pathology*, *27*(2), 765-777.

Lund, E. (2016). Vocabulary knowledge of children with cochlear implants: A meta-analysis. *Journal of Deaf Studies and Deaf Education*, *21*(2), 107-121.

Lund, E., Douglas, W. M., & Schuele, C. M. (2015). Semantic richness and word learning in children with hearing loss who are developing spoken language: A single case design study. *Deafness & Education International, 17*(3), 163-175.

Lund, E., & Schuele, C. M. (2014). Effects of a word-learning training on children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 19*(1), 68-84.

McCreery, R. W., Walker, E. A., Spratford, M., Oleson, J., Bentler, R., Holte, L., & Roush, P. (2015). Speech recognition and parent-ratings from auditory development questionnaires in children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 60S.

McDonald, L., & Pien, D. (1982). Mother conversational behaviour as a function of interactional intent. *Journal of Child language*, *9*(2), 337-358.

Moeller, M. P., & Tomblin, J. B. (2015). An introduction to the outcomes of children with hearing loss study. *Ear and Hearing*, *36*(0 1), 4S.

Moeller, M. P., Carr, G., Seaver, L., Stredler-Brown, A., & Holzinger, D. (2013). Best practices in family-centered early intervention for children who are deaf or hard of hearing: An international consensus statement. *Journal of Deaf Studies and Deaf Education*, *18*(4), 429-445.

Morrison, H. M. (2017) Home visits—Service delivery in the natural environment. In E. A. Rhoades & J. Duncan (Eds.), *Auditory-verbal practice: Family-centered early intervention* (pp. 266-277). Springfield, IL: Charles C. Thomas.

Nittrouer, S., & Burton, L. T. (2001). The Role of Early Language Experience in the Development of Speech Perception and Language Processing Abilities in Children with Hearing Loss. *The Volta Review*, *103*(1).

Nittrouer, S., Muir, M., Tietgens, K., Moberly, A. C., & Lowenstein, J. H. (2018). Development of phonological, lexical, and syntactic abilities in children with cochlear implants across the elementary grades. *Journal of Speech, Language, and Hearing Research*, *61*(10), 2561-2577.

Nott, P., Cowan, R., Brown, P. M., & Wigglesworth, G. (2009). Early language development in children with profound hearing loss fitted with a device at a young age: Part I- the time period taken to acquire first words and first word combinations. *Ear and Hearing*, *30*, 526–540.

Oller, D. K., Niyogi, P., Gray, S., Richards, J. A., Gilkerson, J., Xu, D., ... & Warren, S. F. (2010). Automated vocal analysis of naturalistic recordings from children with autism, language delay, and typical development. *Proceedings of the National Academy of Sciences*, *107*(30), 13354-13359.

Paatsch, L. E., Blamey, P., J., Sarant, J. Z., & Bow, C. P. (2006). The effects of speech production and vocabulary training on different components of spoken language performance. *Journal of Deaf Studies and Deaf Education*, *11*(1), 39-55.

Quittner, A. L., Cruz, I., Barker, D. H., Tobey, E., Eisenberg, L. S., Niparko, J. K., & the CDaCI Investigative Team. (2013). Effects of maternal sensitivity and cognitive and linguistic stimulation on cochlear implant users' language development over four years. *The Journal of Pediatrics*, *162*(2), 343-348.

Richels, C. G., Bobzien, J. L., Schwartz, K. S., Raver, S. A., Browning, E. L., & Hester, P. P. (2016). Teachers and peers as communication models to teach grammatical forms to preschoolers with hearing loss. *Communication Disorders Quarterly, 37*(3), 131–140. https://doi.org/10.1177/1525740115598770

Rhoades, E. A., Estabrooks, W., Lim, S. R., MacIver-Lux, K., & MacIver, K. (2016). Strategies for listening, talking, and thinking in auditory-verbal therapy. In W. Estabrooks, K. MacIver-Lux, & E. A. Rhoades (Eds.), *Auditory-verbal therapy for young children with hearing loss and their families, and the practitioners who guide them* (pp. 285-326). San Diego: Plural Publishing.

Roberts, M. Y. (2018). Parent-Implemented Communication Treatment for Infants and Toddlers With Hearing Loss: A Randomized Pilot Trial. *Journal of Speech, Language, and Hearing Research*, *62*(1), 143-152.

Rowe, M. L., Leech, K. A., & Cabrera, N. (2016). Going beyond input quantity: Wh-questions matter for toddlers' language and cognitive development. *Cognitive Science, 41*(S1), 162-179. https://doi.org/10.1111/cogs.12349

Rufsvold, R., Wang, Y., Hartman, M. C., Arora, S. B., & Smolen, E. R. (2018). The impact of language input on deaf and hard of hearing preschool children who use listening and spoken language. *American Annals of the Deaf*, *163*(1), 35-60.

Soderstrom, M., & Wittebolle, K. (2013). When do caregivers talk? The influences of activity and time of day on caregiver speech and child vocalizations in two childcare environments. *PLOS ONE*, *8*(11), e80646.

Sosa, A. V. (2016). Association of the type of toy used during play with the quantity and quality of parent-infant communication. *JAMA Pediatrics*, *170*(2), 132-137.

VanDam, M., Ambrose, S.E., & Moeller, M.P. (2012). Quantity of parental language in the home environments of hard of hearing 2-year-olds. *Journal of Deaf Studies and Deaf Education, 17*(4), 402-420.

Vohr, B., Topol, D., Watson, V., St Pierre, L., & Tucker, R. (201). The importance of language in the home for school-age children with permanent hearing loss. *Foundation Acta Paediatrica, 103,* 62-69.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Weizman, Z. O., & Snow, C. E. (2001). Lexical output as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. *Developmental psychology*, *37*(2), 265.

Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENA Language Environment Analysis System in young children's natural home environment.* Boulder, CO: LENA Foundation.

Yoshinaga-Itano, C., Sedey, A. L., & Mallene Wiggin, W. C. (2017). Early hearing detection and vocabulary of children with hearing loss. *Pediatrics*, *140*(2), e20162964.

Table 1

Characteristics of Participants

Characteristics		*n* (%)
Sex	Female	21 (56.8%)
	Male	16 (43.2%)
Degree of hearing loss	Mild	2 (5.4%)
	Moderate	12 (32.4%)
	Moderately severe	3 (8.1%)
	Severe	4 (10.8%)
	Profound	16 (43.2%)
Type of hearing loss	Sensorineural	32 (86.5%)
	Conductive	3 (8.1%)
	Mixed	2 (5.4%)
Type of hearing technology	Hearing aid(s)	16 (43.2%)
	Cochlear implant(s)	19 (51.4%)
	Bimodal (hearing aid and cochlear implant)	2 (5.4%)
Additional disability	No additional disability	32 (86.5%)
	Additional disability	5 (13.5%)

Note. Degree and type of hearing loss are reported for the better ear, except in the one case of unilateral hearing loss, where degree and type are reported for the ear with hearing loss.

Table 2

Demographic Characteristics of Participants' Families

Characteristics		*n* (%)
Annual family income	< $10,000	0 (0%)
	$10,000-29,999	1 (2.7%)
	$30,000-49,999	3 (8.1%)
	$50,000-69,999	5 (13.5%)
	$70,000-89,999	3 (8.1%)
	$90,000-119,999	4 (10.8%)
	$120,000-139,999	1 (2.7%)
	$140,000 or more	12 (32.4%)
	Declined to state	8 (21.6%)
Maternal education level	High school	0 (0%)
	Some college	8 (21.6%)
	Associate degree	2 (5.4%)
	Bachelor's degree	15 (40.5%)
	Master's degree	5 (13.5%)
	Doctoral degree	3 (8.1%)
	Declined to state	4 (10.8%)
Paternal education level	High school	4 (10.8%)
	Some college	7 (18.9%)
	Associate degree	5 (13.5%)
	Bachelor's degree	9 (24.3%)
	Master's degree	4 (10.8%)
	Doctoral degree	4 (10.8%)

Declined to state	4 (10.8%)

Table 3

Correlations Among Techniques, Quantity Variables, and Vocabulary Scores

	1	2	3	4	5	6	7	8	9	10	11
1. Imitation	1										
2. Reform.	.590**	1									
3. Closed	.336*	.503**	1								
4. Open	.345*	.465**	.325*	1							
5. Vocab.	.278	.577**	.259	.481**	1						
6. Directives	-.040	.195	.476**	.012	.184	1					
7. AWC	.086	.051	.207	.263	.076	-.100	1				
8. CTC	.038	.150	.192	.242	.073	.214	.634**	1			
9. CVC	-.063	.052	.048	.024	.014	.378*	-.032	.609**	1		
10. BTBC-3	.269	.219	.184	.290	.410*	.111	.242	.187	.136	1	
11. PPVT-4	.315	.248	.214	.339*	.313	.058	.342*	.387*	.302	.632**	1

Notes. Reform. = reformulation. Vocab. = vocabulary. AWC = adult word count. CTC = conversational turn count. CVC = child vocalization count. BTBC-3 = Boehm-3 Preschool Test of Basic Concepts. PPVT-4 = Peabody Picture Vocabulary Test-4.

**$p < .01$. *$p < .05$.

Table 4

Occurrence of Conversation Techniques and Explicit Instruction

Parent Behavior	Mean	SD	Min.	Max.
Reformulation	1.78	2.08	0	9
Open-ended language elicitation	2.51	2.73	0	11
Closed-ended language elicitation	19.32	12.33	2	51
Imitation	.84	1.21	0	4
Directives	10.51	8.48	1	48
Explicit vocabulary instruction	.43	1.12	0	6

Note. Raw frequency of parents' use of behaviors during 20-minute dinnertime segments are shown.

Table 5

Summary of Nested Regression Models Predicting PPVT-4 Standard Score (N = 37)

	Model 1			Model 2		
Variable	*B*	*SE B*	β	*B*	*SE B*	β
Intercept	58.973**	16.624		55.278**	16.613	
Age	.467	.344	.225	.490	.340	.236
Hearing aids	13.479	6.713	.339	10.265	7.016	.258
Bimodal hearing technology	13.520	13.774	.155	3.569	15.370	.041
Open-ended language elicitation				1.777	1.283	.243

Notes. Age = age in months. Model 1 R^2 = .226. Model 2 R^2 = .270. *F* for R^2 change from Model 1 to Model 2 was not significant, $p > .05$. *$p < .05$. **$p < .01$.

Table 6

Summary of Nested Regression Models Predicting BTBC-3 Percentile Rank (N = 36)

	Model 1			Model 2		
Variable	*B*	*SE B*	β	*B*	*SE B*	β
Intercept	17.316**	6.094		14.990**	5.817	
Hearing aids	29.484**	9.176	.497	25.329**	8.812	.427
Bimodal hearing technology	24.684	19.748	.193	27.010	18.594	.211
Open-ended language elicitation				8.837*	3.826	.337

Notes. Age = age in months. Model 1 R^2 = .245. Model 2 R^2 = .353. F for R^2 change from Model 1 to Model 2 was significant, $F(1, 32) = 5.336$, $p = .027$. *$p < .05$. **$p < .01$.

Chapter 3

A Longitudinal Study of the Language Environments of Preschoolers with Hearing Loss who use Listening and Spoken Language

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Abstract

This longitudinal study explored the quantity and complexity of the home language environments experienced by 14 preschool children with hearing loss who used listening and spoken language. LENA technology was used to collect naturalistic, daylong recordings and estimate the number of adult words and conversational turns to which the children were exposed at the initial time point and again one year later. Twenty-minute dinnertime conversations were transcribed at each time point, and adult and child utterances were coded for syntactic and clausal complexity and lexical diversity. Children's receptive vocabulary and knowledge of basic concepts were also measured. Mean scores were found to be within one standard deviation of the tests' normative means at both time points, though they were below the normative means for children with typical hearing. The quantity and complexity of adult language input remained consistent over one year. The initial clausal complexity of the children's utterances related to their general receptive vocabulary, and the initial syntactic complexity of the children's utterances related to their understanding of basic concepts one year later.

Many children with hearing loss (HL) can learn to listen and talk alongside their peers with typical hearing with intensive early intervention and rich language input from their parents and other adults (Ching, 2015; Moeller & Tomblin, 2015). Research has shown that this language input—parents and children engaged in language-rich interactions—is critical for children's language development, but the quality and quantity of daily language experienced by infants and preschoolers with HL continues to vary widely (Cruz, Quittner, Marker, DesJardin, & the CDaCI Investigative Team, 2013; Lederberg & Everhart, 2000). Many children who experience reduced language input lag behind their hearing peers in basic knowledge and vocabulary skills, placing them at risk for academic delays (Davidson, Geers, & Nicholas, 2013; Lund, 2016). Previous research has highlighted the link between the quantity and diversity of language input and language output using short samples of parent-child interactions (e.g., Cruz et al., 2013; DesJardin, 2006), but few longitudinal studies have used daylong recordings of the natural language environments of children with HL (Ambrose, VanDam, & Moeller, 2014; Vohr, Topol, Watson, St. Pierre, & Tucker, 2014). More research is required to understand the longitudinal effects of the language environment experienced by a child with HL who uses listening and spoken language (LSL). A deeper understanding of these longitudinal effects would inform the development of more effective early intervention for young children and their families, bringing the field closer to closing the language achievement gap between children with and without HL.

This study examined the relation between the quantity and complexity of language input experienced by 14 preschoolers with HL and their receptive vocabulary and basic-concepts development after one year. Language ENvironment Analysis (LENA) digital language processors and software were used to collect and analyze the quantity of language input.

Mealtime transcripts were coded to examine the lexical diversity and syntactic and clausal complexity of the language input and language output at each time point.

Theoretical Framework

According to sociocultural theory, young children learn the languages of their homes and communities by interacting with adults who are advanced language users (Bruner, 1981; Vygotsky, 1978). These adults, typically parents, ideally adjust the language input they provide to ensure that it is just above what children can produce independently. This scaffolded approach to new vocabulary and concepts allows children with typical hearing to begin producing first words shortly before their first birthdays. During the next few years of early childhood, children typically demonstrate rapid expressive vocabulary growth in a "spurt" after they have mastered approximately 50 to 100 words (e.g., Benedict, 1979; Dapretto & Bjork, 2000; Fenson et al., 1994). Receptive vocabulary appears to develop even earlier, with children understanding their first words several months before they are able to produce them (Reznick & Goldfield, 1992). Comprehension of new words introduced during interactions with parents and other caregivers grows rapidly even before children demonstrate an expressive spurt, with some estimating receptive lexicons to be five to 10 times larger than expressive ones during the second year of life (Benedict, 1979; Woodward, Markman, & Fitzsimmons, 1994).

While many children follow these "average" trajectories in their receptive and expressive vocabulary growth, research has found wide variation in vocabulary development for young children with typical hearing. Children from families living in poverty generally understand and produce fewer words by the time they enter school than do those from professional families (Hart & Risley, 1995). Differences in vocabulary development have also been found on the basis of maternal education level, the presence of speech-language delays and other disabilities, and the home literacy environment, all of which have also been associated with later academic difficulties (Catts, Fey, Zhang, & Tomblin, 1999; Hammer, Farkas, & Maczuga, 2010; Hoff-Ginsberg, 1994).

Early Childhood Intervention using LSL

Auditory-verbal practice, implemented through early intervention and preschool programs that specialize in developing LSL skills, focuses on coaching families to provide linguistically rich input that stimulates the auditory brains of young children with hearing loss (Cole & Flexer, 2015). While child outcomes depend on a variety of factors, including appropriate use of hearing technology, the presence of an additional disability, and family engagement, children who undergo auditory-verbal therapy have been shown to demonstrate improved lexicons and more rapid gains in vocabulary and overall spoken language in comparison to those exposed to other forms of aural habilitation (Hogan, Stokes, White, Tyszkiewicz, & Woolgar, 2008; Kaipa & Danser, 2016; Lim, Goldberg, & Flexer, 2018). Results of a study of children with hearing loss from a diverse group of families enrolled in auditory-verbal therapy found household income had no effect on spoken language outcomes, suggesting that specialized intervention in listening and spoken language may help to mitigate the effects of socioeconomic status found in studies of adult language input for typically hearing children (Hogan, Stokes, & Weller, 2010). However, access to qualified professionals (i.e., Listening and Spoken Language Specialists) remains limited for families in many areas of the United States (Rizk, Tomashitis, Goldberg, & Meyer, 2017).

Vocabulary Development for Children with Hearing Loss

Receptive vocabulary, or the words that children comprehend, has been a focus of much of the research on language input and language development because it remains an area of challenge for many children with HL. When compared to their age-matched peers with typical hearing, young children with cochlear implants demonstrate fewer words in their receptive and expressive vocabularies (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006). Children with congenital HL are born with delays with respect to time listening in utero, and late amplification often compounds these delays (Bobzien et al., 2015). Children whose families choose LSL must make rapid progress—more than one month's vocabulary growth in one month's time—to achieve age-appropriate word knowledge (Cole & Flexer, 2015). A comparative study by Nott, Cohen, Brown, and Wigglesworth (2009), however, suggests that preschoolers with cochlear implants often add to their lexicons at a slower rate than do their age-matched peers with typical hearing. While children with typical hearing learn new vocabulary words through incidental exposure, HL may limit a child's ability to learn new words, as well as new meanings for familiar words (Davidson, Geers, & Nicholas, 2013). Without increased access to what Lund, Douglas, and Schuele (2015) term adults' "semantically rich input" (p. 164), children's vocabularies develop slowly, leading to potential academic and social delays (Morgan, Farkas, Hillemeier, Hammer, & Maczuga, 2015). Delays in vocabulary development have also been shown to relate to differences in age at identification and intervention, fit and use of appropriate hearing technology, degree of hearing loss, maternal education level, and the presence of a concomitant disability (Ching, Dillon, Leigh, & Cupples, 2018; Geers, Moog, Biedenstein, Brenner, & Hayes, 2009; Geers, Strube, Tobey, Pisoni, & Moog, 2011; Lederberg & Spencer, 2009; McCreery et al., 2015; Nittrouer & Burton, 2001).

Children with HL who demonstrate delays in receptive vocabulary also often struggle to master basic concepts. *Basic concepts* are a subset of receptive vocabulary that includes words related to quantity (*most/least*), location (*around/in/over*), size (*longest/shortest*), and time sequence (*before/after*) (Bracken, 1984). Although they are not as well represented in receptive-vocabulary assessments as nouns and verbs, basic concepts are often critical for full comprehension of a sentence (e.g., "Put the paper *in* the box." versus "Put the paper *under* the box."). Perhaps due to their unstressed position and decreased auditory salience in sentences, children with HL have historically demonstrated poorer basic-concepts knowledge than their peers with typical hearing (Bracken & Cato, 1986; Davis, 1974). A recent study by Rufsvold, Wang, Hartman, Arora, and Smolen (2018) suggests that these delays persist, particularly for children with cochlear implants.

Quantity of Language Input

Because of the role that children's language environment plays in their development, delays in receptive-vocabulary acquisition for children with and without HL might partially be explained by differences in the language input that they experience (Bruner, 1981; Hoff-Ginsberg, 1986). This input has often been conceptualized in two ways: in terms of its *quantity*, or the number of words directed to or uttered around a child, and its *quality*, or the specific types of words or complexity of adult speech. Early research found significant differences in the sheer amount of adult language input to which young children with typical hearing were exposed based upon their socioeconomic status (Hart & Risley, 1995). These differences predicted vocabulary size and academic readiness as the children entered school, with children who were exposed to more words demonstrating more advanced language and pre-literacy skills. More recent research suggests that the number of conversational turns in which children are engaged may be more important than the sheer number of adult words said within their earshot (Romeo et al., 2018). Children who participate in more conversational turns appear to have greater activation of areas of the brain used for processing language, which relates to more advanced language skills.

The quantity of language parents use may also depend on the setting in which their conversations are recorded. Book-reading and looking at images in a mock art gallery often yield greater numbers of adult words than do free-play activities (Gilkerson, Richards, & Topping, 2017; Soderstrom & Wittebolle, 2013; Sosa, 2016). The quantity of adult language input also appears to vary with the quantity of children's language output, though the direction of this relationship is not clear in the literature (Hoff-Ginsberg, 1994; Dykstra et al., 2013; Oller, et al., 2010). Parents' providing a large quantity of input may cause their children to be more talkative; alternatively, more talkative children prod parents to talk more themselves. Research does show that, once established, the level of parental talkativeness is relatively stable for children with typical hearing (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Huttenlocher et al., 2007). Although what parents talk about may change as their children's language develops over a year, the amount they talk appears not to vary significantly.

This stability of the quantity of language input over time has also been demonstrated in a longitudinal study of children with HL (Ambrose, Walker, Unflat-Berry, Oleson, & Moeller, 2015). Other research suggests that children with HL benefit from exposure to greater numbers of words in their language environments. Just as it does for children with typical hearing, increases in the quantity of language input relate to gains in receptive vocabulary and overall language for children with HL (VanDam, Ambrose, & Moeller, 2012; Vohr et al., 2014). A particular component of input quantity, the number of conversational turns in which adults engage a child with HL, appears especially important for language growth (Ambrose, VanDam, & Moeller, 2014; Arora et al., in preparation).

Quality of Language Input

Investigations of the quality of language input have sought to discover what specific components of adult speech and conversational turns predict children's language growth. Quality has been given a variety of definitions in the literature, from measures of maternal sensitivity and the use of conversation-eliciting techniques to the complexity of parental speech (e.g., Giromaletto, Weitzman, Wiigs, & Steig Pearce, 1999; Hirsh-Pasek et al., 2015; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). Parental responsiveness to children's needs and the objects of their attention relate to higher receptive vocabulary skills in children with typical hearing (Landry, Smith, Swank, & Guttentag, 2008). Similar relations have been found between the fluency and connectedness of parents' speech and their use of joint attention with their children (Hirsh-Pasek et al., 2015; Hoff & Naigles, 2002).

Adults' use of various techniques to elicit conversation or direct behavior also predict language outcomes for children with and without HL. Verbal directives do not appear to predict later language growth and, in fact, may hinder development in children with typical hearing (McDonald & Pien, 1982) and those with HL (DesJardin, 2006; DesJardin & Eisenberg, 2007; Vohr et al., 2010). In contrast, reformulating children's utterances, using open-ended prompts, and asking *wh*-questions all appear to relate to greater vocabulary growth in young children with typical hearing (Cristofaro & Tamis-LeMonda, 2012; Hoff-Ginsberg, 1986; Rowe, Leech, & Cabrera, 2016) and those with HL (Cruz et al., 2013; DesJardin, 2006; DesJardin & Eisenberg, 2007; Duncan & Lederberg, 2018).

Adults can produce reformulations, open-ended questions, and advanced conversation techniques in a variety of ways, from simple to more complex. *Complexity of language input* refers to the manner in which adults conjoin clauses, employ parts of speech, and vary their lexicon. While the overall quantity of the language input parents provide remains relatively stable over time, the complexity of the input does change (Huttenlocher, Vasilyeva, Vevea, Waterfall, & Hedges, 2007). Parents' speech has been shown to grow increasingly syntactically and clausally complex and lexically diverse as children age. Research suggests that this complexity of language input predicts vocabulary and overall language development of children with typical hearing (Cristofaro & Tamis-LeMonda, 2012; Hoff & Naigles, 2002; Huttenlocher et al., 2010).

Syntactic complexity. *Syntactic complexity* refers to the number of different syntactic elements, including adjectives, adverbs, prepositional phrases, and other parts of speech, included in a language sample. Few of these elements may be present in simple sentences (e.g., noun-verb or noun-verb-noun), but they increase in frequency as sentences become more complex. Wide variation in the syntactic complexity of caregivers' speech has been found, particularly on the basis of socioeconomic status (Huttenlocher et al., 2007). This variation in language input appears to relate to variation in children's language output, with children with typical hearing who are exposed to more complex syntax demonstrating more syntactically complex expressive language (Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002). Exposure to specific syntactic elements, including noun and verb phrases, also relates to children's use of these elements (Hoff-Ginsberg, 1986; Naigles & Hoff-Ginsberg, 1998). Parental syntactic complexity also often accompanies the presentation of new vocabulary words in a variety of syntactic contexts, which has been shown to relate to children's general vocabulary growth (Hoff & Naigles, 2002). While a mutual influence between caregivers and children has been posited for other elements of language input (Hoff-Ginsberg, 1986), Huttenlocher and colleagues

(2010) found a direct causal relationship between the syntactic complexity of adult input and children's later language development.

Clausal complexity. *Clausal complexity* refers to the use of a variety of devices to conjoin clauses within sentences. Simple sentences contain one independent clause only, while complex sentences comprise an independent clause joined with at least one dependent or independent clause. These clauses may be combined using coordination, using one clause as the subject or object or a sentence, or by including a relative clause. The use of complex sentences, particularly those that join clauses in diverse ways, has been shown to vary across parent-child dyads for children with typical hearing (Huttenlocher et al., 2007). Higher levels of maternal education are associated with parents' and children's use of more clausally complex sentences (Huttenlocher et al., 2010). Clausal complexity of language input has also been shown to increase over time; as children grow older, parents tend to produce multi-clause sentences more frequently and increase the variety of ways they combine clauses (Huttenlocher et al., 2007). The clausal complexity of the language input to which children are exposed appears to have a direct causal link to their longitudinal language outcomes (Huttenlocher et al., 2010).

Lexical diversity. *Lexical diversity* refers to the number of unique words used by a speaker in a language sample. Speakers who repeat words or phrases again and again demonstrate low lexical diversity, while those who use a wide variety of different words demonstrate greater levels of lexical diversity. As with syntactic and clausal complexity, the diversity of lexical input varies across parent-child dyads and within dyads across time for children with typical hearing (Huttenlocher et al., 1991). This variation in lexical input relates to differences in maternal education level and other measures of socioeconomic status (Hart & Risley, 1995; Huttenlocher et al., 2007). Greater lexical diversity in parents' language input relates to more rapid language development and larger receptive vocabularies in children with typical hearing (Hoff & Naigles, 2002; Huttenlocher et al., 2010).

Few longitudinal studies have investigated the effects of the complexity of language input on language development for children with HL. Syntactic complexity, measured by the mean length of utterance (MLU) and number of different word types in adult input, has been shown to relate positively to receptive and expressive language growth in young children with cochlear implants (Cruz et al., 2013; DesJardin & Eisenberg, 2007). Though parents of children with HL who use LSL are often encouraged to use a wide variety of vocabulary words in their speech (Cole & Flexer, 2015), at least two studies have found no relation between the lexical diversity of mothers' language input and the language development of their children with HL (Arora et al., in preparation; DesJardin & Eisenberg, 2007). Arora and colleagues (in preparation) also found no relation between the clausal complexity of parents' input and children's receptive vocabulary, though the sample size was relatively small. More research is needed to illuminate the link, if it exists, between the complexity of the language input and the development of LSL for children with HL.

Longitudinal Studies with Children with HL

The development of LSL itself has been the subject of several large-scale longitudinal studies in recent years. The Longitudinal Outcomes of Children with Hearing Impairment (LOCHI; Ching, Leigh, & Dillon, 2013), Childhood Development after Childhood Cochlear Implantation (CDaCI; Fink et al., 2007), and Outcomes of Children with Hearing Loss (OCHL; Moeller & Tomblin, 2015) studies have all investigated factors affecting language and vocabulary outcomes for children with HL, particularly those with cochlear implants and those identified as hard of hearing. This body of research has highlighted the importance of early identification, proper technology fitting, and high-quality intervention (Ching, 2015; McCreery et al., 2015; Moeller & Tomblin, 2015). The effects of general aspects of parental language input, such as their early use of spoken or signed languages and their engagement in intervention have also been studied (Erbasi, Scarinci, Hickson, & Ching, 2018; Geers et al., 2017).

Few longitudinal studies have investigated the effects of specific aspects of the quantity and quality of language input on the language outcomes of children with HL. Cruz and her colleagues on the CDaCI team (2013) studied parent-child interactions during free play and an "art gallery" task in the laboratory setting. Parents' use of higher-level conversation techniques and lexically diverse speech positively predicted the language outcomes of the participants with cochlear implants. The CDaCI team also found that maternal sensitivity during recorded interactions bolstered children's longitudinal language development (Quittner et al., 2015). Ambrose and her OCHL colleagues (2015) used a short "art gallery" task to investigate the effects of the quantity of language input and mothers' use of conversation techniques sampled during the task. These conversation techniques, but not the sheer number of words mothers uttered, were found to predict children's language abilities 18 months later. To our knowledge, only two longitudinal studies with children with HL have used the quantity of language input measured by a daylong recording in children's natural settings, although Vohr and colleagues' (2014) study used LENA data collected concurrently with language outcomes (Ambrose et al., 2014; Vohr et al., 2014). Although the quantity of adult words was found to be insignificant in Ambrose and colleagues' (2014) study, both studies found that the number of conversational turns in which children with HL engaged positively related to their language outcomes.

The Present Study

The present study appears to be the first to use naturalistic daylong recordings to examine both the quantity and complexity of language input for children with HL over time. Using LENA technology (Xu, Yapanel, & Gray, 2009), the present study captured full days of the language input to which preschool children with HL were exposed in their natural environments. The longitudinal effects of the quantity, syntactic and clausal complexity, and lexical diversity of this input on children's receptive vocabulary were examined. The following research questions guided the investigation:

1. Is there a significant difference between the quantity and complexity of the initial language input and the quantity and complexity of language input one year later?
2. What initial language variables relate significantly to changes in children's vocabulary and basic concepts over one year?

Method

Participants

Study participants included 14 children with HL (8 females, 6 males) and their families. Children were recruited from three preschool programs that focused on developing LSL in California, Missouri, and New York. Children were eligible to participate in the study if (a) they were between 3 and 5 years old at the onset of the study, (b) they used LSL to communicate, (c) they had an identified hearing loss and wore hearing technology, and (d) their families spoke English at home.

The participants had a mean age of 47.07 months at recruitment (SD = 7.416) and received follow-up assessments approximately one year later (M_{age} = 59.3, SD = 7.438 months). The participants all had diagnosed sensorineural hearing loss in at least one ear, and, for most, their hearing loss was at the severe or profound level (degree of hearing loss in the better ear:

moderate [$n = 4$], moderately severe [$n = 1$], severe [$n = 2$], profound [$n = 7$]). Most participants used bilateral cochlear implants ($n = 8$), binaural hearing aids ($n = 4$), with 1 participant fit with bimodal amplification (1 hearing aid and 1 cochlear implant) and another fit with just 1 hearing aid (see Table 1). One participant had an additional diagnosed disability, Waardenburg syndrome. The participants' family income and levels of parental education are presented in Table 2.

Procedures

Approval was obtained from the Institutional Review Board of Teachers College, Columbia University, prior to beginning the study. All parents and school staff whose voices were audio recorded provided written informed consent. Participants were recruited from LSL preschool programs around the United States. With the support of school administration, all children and families who met the inclusion criteria were invited to participate. Fourteen families provided informed consent to participate and contributed data during both the initial and one-year follow-up phases. Demographic data, including age at identification, type/degree of HL, technology use, and family socioeconomic status, were collected via comprehensive file review and/or parent questionnaire. Data were initially collected over a 2- to 4-day school visit. Participants in the initial phase of data collection were invited to participate again during a school visit approximately one year later.

Data collection procedures were identical during each phase of the study. All participants were assessed using the Boehm-3 Preschool Test of Basic Concepts (BTBC-3; Boehm, 2001) and Peabody Picture Vocabulary Test-4 (PPVT-4; L. Dunn & D. Dunn, 2007). The researchers, all experienced teachers of the deaf and hard of hearing, administered the assessments in a child-friendly therapy room or classroom in the child's school. The assessment rooms were familiar to the children and contained few visual or auditory distractions. Participants were given breaks during and between the two assessments as needed. The assessments took approximately 30 minutes to administer.

The LENA system was used to record the participants' spoken-language environments. Participants wore a specially designed vest with an acoustically transparent pocket into which a LENA digital language processor (DLP) was placed. Participants wore the LENA DLP for two full days at each time point, beginning when they awoke in the morning and recording about 16 hours until the DLP automatically turned off after the children went to sleep at night. Although four total days were recorded, only two days of LENA recording were used for this study. At the initial phase, the first day with a clear dinnertime was selected for analysis of both the quantity and complexity of language input. The criteria for a clear dinnertime were: (a) a clear announcement was made (e.g., "*It's dinnertime!*"), (b) the child was called to the table (e.g., "*Come sit down for dinner.*"), (c) the child was first offered food (e.g., "*Want some noodles?*"), or (d) the child first requested food ("*Can I have a roll?*"). Criteria (c) and (d) were only used if neither (a) nor (b) could be found in the recording. If the first day of recording contained a dinnertime that met the criteria, that mealtime conversation was transcribed, and the AWC, CTC, and CVC from that day were used. In several cases, no clear dinnertime could be found in the first day of recording (e.g., because the family grazed on snacks, but did not sit down to a full dinner). In those cases, a clear dinnertime was located on the second day of recording. The quantity and complexity variables for that day were used in subsequent analyses. The same procedures were followed for the recordings collected in the follow-up phase, yielding one dinnertime conversation and daylong recording at the initial phase and another dinnertime conversation and daylong recording one year later. Families were advised that they could return the DLP and request that the data be deleted if they were uncomfortable with that day's recording for any reason. None of the participating families expressed concerns.

Measures

Receptive vocabulary. Children's receptive vocabulary skills were measured using the Peabody Picture Vocabulary Test-4 (PPVT-4; L. Dunn & D. Dunn, 2007). A standardized, norm-referenced assessment, the PPVT-4 measures the examinee's comprehension of a wide range of vocabulary words, from everyday objects (e.g., *doll*, *uniform*) to more specialized items (e.g., instruments) and actions (e.g., *delivering*). The PPVT-4 has two parallel forms; the present study used Form B. The assessment comprises 228 test items presented as illustrations. Only those test items that fall within a child's basal and ceiling are presented during a single administration. For participants in this study, the number of items presented during administration of the PPVT-4 ranged from 12 to 84. To test an item, the examiner displays an easel with four illustrations and prompts the child to point to the item (e.g., "Show me ______."). Widely used in vocabulary research, the PPVT-4 has a normative mean of 100 and a standard deviation of 15. The measure was standardized on a sample of 3,540 individuals from ages 30 months to over 90 years (L. Dunn & D. Dunn, 2007). The normative sample was designed to resemble the English-proficient U.S. population based on key demographic variables. Internal consistency was found to be between .94 and .95, and alternate-forms reliability was reported to be .89. Participants' standard scores on the PPVT-4 were used as variables in this study.

Basic concepts. Children's knowledge of basic concepts was measured using the Boehm-3 Preschool Test of Basic Concepts (BTBC-3; Boehm, 2001). A standardized assessment that provides age equivalents and percentile ranks, the BTBC-3 measures children's comprehension of concepts like position (*in front of/behind*), amount (*empty/full*), location (*over/around*), and size (*long/short*) in connected speech. The BTBC-3 is a preschool assessment and can be administered to children ages 3 years, 0 months, to 5 years, 11 months. It comprises 78 total test items. Based on the child's age, a set of 52 items is administered in one sitting. To test an item, the examiner displays an easel with four pictures and reads a scripted prompt using acoustic highlighting to emphasize the basic concept being assessed (e.g., "Point the girl who is line *before* a boy."). The BTBC-3 was normed on a sample of 660 children between the ages of 3 and 5;11 years. Internal consistency was reported to be high (between .85 and .92), with test-retest reliability between .9 and .94. Because the BTBC-3 does not give a standard score, children's percentile ranks were used as variables in this study.

Quantity of language input. The quantity of language input experienced by study participants was collected using LENA DLPs and LENA Pro Software (Xu, Yapanel, & Gray, 2009). Large-scale natural-language studies have validated the use of the LENA system in the homes of representative samples of American infants and children (Gilkerson & Richards, 2008; Gilkerson, Coulter, & Richards, 2008). Strong reliability was found between its automated estimates of AWC, CTC, and CVC in naturalistic daylong recordings and those found through hand-coding by professional transcribers.

LENA Pro was used to analyze two daylong (approximately 16-hour) recordings from each participant: one collected during the initial phase and one collected during the follow-up phase one year later. Three variables were used to estimate the quantity of language input and output. AWC was considered to be the number of words said by caregivers and other adults within 6 to 10 feet of the child during the daylong recording. CTC was estimated as the number of times an adult responded to the child's vocalization within 5 seconds. CTC also included instances when the child responded to an adult's utterance within 5 seconds. CVC was considered to be the number of times the child vocalized using speech or speech-like babble. Because participants varied in the amount of time they were awake and receiving language input throughout the day, proportions of AWC, CVC, and CTC were used as standardized measures across participants. These proportions were found by dividing each variable by an estimate of the number of waking hours for each child (beginning when the DLP was turned on and ending when CVC and CTC ceased at the end of the day).

Complexity of language input. The complexity of language input was analyzed using 20-minute dinnertime conversations recordings during each phase of data collection. The first day at each time point that contained a clear dinnertime according to the criteria outlined in Procedures above was used. The investigator or a trained research assistant listened to the LENA recording and located the child's dinnertime. Mealtimes naturally varied in length, so 20-minute clips were selected in order to standardize the complexity measures across participants. Audio clips were extracted from LENA Pro, and professional transcribers transcribed each dinnertime conversation using a broad orthographic approach. The investigator or a trained research assistant checked each transcript; no major discrepancies were found. Each transcript was then coded for syntactic complexity, clausal complexity, and lexical diversity using a coding scheme adapted from Huttenlocher and colleagues (2010).

Syntactic complexity. Seven syntactic elements were coded: (1) adjectives (e.g., *purple flower*, loud *drum*); (2) adverbs that modify verbs (e.g., *sit carefully*, *eat slowly*); (3) adverbs that modify adjectives (e.g., *really* cold, *dark* blue), (4) prepositional phrases (e.g., *to the store*, *for my mother*), (5), noun phrases that occur outside of argument positions (e.g., *Last year*, *I was 3*.), (6) possessives (*my plate*, *Julio's hat*), and (7) quantifiers for mass nouns (e.g., *some pasta*, *a little water*). Huttenlocher and colleagues (2010) followed the same definitions for syntactic elements, but coded only those elements that were considered optional in a sentence. For example, a child's responding "red" to "What color is that?" would not have been coded because the use of the adjective *red* in this instance is not optional. In contrast, the use of *red* in "The red truck is driving." is optional and would be coded under Huttenlocher and colleagues' (2010) scheme. Because of the auditory and language delays demonstrated by many children with HL, coding only the optional syntactic elements they use might unfairly represent their use of syntactic complexity. Thus, all syntactic elements, not just those considered optional, were coded in the present study.

Each syntactic element was assigned a color (e.g., orange for prepositional phrases), and coders used the colors to highlight each relevant word or phrase in the transcript. The total number of syntactic elements highlighted in adult speech and the total number highlighted in the child's speech were then calculated. These totals were used to represent the syntactic complexity of language input and of the child's expressive language.

Clausal complexity. Complex sentences were coded if they contained at least two clauses combined in one of the following 7 ways: (1) coordination using *and*, *or*, or *but* (e.g, *I cut the food <u>and ate it.</u>*), (2) adjunct clause preceding the main clause (e.g., *<u>When I was a little kid,</u> I didn't like broccoli.*), (3) adjunct clause following the main clause (e.g., *I didn't like broccoli <u>when I was a little kid</u>*.), (4) subject relative clause modifying the subject of the main clause (e.g., *The pie <u>that I made</u> has a chocolate crust*.), (5) object relative clause modifying the object of the main clause (e.g., *I want the pie <u>that you made</u>*.), (6) the subject of the main clause (e.g., *<u>Cooking</u> is really fun.*), or (7) the object of the main clause (e.g., *She wants <u>to help</u>*.) (Huttenlocher et al., 2010). A color-coding strategy was applied to code the clausal complexity of the language input, with each type of clausal combination assigned a specific color (e.g., red for coordination). The total numbers of color-coded clausal combinations uttered by adults and by the child were used to represent clausal complexity.

Lexical diversity. The total number of unique words produced by the child and adults in each transcript was calculated to represent the lexical diversity of the sample (Huttenlocher et al., 2010). Variations of the same name were counted only once (e.g., *Madelyn* and *Maddy* counted as one unique word), as were multi-word proper nouns (e.g., *KnuffleBunny* counted as one word). Words and all their inflected types (e.g., *walk*, *walks*, *walking*), including those with irregular inflectional morphology (e.g., *teach*, *taught*), were also counted as only one unique word. Words with the same root but different derivational morphology (e.g., *happy*, *happily*) were each counted as a unique word. The total number of unique words uttered by adults and the total number of unique words uttered by the child were both calculated and used to represent lexical diversity.

Reliability. Several research assistants, all of whom were graduate students in communication sciences or deaf education or had attained at least a master's degree in the field, underwent training as reliability coders. After guided analysis of sample coded transcripts, the research assistants practiced coding independently until they attained at least 85% agreement with a gold-standard coded transcript. Twenty-five percent of the transcripts were coded by both the investigator and a reliability coder. Mean percent agreement for all elements of lexical diversity and syntactic and clausal complexity was 87.7 percent. Mean interrater percent agreement was 94.3 percent for lexical diversity, 80.6 percent for syntactic complexity, and 88.1 percent for clausal complexity. Percent agreement for coded elements in individual transcripts ranged from 71.6 to 100 percent. The coders discussed all instances of disagreement in coding until consensus was reached. The totals reached by consensus were used in subsequent analyses.

Results

IBM SPSS Version 25 for Mac was used to conduct all statistical analyses.

Research Question 1: Is there a significant difference between the quantity and complexity of the initial language input and the quantity and complexity of language input one year later?

Results of paired-samples *t*-tests for the initial quantity of adult input and the quantity of adult input one year later were not significant (AWC: $t(13) = .345$, $p = .736$; CTC: $t(13) = 1.327$, $p = .207$). No difference was found between the adults' initial and follow-up lexical diversity, $t(13) = -.160$, $p = .875$; clausal complexity, $t(13) = -1.655$, $p = .122$; or syntactic complexity, $t(13) = -1.349$, $p = .200$.

Research Question 2: What initial language variables relate significantly to changes in children's vocabulary and basic concepts over one year?

Participants achieved an initial standard score of 88.57 ($SD = 13.65$) on the PPVT-4, and mean standard score of 92.57 ($SD = 11.17$) one year later. Mean percentile ranks on the BTBC-3 were 34.29 ($SD = 37.62$) at initial testing and 29.57 ($SD = 24.70$) one year later. Paired-sample *t*-tests did not find significant differences in performance from initial testing to follow-up testing for the PPVT-4, $t(13) = -1.376$, $p = .192$, or the BTBC-3, $t(13) = .751$, $p = .466$. Significant correlations were found between follow-up PPVT-4 score and initial child clausal complexity, $r(12) = .797$, $p = .001$, and initial child syntactic complexity, $r(12) = .643$, $p = .013$. Significant correlations were also found between follow-up BTBC-3 score and initial child lexical diversity, $r(12) = .729$, $p = .003$, and initial child syntactic complexity, $r(12) = .873$, $p < .001$. Correlations between the initial adult complexity and quantity and children's follow-up PPVT-4 and BTBC-3 scores were not significant.

Stepwise regression analyses were performed with follow-up PPVT-4 and BTBC-3 scores as the dependent variables and initial adult and child language variables entered as possible independent variables, controlling for initial test scores. Only initial child clausal complexity explained a significant amount of variation in receptive vocabulary at follow-up when controlling for initial PPVT-4 score, $R^2 = .649$, $F(2, 11) = 10.168$, $p = .003$. Only initial child syntax explained a significant amount of variation in basic concepts at follow-up when controlling for initial BTBC-3 percentile rank, $R^2 = .893$, $F(2, 11) = 26.991$, $p < .001$.

Discussion

This study examined the quantity and complexity of language experienced and produced by young children with HL and explored the relation of these language environments to children's progress in receptive vocabulary and knowledge of basic concepts over one year. No difference was found between the quantity of adult words and conversational turns recorded by LENA in daylong, naturalistic recordings and those recorded one year later. Similarly, no difference was found between the complexity of language input (i.e., the syntactic and clausal complexity and lexical diversity of adult utterances) in children's dinnertime conversations during the initial recordings and their dinnertime conversations one year later. The participants, on average, demonstrated receptive vocabulary and knowledge of basic concepts in the average range at both time points, with no significant difference in scores found between initial and follow-up testing. Stepwise regression analysis found that, controlling for initial PPVT scores, the initial clausal complexity of children's utterances predicted their performance on the PPVT one year later. Children's initial syntactic complexity predicted their follow-up performance on the BTBC-3, controlling for initial basic-concepts scores.

Receptive vocabulary has long been an area of challenge for children with HL, with many demonstrating delays that compound year after year (Bobzien et al., 2015; Lund, 2016; Nott et al., 2009). In contrast, the children in this study, on average, performed within the average range or better (i.e., within one standard deviation of the mean for the normative sample) on assessments of both general receptive vocabulary and words related to basic concepts at both times of testing. This finding is heartening in that it demonstrates the potential for young children with HL to develop age-appropriate skills with the intensive intervention offered by the LSL programs from which they were recruited. However, while in the average range, the participants' mean scores on the PPVT and BTBC-3 were well below the mean for the tests' normative sample, suggesting that these children have not yet caught up to their peers with typical hearing. The average standard score and percentile rank, both of which are tied to the examinee's age, for receptive vocabulary and basic concepts did not change significantly over one year. This suggests that the participants made one year's progress in one year's time, enough to keep pace with their peers with typical hearing, but not enough to catch up to them (Tomblin et al., 2018).

Consistent with previous research with children with and without HL (Ambrose et al., 2015; Huttenlocher et al., 1991; Huttenlocher et al., 2007), the quantity of language input to which the children in the present study were exposed remained consistent from one year to the next. The parents and other adult caregivers who were more talkative in the first recording remained just as talkative when they were recorded one year later, and those who were more reticent did not significantly increase the number of words or conversational turns they provided. While the children's receptive vocabulary and knowledge of basic concepts grew over one year, the sheer amount the adults around them talked did not change. Surprisingly, the complexity of adult talk did not change over time in response to the children's language growth. In contrast to previous findings that parents' child-directed speech became more complex and diverse as their children aged (Huttenlocher et al., 2007), the syntactic and clausal complexity and lexical diversity of the adult language to which the children in the present study were exposed did not increase in the year between recordings. Interestingly, though neither difference was statistically significant, the quantity of the input rose slightly over one year, while the complexity of the input declined slightly. This finding is concerning. It is possible that the dinnertime sampling did not represent the complexity of language parents used during other times of the day, though the time period was theorized to provide many opportunities for complex language. Most of the parents had received family-centered coaching during early intervention, but this support was not a regular part of their children's preschool programs. Perhaps they had begun providing language input at a complexity level appropriate for their children's receptive language during this early period, but, without continued coaching, did not significantly increase the level of complexity as their children grew. As many children with HL require a language environment that is even richer than those with typical hearing (Aragon & Yoshinaga-Itano, 2012; Lund et al., 2015), professionals should ensure that parents receive support in providing appropriately challenging input even after their children age out of early intervention.

In this sample, the longitudinal receptive vocabulary growth of children with HL was most strongly predicted by the complexity of the children's initial language output, with different measures of complexity accounting for general vocabulary versus basic concepts. Children's overall receptive lexicon at follow-up, measured by the PPVT-4, was predicted by the clausal complexity of the children's utterances one year earlier. Children who used many multiclause sentences during their initial mealtime conversations had greater receptive vocabulary one year later, even when controlling for their initial PPVT-4 scores. Combining several ideas into a single multiclause utterance usually requires a sophisticated, flexible lexicon to make connections between these ideas (Huttenlocher et al., 2007). It is possible that the children who practiced combining more clauses, even short ones, prompted their adult conversation partners to expand their ideas with new words, leading to greater receptive vocabulary at follow-up. While clausal complexity predicted general receptive vocabulary, the initial syntactic complexity of the children's utterances predicted their understanding of the specific vocabulary words related to basic concepts after one year. Basic concepts involve optional parts of the sentence that contribute meaning; the prepositions, adjectives, and adverbs required for basic concepts are among the same units measured by syntactic complexity. It appears that, in this sample, children who used more syntactic units initially continued to add examples of these words receptively, increasing their reception of basic concepts. That the relations between the complexity variables and child outcomes were different for the PPVT-4 and the BTBC-3 suggests that general receptive vocabulary and basic concepts are related, but separate constructs that may both merit instruction in LSL programs.

Limitations

This longitudinal study included 14 English-speaking families. While many efforts were made to recruit as large and diverse a sample as possible, the findings are necessarily limited by the relatively small number of participants and monolingual nature of their language input. That the initial complexity of the adult language input did not predict children's growth in vocabulary or basic concepts, for example, is surprising. It is possible that the small sample size or relatively short mealtime clips used prevented significant relations from emerging. The daylong recordings used in this study presented an opportunity to measure children's natural language environments without artificial, laboratory-based tasks, like the "art gallery" activity used in previous studies (e.g., Ambrose et al., 2015; Cruz et al., 2013). While dinnertime was chosen as a way to "standardize" the opportunities for complex language input across the participants, the naturalistic recording format necessarily introduces random factors, such as speakers present and the family's previous activities that day. These factors could affect the complexity of mealtime conversations. Future research might incorporate multiple daylong recordings for a single time point or analyze language input and output during multiple parts of the day, including other meals.

Conclusion

This study highlights the relations between the quantity and complexity of language input and the language children produce and understand. For children with HL who use LSL, access to rich language environments is often considered critical, not just during the school day, but also at home. This study is one of the first to examine the complexity of parents' language input during dinnertime at home with their children with HL. While the children in this study demonstrated receptive vocabulary within the average range, their mean performance was well below that expected of children with typical hearing, and they did not make enough progress over one year to begin to close this gap. Similarly, while many parents' utterances demonstrated some lexical diversity and syntactic and clausal complexity at their initial recording, they did not significantly increase this complexity over one year, as parents of children with typical hearing usually do. These findings suggest parents may need continued support and coaching to enrich their language input, even after the child has aged out of formal family-centered early intervention. Future research might continue to use naturalistic, daylong recording techniques to explore the home environments of larger samples of children with HL, including those who are culturally and linguistically diverse. A deeper understanding of these natural language environments will help professionals better support parents as they become the first and best teachers for their young children with HL who use LSL.

References

Ambrose, S. E., VanDam, M., & Moeller, M. P. (2014). Linguistic input, electronic media, and communication outcomes of toddlers with hearing loss. *Ear & Hearing*, *35*(2), 139-147.

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 48S.

Aragon, M., & Yoshinaga-Itano, C. (2012). Using Language ENvironment Analysis to improve outcomes for children who are deaf or hard of hearing. *Seminars in Speech and Language*, *33*(4), 340–353.

Arora, S. B., Smolen, E.R., Wang, Y., Hartman, M. C., Rufsvold, R., & Howerton Fox, A. (2018). Quantity or diversity: Language environments and language development of children with hearing loss. Manuscript in preparation.

Barnes, S., Gutfreund, M., Satterly, D., & Wells, G. (1983). Characteristics of adult speech which predict childrenÕs language development. *Journal of Child Language, 10*, 65–84.

Benedict, H. (1979). Early lexical development: Comprehension and production. *Journal of Child Language*, *6*(2), 183-200.

Bobzien, J. L., Richels, C., Schwartz, K., Raver, S. A., Hester, P., Morin, L. (2015). Using repeated reading and explicit instruction to teach vocabulary to preschoolers with hearing loss. *Infants & Young Children, 28*(3), 262-280.

Boehm, A. (2001). *Boehm Test of Basic Concepts – Preschool (3rd ed.)*. San Antonio, TX: Pearson.

Bracken, B. A. (1984). *Bracken Basic Concept Scale*. San Antonio, TX: Psychological Corporation.

Bracken, B. A., & Cato, L. A. (1986). Rate of conceptual development among deaf preschool and primary children as compared to a matched group of nonhearing impaired children. *Psychology in the Schools*, *23*(1), 95-99.

Bruner, J. S. (1981). The social context of language acquisition. *Language & Communication, 1*(2-3), 155-178.

Catts, H., Fey, M., Zhang, X., & Tomblin, J. B. (1999). Language basis of reading and reading disabilities: Evidence from a longitudinal investigation. *Scientific Studies of Reading, 3*, 331–361.

Ching, T. Y. (2015). Is early intervention effective in improving spoken language outcomes of children with congenital hearing loss?. *American Journal of Audiology*, *24*(3), 345-348.

Cole, E., & Flexer, C. (2015). *Children with hearing loss: Developing listening and talking birth to six (3rd ed.)*. San Diego, CA: Plural Publishing.

Connor, C. M., Craig, H. K., Raudenbush, S. W., Heavner, K., & Zwolan, T. A. (2006). The age at which young deaf children receive cochlear implants and their vocabulary and speech-production growth: Is there an added value for early implantation? *Ear and Hearing*, *27*, 628–644.

Cristofaro, T. N., & Tamis-LeMonda, C. S. (2012). Mother-child conversations at 36 months and at pre-kindergarten: Relations to children's school readiness. *Journal of Early Childhood Literacy*, *12*(1), 68-97.

Cruz, I., Quittner, A. L., Marker, C., DesJardin, J. L., & CDaCI Investigative Team (2013). Identification of effective strategies to promote language in deaf children with cochlear implants. *Child Development, 84*(2), 543-559. https://doi.org/10.1111/j.1467-8624.2012.01863.x

Dapretto, M., & Bjork, E. (2000). The development of word retrieval abilities in the second year and its relation to early vocabulary growth. *Child Development, 71,* 635–648.

Davidson, L.S., Geers, A.E., & Nicholas, J.G. (2013). The effects of audibility and novel word learning ability on vocabulary level in children with cochlear implants. *Cochlear Implants International, 15*, 211–21.

Davis, J. (1974). Performance of young hearing-impaired children on a test of basic concepts. *Journal of Speech and Hearing Research*, *17*(3), 342-351.

DesJardin, J. L. (2006). Family empowerment: Supporting language development in young children who are deaf or hard of hearing. *The Volta Review, 106*(3), 275-298.

DesJardin, J. L., & Eisenberg, L. S. (2007). Maternal contributions: Supporting language development in young children with cochlear implants. *Ear and Hearing, 28*(4), 456-469. https://doi.org/10.1097/AUD.0b013e31806dc1ab

Dunn, L., & Dunn, D., (2007). *Peabody Picture Vocabulary Test* (4th ed.). San Antonio, TX: Pearson.

Dykstra, J. R., Sabatos-DeVito, M. G., Irvin, D. W., Boyd, B. A., Hume, K. A., & Odom, S. L. (2013). Using the Language Environment Analysis (LENA) system in preschool classrooms with children with autism spectrum disorders. *Autism*, *17*(5), 582-594.

Erbasi, E., Scarinci, N., Hickson, L., & Ching, T. Y. (2018). Parental involvement in the care and intervention of children with hearing loss. *International Journal of Audiology*, *57*(sup2), S15-S26.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., ... & Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, i-185.

Fink, N. E., Wang, N. Y., Visaya, J., Niparko, J. K., Quittner, A., Eisenberg, L. S., & Tobey, E. A. (2007). Childhood development after cochlear implantation (CDaCI) study: Design and baseline characteristics. *Cochlear Implants International*, *8*(2), 92-116.

Geers, A. E., Mitchell, C. M., Warner-Czyz, A., Wang, N. Y., Eisenberg, L. S., & CDaCI Investigative Team. (2017). Early sign language exposure and cochlear implantation benefits. *Pediatrics*, *140*(1).

Geers, A. E., Moog, J. S., Biedenstein, J., Brenner, C., & Hayes, H. (2009). Spoken language scores of children using cochlear implants compared to hearing age-mates at school entry. *Journal of Deaf Studies and Deaf Education*, *14*(3), 371-385.

Geers, A. E., Strube, M. J., Tobey, E. A., Pisoni, D. B., & Moog, J. S. (2011). Epilogue: factors contributing to long-term outcomes of cochlear implantation in early childhood. *Ear and Hearing, 32,* 84S-92S.

Gilkerson, J., Coulter, K. K., & Richards, J. A. (2008). *Transcriptional analyses of the LENA natural language corpus.* Boulder, CO: LENA Foundation.

Gilkerson, J., & Richards, J. A. (2008). *The LENA natural language study.* Boulder, CO: LENA Foundation.

Gilkerson, J., Richards, J. A., & Topping, K. J. (2017). The impact of book reading in the early years on parent–child language interaction. *Journal of Early Childhood Literacy*, *17*(1), 92-110.

Hammer, C. S., Farkas, G., & Maczuga, S. (2010). The language and literacy development of Head Start children: A study using the Family and Child Experiences Survey database. *Language, Speech, and Hearing Services in Schools, 41*, 70-83.

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

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., ... & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071-1083.

Hoff, E. & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development, 73*(2), 418-433.

Hogan, S., Stokes, J., & Weller, I. (2010). Language outcomes for children of low-income families enrolled in auditory verbal therapy. *Deafness & Education International*, *12*(4), 204-216.

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

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

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

Kaipa, R., & Danser, M. L. (2016). Efficacy of auditory-verbal therapy in children with hearing impairment: A systematic review from 1993 to 2015. *International Journal of Pediatric Otorhinolaryngology*, *86*, 124-134.

Landry, S. H., Smith, K. E., Swank, P. R., & Guttentag, C. (2008). A responsive parenting intervention: the optimal timing across early childhood for impacting maternal behaviors and child outcomes. *Developmental Psychology*, *44*(5), 1335.

Lund, E. (2016). Vocabulary knowledge of children with cochlear implants: A meta-analysis. *Journal of Deaf Studies and Deaf Education*, *21*(2), 107-121.

Lund, E., Douglas, W. M., & Schuele, C. M. (2015). Semantic richness and word learning in children with hearing loss who are developing spoken language: A single case design study. *Deafness & Education International, 17*(3), 163-175.

McCreery, R. W., Walker, E. A., Spratford, M., Oleson, J., Bentler, R., Holte, L., & Roush, P. (2015). Speech recognition and parent-ratings from auditory development questionnaires in children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 60S.

McDonald, L., & Pien, D. (1982). Mother conversational behaviour as a function of interactional intent. *Journal of Child language*, *9*(2), 337-358.

Moeller, M. P., & Tomblin, J. B. (2015). An introduction to the outcomes of children with hearing loss study. *Ear and Hearing*, *36*(0 1), 4S.

Morgan, P. L., Farkas, G., Hillemeier, M. M., Hammer, C. S., & Maczuga, S. (2015). 24-month-old children with larger oral vocabularies display greater academic and behavioral functioning at kindergarten entry. *Child Development*, *86*(5), 1351-1370.

Nittrouer, S., & Burton, L. T. (2001). The role of early language experience in the development of speech perception and language processing abilities in children with hearing loss. *The Volta Review*, *103*(1).

Oller, D. K., Niyogi, P., Gray, S., Richards, J. A., Gilkerson, J., Xu, D., ... & Warren, S. F. (2010). Automated vocal analysis of naturalistic recordings from children with autism, language delay, and typical development. *Proceedings of the National Academy of Sciences*, *107*(30), 13354-13359.

Quittner, A. L., Cruz, I., Barker, D. H., Tobey, E., Eisenberg, L. S., Niparko, J. K., & the CDaCI Investigative Team. (2013). Effects of maternal sensitivity and cognitive and linguistic stimulation on cochlear implant users' language development over four years. *The Journal of Pediatrics*, *162*(2), 343-348.

Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology, 28*, 406-413.

Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., & Gabrieli, J. D. (2018). Beyond the 30-million-word gap: Children's conversational exposure is associated with language-related brain function. *Psychological Science*, *29*(5), 700-710.

Rowe, M. L., Leech, K. A., & Cabrera, N. (2016). Going beyond input quantity: Wh-questions matter for toddlers' language and cognitive development. *Cognitive Science, 41*(S1), 162-179. https://doi.org/10.1111/cogs.12349

Soderstrom, M., & Wittebolle, K. (2013). When do caregivers talk? The influences of activity and time of day on caregiver speech and child vocalizations in two childcare environments. *PLOS ONE*, *8*(11), e80646.

Sosa, A. V. (2016). Association of the type of toy used during play with the quantity and quality of parent-infant communication. *JAMA Pediatrics*, *170*(2), 132-137.

VanDam, M., Ambrose, S.E., & Moeller, M.P. (2012). Quantity of parental language in the home environments of hard of hearing 2-year-olds. *Journal of Deaf Studies and Deaf Education, 17*(4), 402-420.

Vohr, B., St Pierre, L., Topol, D., Jodoin-Krauzyk, J., Bloome, J., & Tucker, R. (2010). Association of maternal communicative behavior with child vocabulary at 18–24 months for children with congenital hearing loss. *Early Human Development*, *86*(4), 255-260.

Vohr, B., Topol, D., Watson, V., St Pierre, L., & Tucker, R. (201). The importance of language in the home for school-age children with permanent hearing loss. *Foundation Acta Paediatrica, 103,* 62-69.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Woodward, A. L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology, 30*(4), 553-565.

Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENA Language Environment Analysis System in young children's natural home environment*. Boulder, CO: LENA Foundation.

Table 1

Characteristics of Participants

Characteristics		*n* (%)
Sex	Female	8 (57.1%)
	Male	6 (42.9%)
Degree of hearing loss	Moderate	4 (28.6%)
	Moderately severe	1 (7.1%)
	Severe	2 (14.3%)
	Profound	7 (50.0%)
Type of hearing loss	Sensorineural	13 (92.9%)
	Mixed	1 (7.1%)
Type of hearing technology	Hearing aid(s)	5 (35.7%)
	Cochlear implant(s)	8 (57.1%)
	Bimodal (hearing aid and cochlear implant)	1 (7.1%)
Additional disability	No additional disability	13 (92.9%)
	Additional disability	1 (7.1%)

Note. Degree and type of hearing loss are reported for the better ear, except in the one case of unilateral hearing loss, where degree and type are reported for the ear with hearing loss.

Table 2

Demographic Characteristics of Participants' Families

Characteristics		*n* (%)
Annual family income	< $10,000	0 (0%)
	$10,000-29,999	0 (0%)
	$30,000-49,999	2 (14.3%)
	$50,000-69,999	1 (7.1%)
	$70,000-89,999	3 (21.4%)
	$90,000-119,999	0 (0%)
	$120,000-139,999	0 (0%)
	$140,000 or more	5 (35.7%)
	Declined to state	3 (21.4%)
Maternal education level	High school	0 (0%)
	Some college	6 (42.9%)
	Associate degree	0 (5.4%)
	Bachelor's degree	4 (28.6%)
	Master's degree	2 (14.3%)
	Doctoral degree	1 (7.1%)
	Declined to state	1 (7.1%)
Paternal education level	High school	3 (21.4%)
	Some college	4 (28.6%)
	Associate degree	3 (21.4%)
	Bachelor's degree	1 (7.1%)
	Master's degree	0 (0%)
	Doctoral degree	2 (14.3%)
	Declined to state	1 (7.1%)

Chapter 4

Reading Achievement in Children with Hearing Loss who Use Listening and Spoken Language: Results and Implications from a 2-Year Study

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Abstract

This study explored the reading achievement of 64 children with hearing loss enrolled in prekindergarten through third grade in a large listening and spoken language program in the Southwest United States. Eight subtests of the Woodcock-Johnson IV Tests of Achievement were administered, and demographic information was collected. While children with hearing loss have historically struggled to achieve age-appropriate reading skills in elementary school, the mean subtest standard scores for participants in this study were all within the average range. Participants demonstrated relative strengths in basic reading skills, such as spelling, word and non-word reading, and comprehension of short passages. Relative weaknesses were found in the areas of oral reading and word- and sentence-reading fluency. When 53 of the participants were again assessed one year later, significant growth was found in their letter-word identification, sentence-reading fluency, and word-reading fluency, indicating that they had made more than one year's progress in one year's time while enrolled in a specialized program. Clinical and educational implications are addressed.

Improving reading achievement for children with hearing loss (HL) has long been a major focus of educators, speech-language pathologists, auditory-verbal therapists, and other professionals who work with this low-incidence population. Historically, children with HL have graduated high school with reading skills typically achieved by children with typical hearing by fourth grade, with many students reading well below this fourth-grade level (Allen, 1994; Traxler, 2000). Though the field of deaf education has advanced dramatically with the advent of universal newborn hearing screening and pediatric cochlear implantation, there is little recent data to suggest that reading achievement for the population of children with HL as a whole has changed significantly. Many scholars point to the historic difficulty that students with HL have had in developing phonological awareness, which is often considered a necessary skill in building independent reading skills (Paul, 2003; Trezek, Wang, & Paul, 2010). Many of today's children with HL who use listening and spoken language have had auditory access to the phonology of English since early childhood through hearing technology and auditory-based early intervention, which suggests that these children might have the potential to develop age-appropriate reading skills in elementary school. This study contributes to the documentation of current reading achievement for children with HL who receive specialized listening and spoken language intervention.

Previous research on specific areas of reading achievement has identified domains of weakness and relative strength for the population of children with HL who are learning to listen and talk. Significant differences have been found between children with HL and their age-matched peers with typical hearing on early tasks requiring phonological processing and phonological memory (Cupples, Chin, Crowe, Day, & Seeto, 2014; Goldberg & Lederberg, 2015; Halliday & Bishop, 2005; Most, Aram, & Andorn, 2006). Recent studies specifically on young children with cochlear implants (Bell, Angwin, Wilson, & Arnott, 2019) and on those who are hard of hearing (Tomblin, Oleson, Ambrose, Walker, & Moeller, 2018) have found similar delays. Word-reading accuracy in elementary-school children with HL has been shown to be delayed in some studies (Halliday, Tuomainen, & Rosen, 2017; Park, Lombardino, & Ritter, 2013) and age-appropriate in others (Spencer, Barker, & Tomblin, 2003; Tomblin et al., 2018). Few studies have specifically measured sentence- and word-reading fluency, which requires accurate word recognition as well as appropriate prosody and rate of reading. Those that have measured some area of fluency have yielded mixed results, with some finding significant differences between children with HL and their age-matched peers (Bell et al., 2019) and others finding none (Park et al., 2013; Tomblin et al., 2018).

Although historically challenging for those with degraded auditory access to master (e.g., Burden & Campbell, 1994; Gates & Chase, 1926; Sutcliffe, Dowker, & Campbell, 1999), non-word reading (i.e., word attack) and spelling recently have been shown to be areas of relative strength for children with HL, including those with cochlear implants, who use listening and spoken language (Halliday et al., 2017; Halliday & Bishop, 2005; Quick, Harrison, & Erickson, 2019). Reading comprehension, particularly of longer passages of connected text, continues to be an area of weakness for children with HL, even for those with age-appropriate skills in other areas of reading (Bell et al., 2019; Park et al., 2013). Outcomes in all areas of reading development, however, continue to vary widely.

Although children with HL often present with delays in reading achievement, several studies have found a certain longitudinal resilience in this area. Despite their delays when they enter school, many students make more progress in reading than would be expected based on their initial skills (Briscoe, Bishop, & Norbury, 2001; Fitzpatrick et al., 2012; Tomblin, 2008).

This suggests that, with intensive intervention, students with HL can begin to "catch up" to their peers with typical hearing, even if delays are still present.

Significance of the Study

Historically, collecting data on the reading achievement of large groups of children with HL was fairly straightforward, as most attended schools for the deaf that served many potential research participants. It was such research that yielded the "fourth-grade" reading statistic for children who are deaf (Allen, 1994; Traxler, 2000). Today, however, many children with HL who use listening and spoken language graduate from specialized early intervention and preschool programs by kindergarten, remaining only in specialized settings if they require intensive academic support (Bradham, Fonnesbeck, Toll, & Hecht, 2018). These listening and spoken language "graduates" spread out to attend their local mainstream programs, making data collection difficult. Several longitudinal studies have investigated the reading outcomes demonstrated by these children (Geers et al., 2017; Pimperton et al., 2016; Tomblin et al., 2018). Because the participants attended their local schools, wide variation in the type of services and nature of reading instruction they received is to be expected, although no study measured that variable directly. This study follows a unique population of children with HL: those who attend a listening and spoken language program that follows typical reading curricula and in which nearly all students, not just those who need additional support, stay through third grade. By controlling for the type and quality of reading intervention, the present study explores the current reading achievement of children with HL who use listening and spoken language. The following research questions guided the investigation:

1. What are the characteristics of the reading skills demonstrated by prekindergarten and elementary students with HL at a listening and spoken language program?

2. Is there a significant difference between initial reading achievement and skills measured one year later for children enrolled in a specialized listening and spoken language program?

Method

Setting and Participants

Participants were recruited from a large listening and spoken language program that serves children with HL from birth through fifth grade in the Southwest United States. The prekindergarten and elementary programs focus on audition to develop spoken English (and Spanish or any other language spoken in the child's home). Classroom teachers reported that they followed reading curricula developed for use with children with typical hearing, incorporating a variety of resources. The main resource was a commercially available program that aims to develop skills such as print knowledge, alphabet awareness, phonological awareness, phonemic awareness, decoding, spelling, and vocabulary development, through multi-sensory teaching techniques, direct instruction, and focused practice.

Sixty-four children with HL (28 females, 36 males) participated in the present study. Children were eligible to participate if (a) they had an identified permanent HL and used listening and spoken language to communicate, (b) they used hearing technology to access sound, and (c) they were enrolled full-time in the school's prekindergarten or early elementary (kindergarten through third grade) programs. All students who met these criteria were invited to participate, and nearly all the students consented to be included in the study. In all, 18 pre-kindergarten, 16 kindergarten, 11 first-grade, 8 second-grade, and 11 third-grade students participated.

The participants were diverse in terms of race and ethnicity, with most identifying as Latinx or Hispanic (race/ethnicity: Latinx or Hispanic: *n* = 42 , non-Hispanic white: *n* = 14, black: *n* = 5, Asian, *n* = 1, multiracial: *n* = 2). Most participants spoke primarily English (*n* = 52), primarily Spanish (*n* = 3), or a combination of both languages (*n* = 7) at home. Most children had moderately severe (*n* = 18), severe (*n* = 8), or profound (*n* = 23) hearing loss bilaterally, or in the case of unilateral loss, in the ear with hearing loss. Participants used hearing aids (*n* = 28), cochlear implants (*n* = 19), bimodal technology (hearing aid and cochlear implant; *n* = 4), or bone-conduction devices (*n* = 13). See Table 1 for additional demographic information for participants.

One year after the initial collection of data, all participants were invited to participate in the second year of the study. Of the 64 initial participants, 53 children, then in kindergarten through fourth grade, returned signed consent forms and participated again. Table 1 presents demographic information for the subset of students who participated in the second year of the study.

Procedures

Approval from Teachers College, Columbia University's Institutional Review Board was obtained prior to beginning the study. Participants' demographic data were collected through file review and access to the school's retrospective data in the Listening and Spoken Language Data Repository (Bradham, Fonnesbeck, Toll, & Hecht, 2018). The participants' reading achievement was initially evaluated during a three-day site visit. Members of the research team, all experienced teachers of the deaf or speech-language pathologists (most also certified Listening and Spoken Language Specialists), administered eight subtests of the Woodcock-Johnson IV Tests of Achievement (WJ IV; Schrank, Mather, & McGrew, 2014) to each participant. The assessments were administered individually in sound-treated therapy rooms using the participants' typical hearing technology and remote-microphone systems. Administration generally took an hour or less in total, and participants were given breaks between subtests as needed. The same assessments were administered to students who consented to participate again during another three-day site visit one year later following the same procedures.

Measures

The reading subtests of the Woodcock-Johnson IV Tests of Achievement were used to assess the participants' reading achievement. Designed for use with examinees aged 2;0 through 90+ years, the WJ IV is a standardized measure with norms developed with a sample of 7,416 individuals selected to be representative of the population of the United States as a whole (McGrew, LaForte, & Schrank, 2014). Raw scores on the WJ IV can be converted to standard scores derived from the performance of individuals of the same age or in the same grade in the normative sample. Each subtest has a mean standard score of 100, with a standard deviation of 15. Standard scores within one standard deviation of the mean (85-115) are considered to be within the average range of performance for individuals with typical hearing.

One of two parallel forms, Form A or Form B, was administered to each participant, based upon the availability of testing materials. The following eight reading subtests from the WJ IV were used in this study to measure achievement across a variety of skills:

- Letter-Word Identification, which requires examinees to identify and label letters and read increasingly difficult real words;
- Spelling, which comprises writing upper- and lowercase letters and then spelling real words presented auditorially;

- Passage Comprehension, which requires children to identify pictures that represent the main idea of short printed phrases and then to provide words that fill in the blanks in increasingly challenging printed sentences;
- Word Attack, which requires reading syllables and nonwords aloud;
- Oral Reading, which assesses examinees' fluency and accuracy in reading increasingly difficult passages aloud;
- Sentence Reading Fluency, which requires examinees to read as many sentences as they can and decide whether each is true or false within 3 minutes;
- Word Reading Fluency, in which examinees read as many groups of four words as they can and mark the pair of words that belong together within 3 minutes; and
- Reading Vocabulary, which requires examinees to provide a synonym or antonym for printed words.

The WJ IV also provides standard scores for clusters of reading skills, which measure skills demonstrated across several subtests. The present study used three clusters:

- Broad Reading, which comprehensively measures reading achievement in word reading, reading rate, and comprehension of connected text;
- Basic Reading Skills, an aggregate measure of phonics, sight vocabulary, and structural analysis; and
- Reading Fluency, an aggregate measure of automaticity, prosody, and reading accuracy (Mather & Wending, 2014).

Results

The raw scores achieved by the participants on each of the eight subtests were converted to standard scores using the WJ IV online scoring platform. Because grade-level norms were not available for the prekindergarten participants, standard scores were derived based on participants' chronological age. IBM SPSS was used to perform subsequent data analyses.

Research Question 1: What are the characteristics of the reading skills demonstrated by prekindergarten and elementary students with HL at a listening and spoken language program?

Letter-word identification. Participants achieved a mean standard score of 96.11 (*SD* = 12.04) on the Letter-Word Identification subtest of the WJ IV. On this subtest, 84.38 percent of participants (*n* = 54) performed within the average range or better, defined as a age-normed standard score of 85 or better.

Spelling. The mean standard score for participants on the Spelling subtest was 100.44 (*SD* = 12.36), and 89.06 percent of participants (*n* = 57) performed within the average range or better.

Passage comprehension. Participants' mean standard score on the Passage Comprehension subtest was 94.44 (*SD* = 12.67), with 76.56 percent of participants (*n* = 49) performing within the average range or better.

Non-word reading. Participants achieved a mean standard score of 97.52 (*SD* = 17.93) on the Word Attack subtest. On this subtest, 82.81 percent of participants (*n* = 53) performed within the average range or better.

Oral reading. The mean standard score for participants on the Oral Reading subtest was 89.89 (*SD* = 13.58), and 59.38 percent of participants (*n* = 38) performed within the average range or better.

Sentence-reading fluency. Participants' mean standard score on the Sentence Reading Fluency subtest was 87.11 (*SD* = 11.49), with 42.19 percent of participants (*n* = 27) performing within the average range or better.

Word-reading fluency. Participants achieved a mean standard score of 90.34 (*SD* = 11.18) on the Word Reading Fluency subtest, and 64.06 percent of participants (*n* = 41) performed within the average range or better.

Reading vocabulary. The mean standard score for participants on the Reading Vocabulary subtest was 91.67 (*SD* = 10.46). On this subtest, 76.56 percent of participants (*n* = 49) performed within the average range or better.

Broad reading. Participants achieved a mean standard score of 92.27 (*SD* = 11.73) on the Broad Reading cluster, a combination of the Letter-Word Identification, Passage Comprehension, and Sentence Reading Fluency subtests. On this cluster, 78.13 percent of participants (*n* = 50) performed within the average range or better.

Basic reading skills. The mean standard score for participants was 96.80 (*SD* = 13.84) on the Basic Reading Skills cluster, which combines the Letter-Word Identification and Word Attack subtests. On this cluster, 81.25 percent of participants (*n* = 52) performed within the average range or better.

Reading fluency. Participants' mean standard score was 88.66 (*SD* = 11.22) for the Reading Fluency cluster, which combines the Oral Reading and Sentence Reading Fluency subtests. On this cluster, 51.56 percent of participants (*n* = 33) performed within the average range or better.

Research Question 2: Is there a significant difference between initial reading achievement and skills measured one year later for children enrolled in a specialized listening and spoken language program?

Dependent-samples *t*-tests were performed to test whether the mean subtest and cluster standard scores in the first year differed significantly from those in the second year for the 53 students who participated in both years of data collection. Significant differences between the returning participants' first- and second-year scores for Letter-Word Identification subtest, $t(52) = -3.075$, $p = .003$. Second-year standard scores ($M = 99.04$, $SD = 12.73$) were significantly higher than first-year standard scores ($M = 96.17$, $SD = 12.24$). Significant differences were found for the Sentence Reading Fluency subtest, $t(52) = -3.366$, $p = .001$, with second-year standard scores ($M = 91.85$, $SD = 12.97$) significantly higher than first-year scores ($M = 86.94$, $SD = 11.40$). Significant differences were found for the Word Reading Fluency subtest, $t(52) = -2.620$, $p = .012$, with second-year standard scores ($M = 94.17$, $SD = 13.69$) again significantly higher than first-year scores ($M = 90.17$, $SD = 10.95$). There were also significant differences for the three clusters measured: Broad Reading, $t(52) = -4.054$, $p < .001$ ($M_{Year1} = 92.23$, $SD_{Year1} = 11.88$; $M_{Year2} = 95.74$, $SD_{Year2} = 12.37$); Basic Reading, $t(52) = -2.917$, $p = .005$ ($M_{Year1} = 96.66$, $SD_{Year1} = 14.14$; $M_{Year2} = 99.60$, $SD_{Year2} = 13.91$); and Reading Fluency, $t(52) = -2.641$, $p = .011$ ($M_{Year1} = 88.75$, $SD_{Year1} = 11.22$; $M_{Year2} = 91.92$, $SD_{Year2} = 13.44$). No significant differences between first- and second-year standard scores were found for the Spelling, Passage Comprehension, Word Attack, Oral Reading, or Reading Vocabulary subtests.

Discussion

Children with HL have historically demonstrated significant delays in reading achievement in comparison to their peers with typical hearing (e.g., Allen, 1994; Cupples, Chin, Crowe, Day, & Seeto, 2014; Park, Lombardino, & Ritter, 2013; Traxler, 2000). In contrast, on average, the diverse children in this study—all students at specialized program serving children from birth through elementary school using listening and spoken language—demonstrated reading skills within the average range based upon norms for individuals with typical hearing. The mean scores on all eight subtests and three clusters were all within one standard deviation of the normative sample's mean on the Woodcock Johnson IV Tests of Achievement, indicating performance within the average range. The participants demonstrated strongest skills in spelling, word reading, and phonics. On average, the participants demonstrated comparatively weaker skills in the areas of oral reading and word- and sentence-reading fluency, though mean performance was within the average range in comparison to children with typical hearing. These findings support the results of recent work by Bell and colleagues (2019) and Tomblin and colleagues (2018), demonstrating that children with HL who use listening and spoken language, including those with cochlear implants, can achieve age-appropriate reading skills.

While the mean scores for the study sample were within the average range for all measured areas of reading, individual participants' scores varied widely across subtests and clusters. Because means can mask these differences in performance, the percentage of participants who scored within the average range for each domain was also examined to explore areas of relative strength and challenge for most students. About 80 percent of participants performed within the average range on subtests measuring letter-word identification, spelling, passage comprehension, word reading, and reading vocabulary and in the clusters representing aggregate measures of basic-reading and broad-reading skills. Previous research has found delays in children with HL in phonological processing, including word- and non-word reading (Halliday et al., 2017; Park et al., 2013) and in reading comprehension (Bell et al., 2019).

However, the results of this study show that basic reading skills, including applying phonics skills to decode at the word level and comprehending short passages, were an area of strength for this culturally and linguistically diverse sample of children with hearing loss. Although more research in this area is needed, it is possible that the participants' use of hearing technology and enrollment in a listening and spoken language program laid the foundation for strong skills in basic reading through auditory access to the phonology of spoken English.

While the mean scores in oral reading and word- and sentence-reading fluency were within the average range for the WJ IV, fewer individual children demonstrated age-appropriate performance in these areas. Nearly 50 percent of the participants' performance in the Reading Fluency cluster, an aggregate measure of speed, accuracy, prosody, and comprehension in both silent and oral reading, was rated below average or poorer. While basic reading at the single-word and short-passage levels was a strength for most participants, some began to demonstrate considerably more difficulty when they were required to combine their decoding, vocabulary, and comprehension skills to rapidly and accurately read connected text. This suggests that children with HL who use listening and spoken language may benefit from specific interventions that target reading fluency at both the word and sentence levels.

When 53 of the study participants were assessed one year later using the same instruments, their performance demonstrated similar patterns, with strengths in such basic reading skills as spelling, word reading, and word attack and relative weaknesses in more complex skills, such as oral reading and reading fluency. Importantly, however, when second-year scores were compared to first-year scores for these participants, they had improved significantly in broad reading, basic reading, and reading fluency. They also demonstrated significant growth in letter-word identification and in word- and sentence-reading fluency.

Because standard scores are derived from examinees' chronological ages, the significant change in standard scores indicates that the children made more than one year's progress in one year's time in comparison to their peers with typical hearing. For children with HL, who often enter school with delays in listening, language, and literacy, making more than one year's progress in one year's time is critical to close academic gaps (Tomblin et al., 2018). Importantly, over one year of specialized intervention, the children in this study were able not only to "keep up" with a typical rate of reading learning, but also to begin to "catch up" to their peers with typical hearing in several key areas of reading.

Clinical and Educational Implications

While the children in the study made significant progress in their oral reading and reading fluency, their skills in these areas were still relatively weak in comparison to more basic tasks, such as decoding and spelling single words. Fluency, which Rasinski (2012) defines as "reading with and for meaning," requires both automaticity and prosody and is essential for both effective oral reading and comprehension (Pikulski & Chard, 2005). Fluent readers have the ability to devote minimal attention to decoding print and maximal attention to deriving meaning from text. As fluency acts as a bridge from word recognition to text comprehension, fluency skills may represent one of the missing links for children with HL as they work to develop reading comprehension.

Clinicians and teachers working with children with HL who use listening and spoken language should incorporate activities that explicitly target reading fluency into lessons and therapy sessions. Many fluency activities involve music, poetry, and oral language, all of which are key parts of listening and spoken language intervention. Children in prekindergarten and kindergarten can sing songs, recite poems, and participate in echo reading, matching an adult's expression and tone of voice to convey meaning. These activities should continue into early elementary school. Clinicians and teachers can also add more complex tasks that require repeated oral reading with appropriate prosody and rate, including reader's theater and poems and songs for many voices. In later elementary school and beyond, students can be expected to repeatedly read and recite authentic texts, such as famous speeches, poems, and monologues and dialogues from movies and plays. Choral reading, in which children and adults read aloud in unison, can be incorporated at any age. Increasing oral language skills, vocabulary, and knowledge of grammar at all stages will also support fluency.

Conclusion

Although past studies have highlighted the struggles that children with HL have had in learning to read, this study demonstrated that many students with HL who use listening and spoken language can achieve age-appropriate reading skills with the use of hearing technology and appropriate intervention. While the participants, on average, performed within the average range for all domains, oral reading and sentence- and word-reading fluency were relative areas of challenge. Teachers and clinicians should incorporate fluency activities that highlight automaticity, prosody, rate, and meaning into everyday instruction to build students' reading comprehension.

Future research should continue to follow participants as they begin "reading to learn" in later elementary school to track their rate of progress and explore whether areas of relative strength and challenge change as academic demands become more intense. Early factors that may influence age-appropriate reading achievement, including early intervention and technology use, oral language development, and demographic characteristics, should also be investigated. That only standardized measures of reading fluency were used in the present study may be considered a limitation; future longitudinal research might also incorporate other measures of prosody and reading rate. Data from such longitudinal research may help professionals and families lay the foundation for strong reading skills before children with HL even enter school.

References

Allen, T. E. (1994). Who are the deaf and hard-of-hearing students leaving high school and entering postsecondary education? *A comprehensive evaluation of the postsecondary educational opportunities for students who are deaf or hard of hearing, funded by the US Office of Special Education and Rehabilitative Services.* Washington, DC: Gallaudet University.

Bell, N., Angwin, A. J., Wilson, W. J., & Arnott, W. L. (2019). Reading development in children with cochlear implants who communicate via spoken language: A psycholinguistic investigation. *Journal of Speech, Language, and Hearing Research*, *62*(2), 456-469.

Bradham, T. S., Fonnesbeck, C., Toll, A., & Hecht, B. F. (2018). The Listening and Spoken Language Data Repository: Design and project overview. *Language, Speech, And Hearing Services In Schools, 49*(1), 108-120.

Briscoe, J., Bishop, D.V.M. & Norbury, C.F. (2001). Phonological processing, language, and literacy: A comparison of children with mild-to-moderate sensorineural hearing loss and those with specific language impairment. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 42*, 329–340.

Cupples, L., Ching, T. Y., Crowe, K., Day, J., & Seeto, M. (2014). Predictors of early reading skill in 5-year-old children with hearing loss who use spoken language. *Reading Research Quarterly, 49*(1), 85-104.

Fitzpatrick, E. M., Olds, J., Gaboury, I., McCrae, R., Schramm, D., & Durieux-Smith, A. (2012). Comparison of outcomes in children with hearing aids and cochlear implants. *Cochlear Implants International*, *13*(1), 5-15.

Geers, A. E., Mitchell, C. M., Warner-Czyz, A., Wang, N. Y., Eisenberg, L. S., & CDaCI Investigative Team. (2017). Early sign language exposure and cochlear implantation benefits. *Pediatrics*, *140*(1), e20163489.

Goldberg, H. R., & Lederberg, A. R. (2015). Acquisition of the alphabetic principle in deaf and hard-of-hearing preschoolers: The role of phonology in letter-sound learning. *Reading and Writing*, *28*(4), 509-525.

Halliday, L. F., & Bishop, D. V. M. (2005). Frequency discrimination and literacy skills in children with mild to moderate sensorineural hearing loss. *Journal of Speech, Language, and Hearing Research, 48*(5), 1187-1203.

Halliday, L. F., Tuomainen, O., & Rosen, S. (2017). Language development and impairment in children with mild to moderate sensorineural hearing loss. *Journal of Speech, Language, and Hearing Research*, *60*(6), 1551-1567.

Mather, N., & Wendling, B. J. (2014). Examiner's Manual. *Woodcock-Johnson IV Tests of Achievement.* Rolling Meadows, IL: Riverside.

Most, T., Aram, D., & Andorn, T. (2006). Early literacy in children with hearing loss: A comparison between two educational systems. *The Volta Review*, *106*(1), 5-28.

Park, J., Lombardino, L. J., & Ritter, M. (2013). Phonology matters: A comprehensive investigation of reading and spelling skills of school-age children with mild to moderate sensorineural hearing loss. *American Annals of the Deaf*, *158*(1), 20-40.

Paul, P. (2003). Processes and components of reading. In M. Marschark & P. Spencer (Eds.), *Handbook of deaf studies, language, and education* (pp. 97–109). New York: Oxford University Press.

Pikulski, J.J., & Chard, D.J. (2005). Fluency: Bridge between decoding and reading comprehension. The Reading Teacher, *58*(6), 510–519.

Pimperton, H., Blythe, H., Kreppner, J., Mahon, M., Peacock, J. L., Stevenson, J., ... & Kennedy, C. R. (2016). The impact of universal newborn hearing screening on long-term literacy outcomes: a prospective cohort study. *Archives of Disease in Childhood*, *101*(1), 9-15.

Quick, N., Harrison, M., & Erickson, K. (2018). A multilinguistic analysis of spelling among children with cochlear implants. *Journal of Deaf Studies and Deaf Education*, *24*(1), 41-53.

Rasinski, T. V. (2012). Why reading fluency should be hot!. *The Reading Teacher*, *65*(8), 516-522.

Schrank, F. A., Mather, N., & McGrew, K. S. (2014). *Woodcock-Johnson IV Tests of Achievement*. Rolling Meadows, IL: Riverside.

Spencer, L. J., Barker, B. A., & Tomblin, J. B. (2003). Exploring the language and literacy outcomes of pediatric cochlear implant users. *Ear and Hearing*, *24*(3), 236.

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2018). Early literacy predictors and second-grade outcomes in children who are hard of hearing. *Child Development*, 1-19.

Traxler, C. B. (2000). Measuring up to performance standards in reading and mathematics: Achievement of selected deaf and hard-of-hearing students in the national norming of the 9th Edition Stanford Achievement Test. *Journal of Deaf Studies and Deaf Education*, *5*(4), 337-348.

Trezek, B., Wang, Y., & Paul, P. (2010). *Reading and deafness: Theory, research and practice*. Clifton Park, NY: Cengage Learning.

Table 1

Demographic Characteristics of Participants

Characteristics		Year 1 (*N* = 64)	Year 2 (*N* = 53)
Sex	Female	28 (43.8%)	25 (47.2%)
	Male	36 (56.3%)	28 (52.8%)
Grade	Prekindergarten	18 (28.1%)	0
	Kindergarten	16 (25.0%)	14 (26.4%)
	1st grade	11 (17.2%)	14 (26.4%)
	2nd grade	8 (12.5%)	10 (18.9%)
	3rd grade	11 (17.2%)	6 (11.3%)
	4th grade	0	9 (17.0%)
Race/ethnicity	Latinx or Hispanic	42 (65.6%)	35 (66.0%)
	Non-Hispanic White	14 (21.9%)	11 (20.8%)
	Black	5 (7.8%)	4 (7.4%)
	Asian	1 (1.6%)	1 (1.9%)
	Multiracial	2 (3.1%)	2 (3.8%)
Primary home language	English	52 (81.3%)	43 (81.1%)
	Spanish	3 (4.7%)	3 (5.7%)
	English and Spanish	7 (10.9%)	6 (11.3%)
	English and Other Language	2 (3.1%)	1 (1.9%)
Degree of hearing loss in poorer ear	Mild	3 (4.7%)	3 (5.7%)
	Moderate	12 (18.8%)	8 (15.1%)
	Moderately severe	18 (28.1%)	14 (26.4%)
	Severe	8 (12.5%)	5 (9.4%)

	Profound	23 (35.9%)	23 (43.4%)
Type of hearing loss in poorer ear	Sensorineural	50 (78.1%)	42 (79.2%)
	Conductive	11 (17.2%)	10 (18.9%)
	Mixed	3 (4.7%)	1 (1.9%)
Type of hearing technology	Hearing aid(s)	28 (43.8%)	19 (35.8%)
	Cochlear implant(s)	19 (29.7%)	19 (35.8%)
	Bimodal (hearing aid and cochlear implant)	4 (6.3%)	4 (7.5%)
	Bone-conduction device	13 (20.3%)	11 (20.8%)

Table 2

Participants' Standard Subtest and Cluster Scores

WJ IV Measure	Year 1 (*N* = 64)		Year 2 (*n* = 53)	
	M	*SD*	*M*	*SD*
Letter-Word Identification subtest	96.11	12.04	99.04	12.73
Spelling subtest	100.44	12.36	101.28	13.05
Passage Comprehension subtest	94.44	12.67	97.09	12.03
Word Attack subtest	97.52	17.93	100.25	16.74
Oral Reading subtest	89.89	13.58	93.17	15.04
Sentence Reading Fluency subtest	87.11	11.49	91.85	12.97
Word Reading Fluency subtest	90.34	11.18	94.17	13.69
Reading Vocabulary subtest	91.67	10.46	90.55	12.51
Broad Reading cluster	92.27	11.73	95.74	12.37
Basic Reading cluster	96.80	13.84	99.60	13.91
Reading Fluency cluster	88.66	12.22	91.92	13.44

Notes. WJ IV = Woodcock-Johnson IV Tests of Achievement. Standard scores derived from age norms.

Chapter 5

Discussion of the Studies

This dissertation comprised three studies exploring the trajectory of early language and reading development for children with hearing loss (HL) who used listening and spoken language (LSL). The first study investigated the strategies employed by parents to initiate and continue conversations with their preschool children with HL during dinnertimes in their natural home environments and related this strategy usage to children's receptive vocabulary. The second study used a longitudinal lens to explore the relations among the complexity of parents' early language input to their preschool children with HL, the complexity of children's early language output, and the children's development of receptive vocabulary, including basic concepts, over one year. Finally, the third study examined the reading achievement of children with HL when they entered formal schooling, finding areas of strength and challenge, and investigating the progress demonstrated by these children after one year in a specialized school environment. The findings from these studies shed light on the complex interplay between early linguistic stimulation experienced by children with HL in their natural environments and children's development first of listening and spoken-language skills and then of the phonology, fluency, and comprehension skills needed for early reading success.

Conversation Techniques

Parents of children with HL who have chosen to teach them to listen and talk are coached to enrich their language input as much as possible throughout their daily activities in the home (Morrison, 2017). Previous research with both children with HL and those with typical hearing has highlighted the critical role of conversational turns, rather than the sheer quantity of words provided to the child, in later language development (e.g., Ambrose, VanDam, & Moeller, 2014;

Dykstra et al., 2013; Oller, et al., 2010). As a result, parents and professionals are often encouraged to use open-ended language elicitations and reformulations of children's utterances to initiate and maintain shared conversation, while also providing experiences with new vocabulary words in a variety of contexts. While teachers' use of these techniques has been studied in formal classroom settings (Duncan & Lederberg, 2018), to our knowledge, this was the first study to examine parents' use of conversation strategies using naturalistic, daylong recordings of home environments. Transcription and hand-coding of 20-minute dinnertime segments for each of the 37 preschool participants with HL revealed wide variation in parents' use of techniques during dinnertime conversations. Closed-ended language elicitation and directives were used most frequently during dinner, with less-frequent instances of reformulation, open-ended elicitation, imitation, and explicit vocabulary instruction. No parents used explicit grammar instruction. When the children's receptive vocabulary and knowledge of basic concepts were examined in relation to parents' strategy usage, two relations emerged: open-ended language elicitation related to general receptive vocabulary, and explicit vocabulary instruction related to basic concepts. Thematic analysis of the conversations found concrete conversation topics and siblings speakers across the dinnertime transcripts, with conversations with many instances of open-ended elicitation and reformulation also covering abstract topics of conversation. The transcripts with few instances of these higher-level conversation techniques included frequent use of electronic media throughout dinnertime.

Complexity of Language Input and Longitudinal Outcomes

In addition to being educated on strategies to elicit language from their children, parents of children with HL who participate in specialized LSL interventions are also often coached to make their own language input as frequent and grammatically rich as possible (Moeller, Carr, Seaver, Stredler-Brown, & Holzinger, 2013). Previous research has highlighted the importance of using child-directed speech that is syntactically and clausally complex, and lexically diverse, on the long-term vocabulary and language outcomes of young children with typical hearing (e.g., Cristofaro & Tamis-LeMonda, 2012; Hoff & Naigles, 2002; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). The second study in this dissertation collected two naturalistic, daylong recordings from 14 preschoolers with HL who used LSL one year apart. At each time point, 20-minute dinnertime conversations were transcribed and coded for the syntactic complexity, clausal complexity, and lexical diversity of both parents' and children's utterances. The quantity of adult words and conversational turns provided by parents throughout the day did not change significantly from the initial recording to the follow-up recording, supporting previous findings that the quantity of home language input is static over time (Ambrose, Walker, Unflat-Berry, Oleson, & Moeller, 2015; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). In contrast to previous findings for children with typical hearing (Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007), however, the participants with HL in this study were not exposed to more complex language at follow-up than they were one year earlier, suggesting that the parents had not increased the complexity of their language input as their children aged. Children's receptive vocabulary and knowledge of basic concepts were also measured, and scores were found to be within one standard deviation of the tests' normative means at each time point. A significant relation was found between the initial clausal complexity of children's utterances and their general receptive vocabulary one year later, while the initial syntactic complexity of the children's language related to their knowledge of basic concepts at follow-up.

Reading Achievement

For children with HL who are learning to listen and talk, parents and professionals focus on language stimulation and oral language development during early childhood in preparation for formal schooling, when children are expected to apply their oral language skills to the written word as they learn to read. Learning to read has historically been a struggle for children with HL, many of whom did not have sufficient auditory access to speech to develop the phonological and vocabulary skills that are considered prerequisites for appropriate reading development (Trezek, Wang, & Paul, 2010). Today's children with HL who use cutting-edge technology to learn LSL and whose early intervention enriched their home language environments with complex input and effective conversation strategies, however, may show marked improvement over historical trends, though only a few recent longitudinal studies have focused on these children (Geers et al., 2017; Pimperton et al., 2016; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2018). The third study in this dissertation assessed the skills of 64 children with HL in prekindergarten through third grade across eight areas of reading. Participants' mean scores for all eight subtests were within one standard deviation of the normative mean for age-matched children with typical hearing, with relative strengths found in basic reading skills, such as spelling, word and non-word reading, and passage comprehension. Relative weaknesses were found in oral reading and word- and sentence-reading fluency, though these scores were also considered to be in the average range. When 53 of the participants were assessed one year later, significant increases in their standard scores were found in letter-word identification and fluency, as participants made more than one year's progress in one year's time while attending a specialized, LSL-focused elementary program.

Clinical and Educational Implications

The findings of these dissertation studies affirm many of the practices already used by parents and professionals in their work with children with HL who use LSL. The deleterious effects of electronic media on language learning in young children have become well known through recent research (e.g., Ambrose et al., 2014; Duch et al., 2013), and parent coaching in LSL programs often coaches parents to turn off auditory and visual distractions in the home, particularly during language-rich times, like meals. The dinnertime transcripts with high levels of electronic media in the first study had few to no instances of conversation strategies, supporting this advice and suggesting that some parents may benefit from additional support in reducing their children's exposure to television and tablets. Open-ended language elicitation and explicit vocabulary instruction, on the other hand, should be encouraged, as both related to greater receptive vocabulary and basic-concepts skills. While open-ended language elicitation occurred less frequently than closed-ended elicitation in the dinnertime samples, its characteristics—*wh*-questions, broad comments, invitations for multi-word responses—are probably familiar to most parents. Explicit vocabulary instruction may not be as familiar, as it may be considered a didactic strategy for formal instruction in the classroom. However, several parents in the first study introduced a number of new words using explicit vocabulary instruction during dinnertime conversations with their children with HL. Other parents might benefit from modeling and coaching on how to embed this technique in natural conversation through labeling novel items, providing child-friendly definitions, and affirming children's own definitions. An increased use of these explicit-instruction strategies should increase children's fund of vocabulary relevant to their family life and culture and may improve their knowledge of the basic concepts necessary for academic success.

Coaching parents to increase their use of explicit vocabulary instruction and open-ended prompts may also support them in increasing the complexity of the language input they provide to their children with HL who use LSL. While parents of children with typical hearing have been shown naturally to increase the complexity with which they combine syntactic elements, clauses, and diverse words as their children grow, the parents in the second study provided consistent levels of linguistic complexity in dinnertime recordings one year apart. It is possible that these parents began providing input that was appropriately complex for their toddlers when they received family-centered early-intervention services, but did not add additional complexity when their children entered preschool, when services are generally geared more directly to the child. Parents of children with HL of all ages might benefit from continued intervention designed to help them enrich their children's language environment at home, particularly during routine activities, like mealtimes. This coaching might empower families to maintain high expectations for their children's auditory development by continually increasing the complexity of their language input, thereby increasing children's vocabularies and knowledge of basic concepts by the end of preschool.

These improved vocabulary and language skills may mean that children with HL are then even better prepared to learn to read when they enter formal schooling experiences. While the children in the third study, on average, demonstrated reading achievement that was much closer to age appropriate than have children with HL in historical studies, their skills in oral reading and reading fluency were weaker than their phonological, spelling, and other basic reading skills. This suggests that parents and professionals might benefit from support in developing fluency in children with HL even before they begin elementary school. Many of the evidence-informed strategies recommended to build fluency skills in children with typical hearing match well with the focus on early language input and conversational turn-taking in LSL intervention for children and families. Singing, recitation of age-appropriate poetry, and choral reading of familiar texts may not only develop prosody and fluent word retrieval, but also expose children to more complex language and more diverse vocabulary than parents might typically produce on their own. Similarly, echo reading and reader's theater may not only provide opportunities to listen to and repeat an adult's fluent oral reading, but also reinforce the serve-and-return conversational turns that may lead to greater language growth. These activities may also introduce new topics of discussion, and opportunities for parents to use higher-level conversation techniques, during mealtimes and other home routines. Enhancing the language and literacy environments experienced by children with HL throughout early childhood and elementary school may help close the historical gap in language and academic skills between these children and their peers with typical hearing.

Future Directions

These dissertation studies began to answer many questions that researchers and clinicians have had about the relations among language input and language and literacy development for children with HL who use LSL; they also suggest many avenues for future exploration. The first two studies focused on dinnertimes in the home as routine periods that might provide many opportunities for parent-child conversations, but other time periods would also provide interesting data to compare and contrast. Future studies might transcribe and code breakfast, lunch, playtime, bathtime, or book reading in the home, or comb recordings for errands and other activities that took parents and children away from the home together. These periods might be found to have more or fewer instances of conversation techniques or more or less complex language input. Comparing the results with the findings of these studies would help inform professionals in coaching parents to enrich their language input throughout the day. Future research might also combine these other periods with dinnertime, or record multiple dinnertimes within a short period, to provide a fuller, more nuanced picture of the home language environment experienced by each participant.

Sibling speakers represented an important theme in the first study's dinnertime conversations. Future studies might look more closely at the techniques used by children to initiate and maintain topics of conversation with their siblings with HL during home routines. The influence of siblings on the children's language development, as well as their on the complexity and diversity of language used by their parents, warrants further research with the specific population of young children with HL who use LSL. Interventions specifically designed to increase the quality and quantity of language input provided by parents and siblings might also be designed and tested in future studies.

Finally, the results of the third study suggest that today's children with HL who use LSL can achieve age-appropriate reading skills in early elementary school, but achievement did vary among the participants. Future research should focus on the variables that influence this variation in order to identify fixed and flexible factors in a child's early life that predict grade-level reading achievement by third grade. It is possible that home language environment, including the conversation strategies and complex language used by parents, influence reading outcomes. Early identification, use of hearing technology, and intervention may also play a role, as may listening and oral language skills during early childhood. Future research might investigate these factors longitudinally to build a model of reading success for children with HL who use LSL. Such a model would inform practices in family-centered intervention as parents and professionals develop the prerequisites for literacy beginning in infancy.

References

Ambrose, S. E., VanDam, M., & Moeller, M. P. (2014). Linguistic input, electronic media, and communication outcomes of toddlers with hearing loss. *Ear & Hearing*, *35*(2), 139-147.

Ambrose, S. E., Walker, E. A., Unflat-Berry, L. M., Oleson, J. J., & Moeller, M. P. (2015). Quantity and quality of caregivers' linguistic input to 18-month and 3-year-old children who are hard of hearing. *Ear and Hearing*, *36*(0 1), 48S.

Cristofaro, T. N., & Tamis-LeMonda, C. S. (2012). Mother-child conversations at 36 months and at pre-kindergarten: Relations to children's school readiness. *Journal of Early Childhood Literacy*, *12*(1), 68-97.

Duch, H., Fisher, E. M., Ensari, I., Font, M., Harrington, A., Taromino, C., ... & Rodriguez, C. (2013). Association of screen time use and language development in Hispanic toddlers: a cross-sectional and longitudinal study. *Clinical Pediatrics*, *52*(9), 857-865.

Duncan, M. K., & Lederberg, A. R. (2018). Relations between teacher talk characteristics and child language in spoken-language deaf and hard-of-hearing classrooms. *Journal of Speech, Language, and Hearing Research*, *61*(12), 2977-2995.

Dykstra, J. R., Sabatos-DeVito, M. G., Irvin, D. W., Boyd, B. A., Hume, K. A., & Odom, S. L. (2013). Using the Language Environment Analysis (LENA) system in preschool classrooms with children with autism spectrum disorders. *Autism*, *17*(5), 582-594.

Geers, A. E., Mitchell, C. M., Warner-Czyz, A., Wang, N. Y., Eisenberg, L. S., & the CDaCI Investigative Team. (2017). Early sign language exposure and cochlear implantation benefits. *Pediatrics*, *140*(1), e20163489.

Hoff, E. & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development, 73*(2), 418-433.

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

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

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

Moeller, M. P., Carr, G., Seaver, L., Stredler-Brown, A., & Holzinger, D. (2013). Best practices in family-centered early intervention for children who are deaf or hard of hearing: An international consensus statement. *Journal of Deaf Studies and Deaf Education*, *18*(4), 429-445.

Morrison, H. M. (2017) Home visits—Service delivery in the natural environment. In E. A. Rhoades & J. Duncan (Eds.), *Auditory-verbal practice: Family-centered early intervention* (pp. 266-277). Springfield, IL: Charles C. Thomas.

Oller, D. K., Niyogi, P., Gray, S., Richards, J. A., Gilkerson, J., Xu, D., ... & Warren, S. F. (2010). Automated vocal analysis of naturalistic recordings from children with autism, language delay, and typical development. *Proceedings of the National Academy of Sciences*, *107*(30), 13354-13359.

Pimperton, H., Blythe, H., Kreppner, J., Mahon, M., Peacock, J. L., Stevenson, J., ... & Kennedy, C. R. (2016). The impact of universal newborn hearing screening on long-term literacy outcomes: a prospective cohort study. *Archives of Disease in Childhood*, *101*(1), 9-15.

Tomblin, J. B., Oleson, J., Ambrose, S. E., Walker, E. A., & Moeller, M. P. (2018). Early literacy predictors and second-grade outcomes in children who are hard of hearing. *Child Development*, 1-19.

Trezek, B., Wang, Y., & Paul, P. (2010). *Reading and deafness: Theory, research and practice*. Clifton Park, NY: Cengage Learning.