Language ENvironment Analysis (LENA) with children with hearing loss: A clinical pilot

Le système LENA (Language ENvironment Analysis) chez des enfants ayant une perte auditive : une étude clinique pilote

KEY WORDS
LANGUAGE ENRICHMENT ANALYSIS
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Abstract

The provision of an enriched learning environment is widely advocated to facilitate language acquisition for children with hearing loss. In recent years the Language ENvironment Analysis (LENA) system was designed to collect information in a child's environment via a child-worn recording device, to acoustically analyze the listening/linguistic environment and to analyze variables such as child vocalizations, conversational turn taking, and adults words spoken to a child. This pilot study was undertaken in a clinical program to examine the feasibility of implementing the LENA system as part of the clinical program. Two full-day language recordings using the LENA device were collected for five children with hearing loss enrolled in a listening and spoken language program in a Canadian pediatric hospital. Overall, parents felt that the device was easy to use and that it could be incorporated into the home environment. Useful information was collected about the child's acoustic environment and about exposure to spoken language in the home. Based on the results of this pilot study, the LENA device has been implemented as a clinical tool to assist in coaching families about their child's learning environment.

Abrégé

L'apport d'un environnement d'apprentissage enrichi est largement préconisé pour faciliter l'acquisition du langage des enfants ayant une perte auditive. Au cours des dernières années, le système LENA (Language ENvironment Analysis) a été conçu pour recueillir des informations à propos de l'environnement d'un enfant par l'intermédiaire d'un appareil d'enregistrement qui est porté par l'enfant. Ce système permet d'analyser acoustiquement l'environnement d'écoute/linguistique et d'analyser des variables, telles que les vocalisations de l'enfant, le tour de parole en conversation et les mots utilisés par les adultes avec l'enfant. Cette étude pilote a été amorcée dans un programme clinique pour examiner la faisabilité de l'implantation du système LENA dans ce programme. Le langage de cinq enfants ayant une perte auditive et qui étaient inscrits au programme d'écoute et de langage oral d'un hôpital pédiatrique canadien a été recueilli pendant deux journées complètes à l'aide de l'appareil LENA. Dans l'ensemble, les parents ont eu le sentiment que l'appareil était facile à utiliser et qu'il pourrait être incorporé dans l'environnement de la maison. Des informations utiles quant à l'environnement acoustique de l'enfant et son exposition au langage oral à la maison furent recueillies. À partir des résultats de cette étude pilote, l'appareil LENA a été implanté comme outil clinique afin d'encadrer les familles quant à l'environnement d'apprentissage de leur enfant.

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Introduction

Language sampling is widely used in clinical assessment and research programs for collecting information regarding a child's spontaneous speech and language in an unstructured environment. Language sampling typically involves eliciting one sample of a child's utterances over a short duration in a developmentally appropriate interaction. Formal language analyses typically require a sample of 100 continuous utterances that are judged to be representative of the child's expressive language. However, obtaining a typical language sample from a child during a speech-language pathology evaluation or intervention session can be a challenging task, and it is unclear if the sample collected is truly reflective of the child's language abilities. Various factors can interfere with obtaining a valid natural language sample including the presence of new people, unfamiliar surroundings, the materials used, the topic of conversation, as well as child factors such as fatigue and lack of interest.

Through an influential study that involved extensive and long-term language sampling in the home setting, Hart and Risley (1995) drew attention to the dramatic consequences that a young child's family and learning environment have on language acquisition. In their 3-year longitudinal study of 42 children, the investigators showed that children's verbal abilities were highly related to the amount their parents talked to them in the early years. Socio-economic status was also an important predictor of language abilities. Furthermore, at age 9 years, the academic abilities of children in this study were related to how much their parents talked to them in their first three years. In addition to these important findings, this study highlighted the value of collecting extensive language experiences in naturalistic environments.

In response to these findings, a new Language Environment Analysis system (LENA) was developed in 2004 through the LENA Foundation to help overcome some of the difficulties involved both in obtaining representative data from young children and in conducting detailed analyses of language samples (http://www.lenafoundation.org). The LENA system was specifically designed to allow data collection of continuous speech over an extended period in a natural environment for children ages two months to six years. Accordingly, the system offers a means of acquiring a more representative sample of a child's language abilities. The LENA system comprises two distinct components: the recording hardware and the processing software. The LENA Digital Language Processor (DLP) is a small, lightweight digital recorder that fits into the front pocket of specially designed LENA children's clothing and permits up to 16 hours of audio recording. The recording is subsequently uploaded to a computer for processing through the language analysis software. The processing software analyzes the language environment and provides the user with numerical and graphical data. Details regarding the specific environmental and linguistic components that are analyzed are provided in the methods section of this paper. In addition to the different data analyses that the LENA software can provide, normative data are also available and allow for comparison of a given language sample with typically developing peers. Normative data based on 2,682 hours of recordings for children 2 to 48 months of age with normal hearing and typical development are available in a LENA Foundation technical report (Gilkerson & Richards, 2008).

LENA has been used in several applications to examine language acquisition including with pre-term infants (Caskey, Stephens, Tucker, & Vohr, 2011) and children with autism spectrum disorders (Dykstra et al., 2013; Oller et al., 2010; Xu, Gilkerson, Richards, Yapanal, & Gray, 2009). The system has been found to be useful in identifying important factors influencing language development (Xu et al., 2009; Zimmerman et al., 2009), and in providing feedback to parents (Suskind et al., 2013). These studies suggest that LENA helps parents learn more about their children's learning environment and their own spoken language interactions with their children.

Given the importance of the auditory learning environment for young children with hearing loss, who are developing spoken language, LENA recordings can potentially contribute important clinical information. Research examining the acoustic and linguistic environments with this population of children is beginning to emerge. Aragon and Yoshinaga-Itano (2012) used the LENA technology to examine the language environment of 10 children with hearing loss in Spanish-speaking homes in Colorado and to compare their environments to those of children with hearing loss in English-speaking homes as well as those with normal hearing in Spanish- and in English-speaking homes. These researchers showed that the learning environments for children with hearing loss from Spanish-speaking homes and normal hearing English-speaking children were relatively similar in terms of the LENA variables analyzed (e.g., child vocalizations, adults words, conversational turn taking) whereas children with normal hearing in Spanish-speaking homes had access to less language-rich learning environments. The authors suggested that the LENA system was useful in helping parents understand their child's access to language in real-world environments.

In a study that compared adult input to 22 children with hearing loss who were receiving intervention and 8 children with normal hearing, VanDam, Ambrose, and Moeller (2012) found adult word counts and conversational turns to be comparable. Using the LENA recorder, Vohr (2013) has recently reported a positive association between children's auditory and linguistic environment at home and receptive and expressive language skills measured at school age. Taken together, these studies suggest promising applications of the LENA device not only as a research tool but also as a clinical tool to assist with education and coaching in family-centred intervention programs for children with hearing loss.

The pilot study described in this report was conducted in collaboration with the Children's Hospital of Eastern Ontario Audiology Clinic. The clinic had recently acquired a LENA system and the clinicians were interested in potentially adopting the technology as an assessment and parent guidance tool. The clinicians were therefore interested in exploring the feasibility and utility of these devices and whether parents would accept the recording device when it was incorporated into the intervention program. In addition, we felt it was important to collect preliminary information in the clinical setting prior to starting a larger-scale clinical study in the therapy program. This study had two main objectives: 1) to explore the feasibility of collecting meaningful language samples with the LENA system through a clinical program, and 2) to describe the vocalizations and speech productions of a group of children with hearing loss. We were interested in investigating the practicality for parents, ease of using the recording device, and whether the device was functioning during the planned recording times. Specifically, we sought to examine parents' ability to use the device correctly, turn it on and off accordingly, and pause recordings during naptime, car rides, water activities, and other instances that are inappropriate for recording. Data collected from the recordings were also used to analyze and describe the children's vocalizations and adults' speech. Specifically, for this study, the auditory environment, child vocalizations, conversational turn taking, and adult word counts were analyzed through the LENA software program.

Methods

Participants

Participants were recruited through the Children's Hospital of Eastern Ontario Audiology Program. The hospital services a population of approximately 1 million and is the regional diagnostic center for all children who undergo newborn hearing screening. The Program offers publicly funded early intervention services emphasizing listening and spoken language development to all children of pre-school age with hearing loss. The inclusion criteria for this study were a permanent hearing loss, as well as English and/or French spoken in the home so that the sample could be collected in the home environment. The Research Ethics Boards of the Children's Hospital of Eastern Ontario and the University of Ottawa approved the study. Parents signed a written consent form for participation in the study.

All eligible families were informed of the study by their clinician and given the option to participate. Seven parents initially gave consent to be contacted about the study. Although all seven initially agreed to participate, one family later informed investigators that the time commitment would be too great for the family at the time. Another family who initially enrolled in the study was unable to continue due to timing difficulties, leaving five participants contributing recordings for the pilot study. In accordance with ethics procedures, these two families were not questioned further about their reasons for declining to participate in the study.

Table 1 shows the clinical characteristics of the five participants in the study. The children included two males and three females, ranging in age from 2.4 to 5.8 years at data collection. All but one child (L=06) had undergone newborn hearing screening. The children ranged in age from 3 months to 2 years, 8 months at identification of hearing loss. Two children had congenital or early onset sensorineural hearing loss (less than 6 months) while the remaining three had delayed onset loss. All children had bilateral hearing loss and two of the five had a documented progressive hearing loss. Severity of hearing loss ranged from mild to profound dB (based on better ear pure-tone average at 500, 1000, and 2000 Hz) at the time of recording. All children used binaural hearing aids except one child, who wore a unilateral cochlear implant combined with a hearing aid in the contralateral ear. No child presented with other known disabilities. The children did not undergo a formal cognitive assessment but there were no clinical concerns about developmental or cognitive development for any of the children. All children received auditory-verbal therapy regularly, (weekly or bi-weekly) in the Audiology Program and all were in English-speaking homes. In an auditory-verbal intervention approach, parents participate directly in clinical sessions with their child, where the primary goal is to teach parents how to develop their child's listening and spoken language abilities by integrating language into the child's natural learning environments. Parents are therefore coached extensively on how to provide an optimal and quiet learning environment and are

Table 1. Clinical characteristics of children

ID	Age	Sex	Onset	Age at Identification (years, months)	Age at HA Fitting (years, months)	Progressive HL	Current dB HL-PTA (better ear)	Etiology
L-01	2-4	F	Late onset	1-4	1-6	Yes	66.7	Familial
L-02	2-8	F	Congenital	0-3	0-11	No	26.7	Familial
L-03	5-8	M	Early onset	0-10	1-10	No	31.7	Familial
L-04	3-4	F	Late onset	2-8	2-9	No	70	Genetic
L-06	3-9	M	Late onset	1-10	HA: 1-10 CI: 2-5	Yes	120	Unknown

Key: HA: hearing aid(s); CI: Cochlear implant(s); HL: Hearing loss; PTA: Pure-tone average; early onset: < 6 months

provided with specific techniques to develop their child's listening skills and to facilitate oral language development (Estabrooks, 2006; Fitzpatrick & Doucet, 2013).

Procedures

The families were asked to commit to two to three recording days over a two-month period. At study enrolment, one of the researchers, a speech-language pathology graduate student or the clinician providing services to the child, explained proper wearing and functioning of the LENA Digital Language Processor (DLP) to the parents, including asking parents to have the child wear the recorder in the special LENA clothing. Parents were also provided with an instruction sheet to guide them in using the device and with contact numbers in case further assistance was required. Parents were informed that they had the option of requesting that sections of the data be deleted if they were uncomfortable with exposing certain information from home on the particular recording day. The children wore a LENA DLP device on their recording days.

All of the recordings were collected in the child's home environment. The data collected from the LENA DLP device were analyzed by downloading the recordings to a computer where a specialized LENA software program automatically performed the analysis. The quality of the recording was examined to determine if the device was being worn correctly. In addition, parents were asked to complete a daily activity log on their child's recording day as well as a brief written feedback questionnaire at the end of the study. The purpose of the brief eight-item questionnaire was to collect parents' comments regarding ease of use, their child's response, and any difficulties encountered. In addition, parents were asked to comment on whether the recording day seemed to represent a typical day for the child and family. Parent responses were summarized qualitatively.

Recordings included all vocalizations produced by the child wearing the DLP and all externally-sourced sounds and speech activity within an approximate 4-6 foot radius. This unobtrusive approach to data sampling permitted the collection of naturalistic full-day recordings from the child's home language environment.

The LENA system processed and allowed for extensive analyses of the samples. The analyses provided key language environment statistics related to the child's auditory environment, child vocalizations, conversational turns, and the number of adult words spoken on the recording day. All data collected from the recordings were compared to normative data collected for typically developing children with normal hearing provided by the

LENA Foundation (http://www.lena-foundation.org). The LENA Foundation normative database provides information according to age categories (2 months to 48 months of age) based on 32,000 hours of recording on 329 children in English-speaking households in the United States. A full description of the English data collection process is found in a LENA Foundation technical report titled "Natural Language Study" (Gilkerson & Richards, 2008).

Following the recordings and analysis, the clinician providing services to the child, in consultation with the graduate student when technical expertise was required, provided feedback to the parent during a regular therapy session. This involved interpreting the LENA data and sharing the results of the recordings with the parent. Details about the specific information captured by the LENA program are provided below.

- Auditory environment: Auditory components captured by the LENA DLP in the home environment and described by the LENA Foundation include:
    - Television/electronic devices: the number of minutes or hours that a child is exposed to television/electronic devices during the recording period.
    - Noise: the number of minutes or hours that rattles, bumps, and other non-human signals are captured during the recording period.
    - Silence and background noise: the number of minutes or hours that a child is exposed to silence, quiet, or vegetative sounds during the recording period. The latter include common sounds such as laughing, burping, and coughing. Sounds fall in this category if they are under 32 dB SPL.
    - Meaningful speech: the number of minutes or hours that a child is exposed to distinguishable speech (babble, words, and protophones (squeals, raspberries, etc.) during the recorded time period.
    - Distant speech: the number of minutes or hours that a child is exposed to speech produced from six feet away or more. Over-lapping speech in child and adult conversations during the recording is also included in this category on the basis that the adult's speech is not available to the child during these periods.
- Child vocalizations: the number of vocalizations produced by the child during the recording period. Vocalizations consist of continuous speech segments (e.g., babble, words, or pre-speech sounds).
- Conversational turns: the number of conversational turns, or vocal interactions between the adult and the child where one speaker initiates and the other responds within five seconds. These interactions can include a variety of vocalizations including cooing, babble, and words.
- Adult words: the number of adult words spoken to the child during the recording period.

Data collected for this study

Two 16-hour samples of continuous data were collected from each participant, resulting in a total of 132 hours of recordings for analysis. Participant L-06 provided three recordings; however, for the purpose of this study, consistent with the number of data points for the remaining children, only the first two recordings were used. Following data extraction from the LENA recorder, characteristics of the auditory environment, adult word counts, child vocalizations, and conversational turns were analyzed and compared across participants and between the two recordings for each participant. Given the small number of children, all analyses are presented descriptively.

Results

Auditory environment

Results for the auditory environment are provided below in accordance with the categories that are analyzed by the LENA software. The auditory environment is divided into five categories in the LENA software: 1) TV and electronic sounds, 2) noise, 3) silence and background noise, 4) meaningful speech, and 5) distant speech. For the presentation of results, we have combined the first three environmental sounds categories.

TV/electronic sounds, noise, and silence

Figure 1 shows the amount of time in minutes and seconds that TV and electronic sounds (combined), noise, and silence and background noise (combined) were captured on the first recording for all participants. Only data from the first day are presented due to the similarity between the first and second recordings. Data across each of the categories are similar among participants. Exposure to television ranged from 20 minutes (3rd percentile according to LENA normative data) to 1 hour, 20 minutes

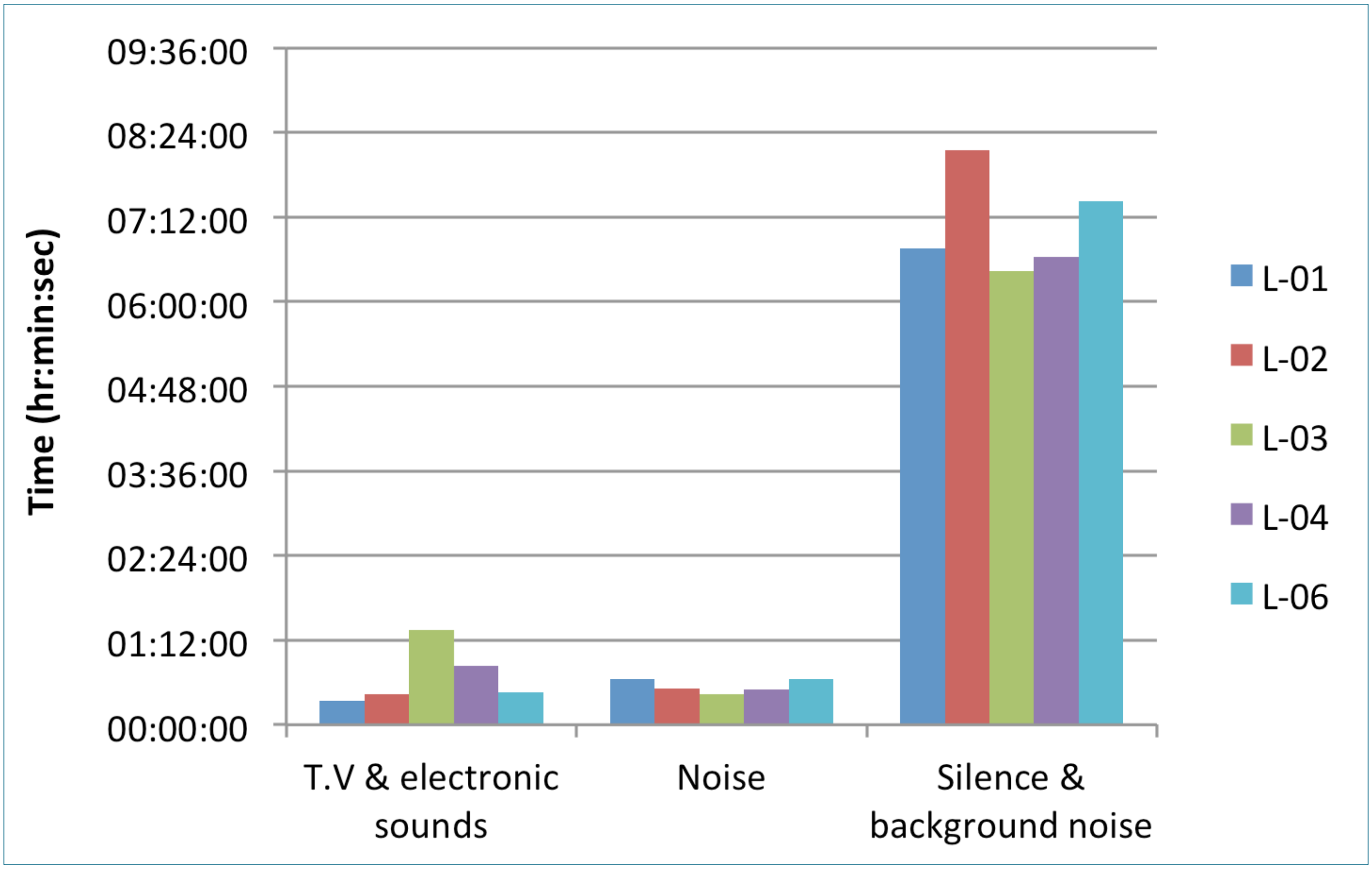

Figure 1. Auditory environment for each child (recording day 1 data)

(8th percentile). The amount of noise captured by the LENA system ranged from 26 minutes (3rd percentile) to 39 minutes (4th percentile). Exposure to silence and background noise varied from 6 hours, 25 minutes (40th percentile) to 8 hours, 8 minutes (53rd percentile). Examination of the parents' activity log (sheets) suggested that the increased amount of silence and background noise observed for participant L-02 may potentially be explained by the fact that the child is one of the younger participants in this study, and as a result spent more time sleeping than the other participants (according to parents' activity log). Overall, these five children spent most of their day in a quiet listening environment without interference from electronic devices or noise.

Meaningful and distant speech

Information concerning the amount of exposure to meaningful and distant speech is presented in Figures 2a and 2b. Figure 2a shows how much of each recording the LENA processing system interpreted as meaningful and distant speech across the five participants. This group of children spent a median of 3:35:45 hours (Interquartile range [IQR]: 2:54:10, 4:09:30) exposed to meaningful speech. Figure 2b shows a comparison for meaningful and distant speech for each individual child. The discrepancy noted between distant and meaningful speech for participant L-01 can be explained by the fact that the caregiver carried the recorder around near the child, however, not always close enough for the LENA system to interpret input as meaningful (i.e., close proximity speech). This deviation from the recommended use of the LENA clothing explains why distant speech is much more elevated than meaningful speech. Information from the parent activity log sheets indicated that L-03 and L-06 were wearing snowsuits during part of the recording. This may have affected how the LENA system analyzed the data with respect to meaningful versus distant speech.

Child vocalizations

Figure 3 shows the number of child vocalizations collected from each participant at each of the two recordings. The number of vocalizations from participant L-01 is substantially lower than the total vocalizations recorded from the other children. As noted above, this is likely explained by the fact that participant L-01 did not agree to wear the special LENA vest that typically houses

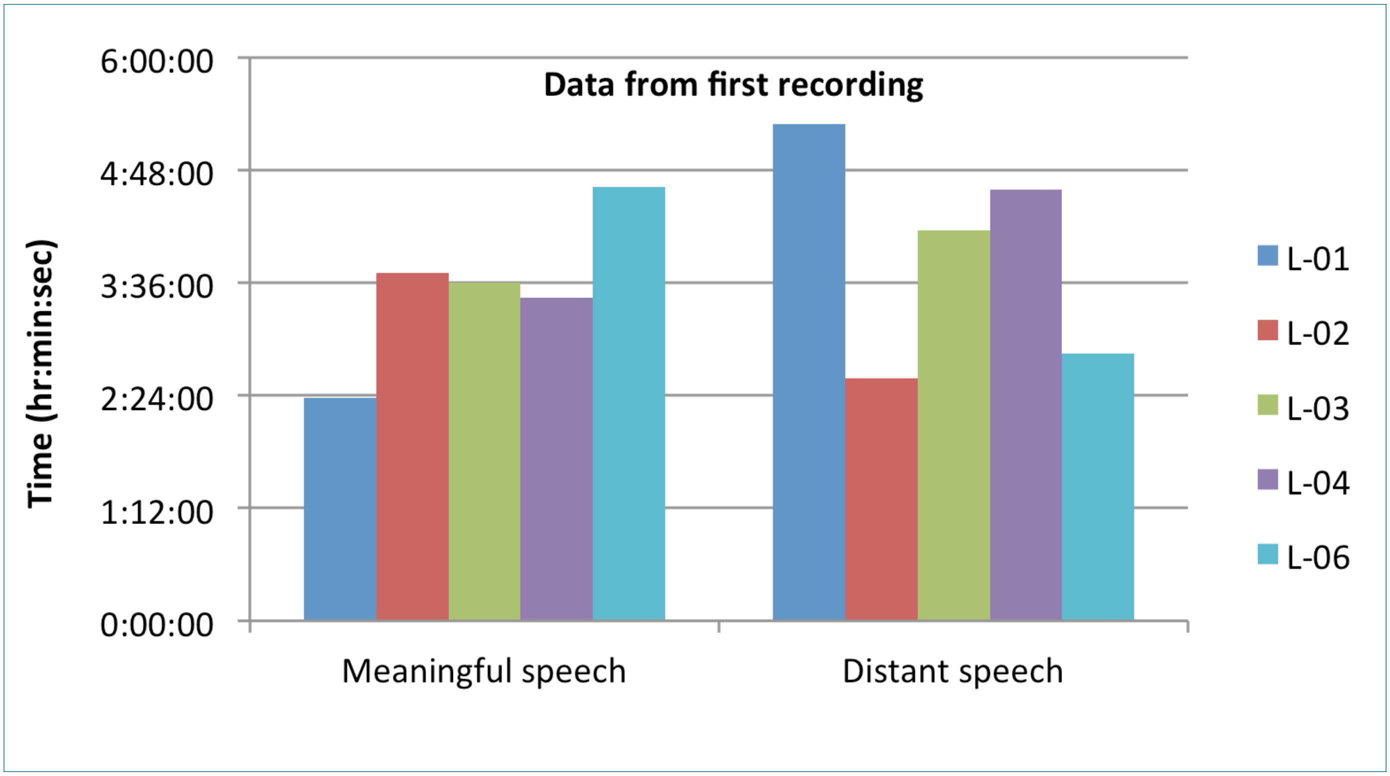

Figure 2a. Amount of time spent in meaningful and distant speech across children

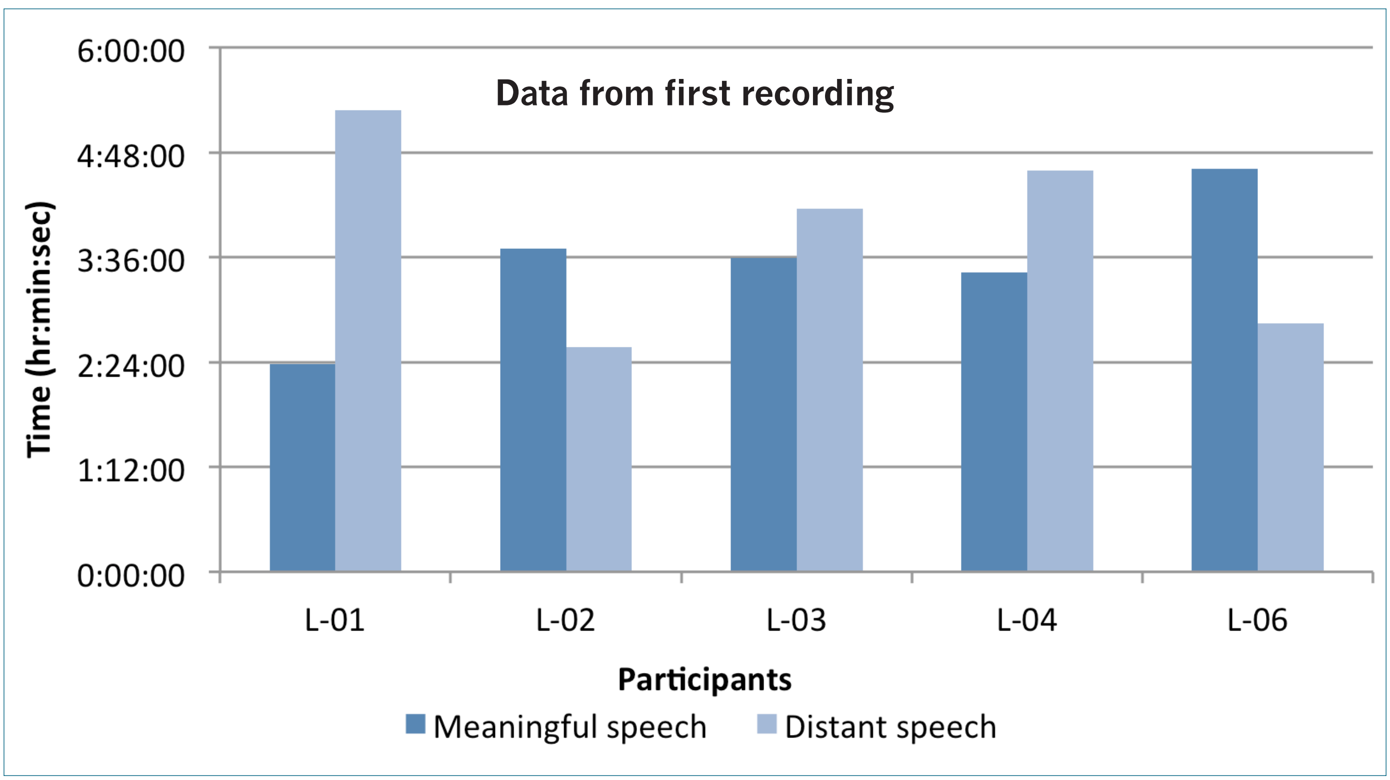

Figure 2b. Comparison of time (two recordings) spent in meaningful and distant speech for each child

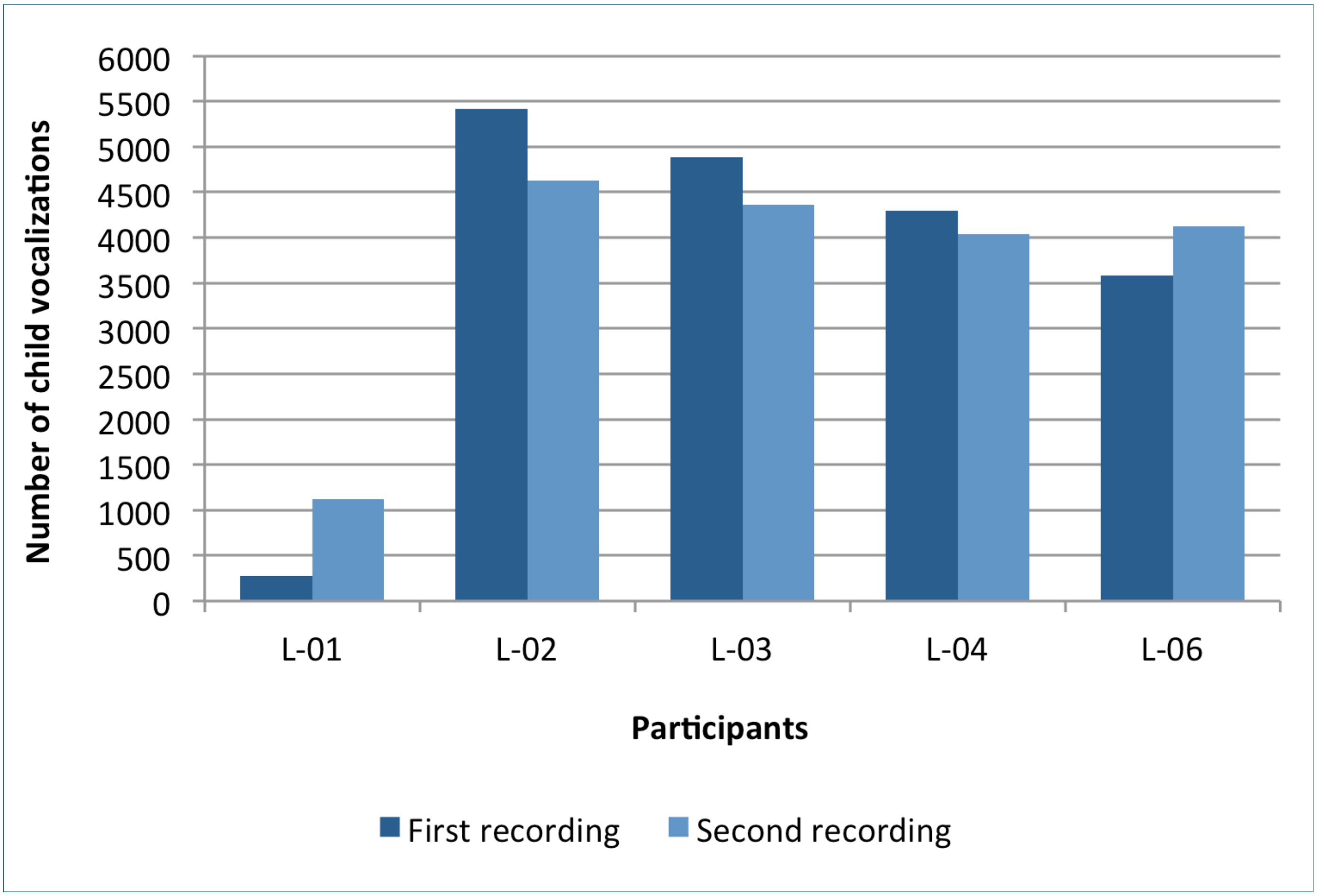

Figure 3. Number of child vocalizations on each recording day

the recorder but rather the child's mother carried the LENA DLP around in proximity to the child. As a result, the LENA DLP was unable to capture all of the child's vocalizations. Both recording samples collected from each participant were similar with respect to the vocalization counts captured. When compared to LENA normative data for typically developing children, all recordings with the exception of L-01 are between the 77th and 98th percentile with a maximum difference of 8% between the first and second recording.

Conversational turns

Figure 4 displays the number of conversational turns that occurred between the caregiver and child. Consistent with Figure 3, both recordings obtained from each participant are quite similar in the number of conversational turns captured by the LENA DLP. The difference in conversational turns between recording day 1 and recording day 2 ranged from 30 conversational turns for L-06 to 228 turns for L-04. There were less than 100 conversational turn differences between recording days for all children except L-06. The small differences noted between the first and second recordings further suggest that the recording days represent a typical day in the participant's life. Norms available for conversational turns situate all applicable recordings between the 85th and 99th percentile for typically developing children (LENA norms) with a maximum difference of 5% between the first and second recording.

Adult word count

Figure 5 shows the number of spoken adult words captured by the LENA DLP on each recording day. With the exception of the recordings from participant L-02, all recordings were at the 99th percentile compared to LENA normative data. For L-02, recording data on day one was at the 55th percentile and recording two was at the 77th percentile.

Parent Questionnaire Information

Parent questionnaires were returned for all five children and all reported that the LENA device was easy to use.

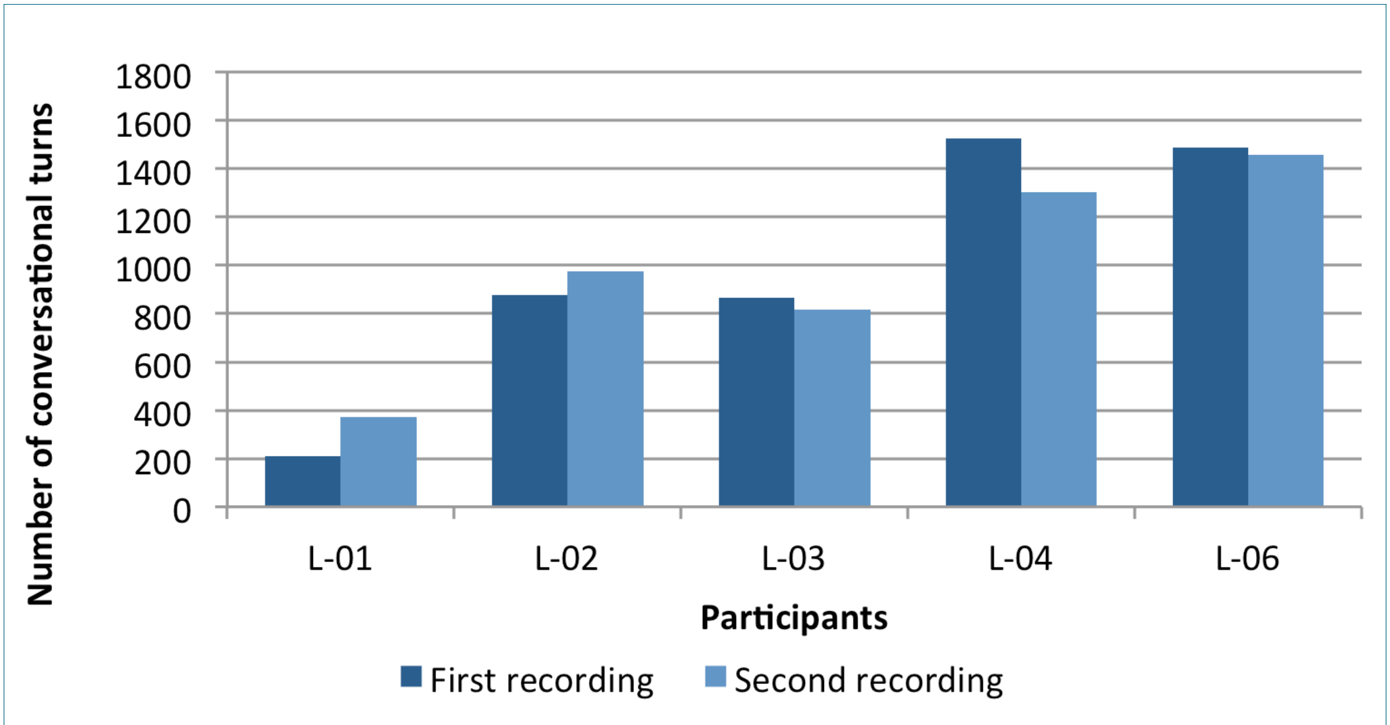

Figure 4. Number of conversational turns on each recording day

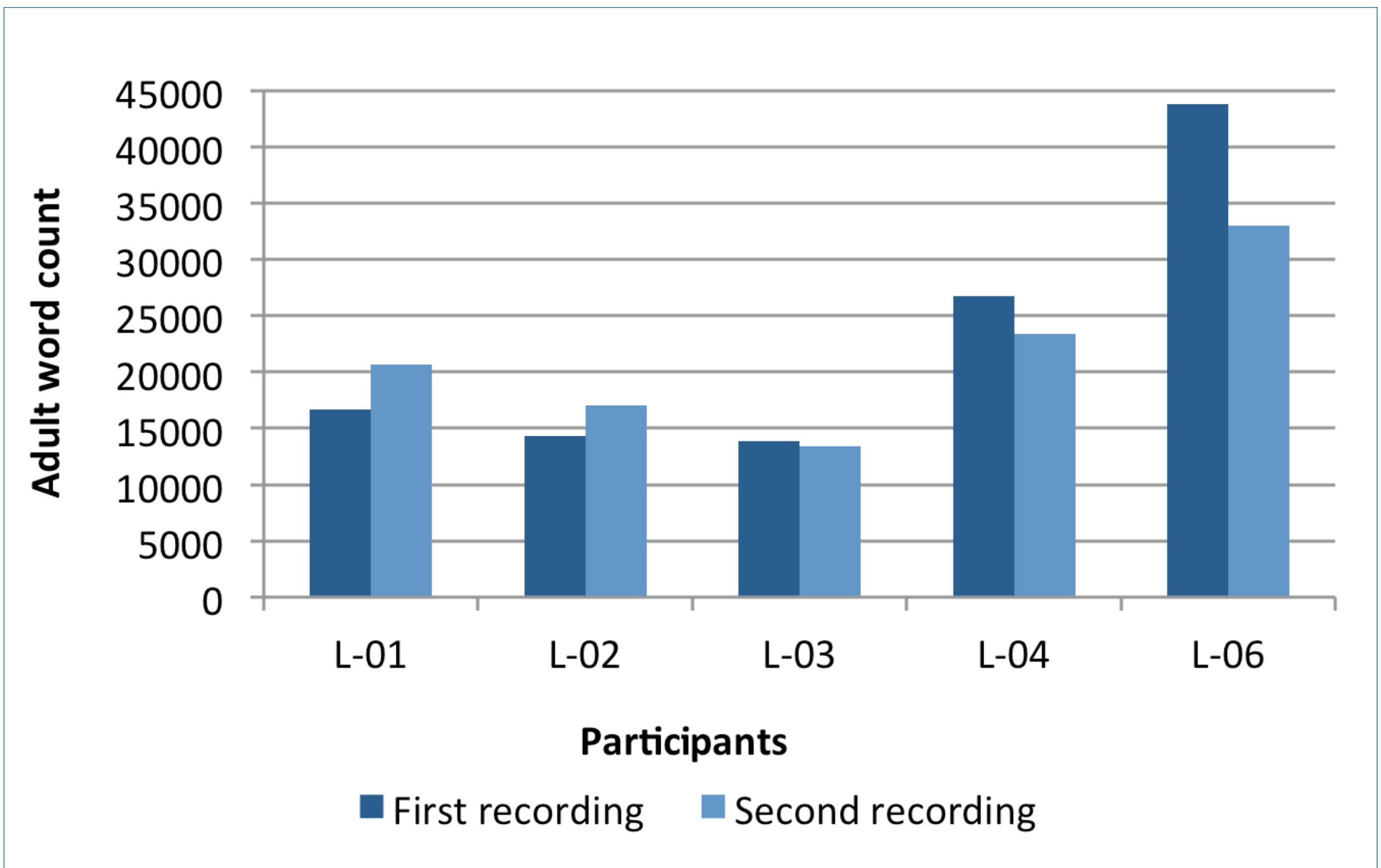

Figure 5. Number of adult words spoken to child on each recording day

However, for all children, parents also noted that their children either always or occasionally had a negative reaction to wearing the LENA clothing and this seemed to be one of the most challenging aspects for parents when using the recorder. None of the parents reported that using the device affected how they interacted with their child. Three parents also commented that it was necessary and in some cases challenging to organize family schedules to use the device for an extended period only in the home environment. These parents noted that this requirement impacted typical routines and in two cases resulted in a sample that was not representative of a typical day in their child's life. One parent positively commented that the LENA results confirmed that peak speech time for the child was in the afternoon and was pleased that this time coincided with the child's typical scheduled rehabilitation therapy appointment compared to a previous schedule of a morning appointment. One parent also indicated that she would appreciate receiving information about her child's daycare environment through use of the LENA system. For two children, parents indicated that they would definitely use the device again if requested by their therapist while the three other parents indicated they would maybe accept to use it.

Discussion

The purpose of this study was to examine the overall feasibility of using the LENA system as part of a clinical intervention program for preschool children with hearing loss. We were particularly interested in investigating the practicality for parents in a clinical program including how easy it was for parents to use the recorder, and whether parents would be able to use the device during the allotted recording times. In addition, this pilot project enabled us to describe the vocalizations and speech productions of a group of young children with permanent hearing loss receiving therapy in a listening and spoken language program.

Overall, LENA was found to be a useful tool for collecting naturalistic language samples from these young children. Parents were able to operate the device and reliable information regarding the child's home language and auditory environment was captured. Based on parent reports, the LENA device seems to have been easy to operate. However, parents also reported that their children either always or occasionally reacted with hesitation to wearing the LENA vest. Therefore, consideration of clothing, for example, familiarizing the child with the clothing (vest) by having him or her wear it for a period of time or incorporating the device into the child's own clothing might be useful to facilitate use of the device and ensure more accurate data collection. As the results demonstrate, when the device is worn correctly in a specially designed clothing item, the LENA system captures data representative of the child's auditory and language environment. In this study, parents first introduced the LENA vest to their child at home and one option might be for the child to first have an opportunity to use it in the clinical situation with both the therapist and parent during enjoyable play activities.

In a few cases, recordings were not completed on the anticipated day due to unplanned events in the family's everyday life. For this pilot project, we opted to limit recording to the home setting, and it is possible that it will be easier for parents to carry out the recording when there are no restrictions on the recording environment. Expanding the recording to multiple settings outside the home will also permit data collection that is more representative of typical daily activities for some children. Parents' comments confirmed this concern as they reported that the requirement to collect recordings in the home made the activity slightly more challenging to coordinate with their everyday schedules. Other important limitations of this study include the small sample size and the short time period over from which the recordings were collected. Finally, we did not specifically collect socioeconomic data on the families; however, these families all attended regular therapy sessions and as such were well informed of the importance of providing an enriched auditory and language environment for their children. Therefore, our findings from this small group may not be transferable to other program settings. It would therefore be useful to replicate this study on a larger scale and with a more diverse sample in future research.

These data indicate that LENA can provide useful information for clinicians to assist them in providing feedback to parents about their child's language learning environment. Based on information from LENA recordings, clinicians can offer parents' suggestions to further enrich the learning environment for the child. We did not collect comments in a systematic format from the clinicians involved in the clinic where the study was carried out. However, the pilot project laid the foundation for use of the LENA system such that it is currently being integrated more broadly into the auditory-verbal therapy program as a clinically useful tool for collecting extensive language samples and coaching families about the need for a stimulating language learning environment.

This is one of few studies that have investigated use of the LENA system with young children with hearing loss. Our findings, similarly to those of Aragon and

Yoshinaga-Itano (2012), suggest that the LENA system has useful applications for children with hearing loss in spoken language programs. In our study, all data that were appropriately collected, (child wore device in LENA clothing) were found to be within normative data for the LENA system. As noted, these children were all enrolled in an intensive therapy program with a focus on listening and spoken language since diagnosis. Therefore, parents had specifically received guidance regarding the importance of enriching the auditory environment by reducing background noise and received ongoing coaching related to exposing their children to good spoken language models. These data suggest that these children are in optimal learning environments. The findings regarding the environment can be used to reinforce parents' efforts to provide an enriched environment for spoken language development. For example, clinicians were able to visually demonstrate to parents which home situations and times of the day resulted in more (or less) adult talk and/or child vocalizations. Using this information, parents can be encouraged to capitalize on these time periods to provide an abundance of meaningful interactions and to teach new linguistic information such as vocabulary and grammatical structures. For children with hearing loss, the information about the auditory environment, particularly the presence of electronic sounds and noise, can be particularly useful in showing parents how much time their child spends in a listening context where there is less than optimal acoustic stimulation due to background noise.

Our results for this small sample are aligned with the positive results reported in a recent study for adult word counts and conversational turns in a larger group of children with mild to severe hearing loss from high socio-economic levels (VanDam et al., 2012). As noted, a sample that reflects a more diverse clinical population may yield different results in terms of the learning environment. For example, Aragon and Yoshinaga-Itano (2012) found that on average, children with hearing loss in English-speaking homes obtained higher scores on child vocalizations, conversational turns, and adult word counts than Spanish-speaking children with hearing loss. However, these authors also reported that conversational turns and adult word counts for this disadvantaged sample of Spanish-speaking children with hearing loss were higher than those recorded in Spanish-speaking homes of children with normal hearing. Based on these results, the authors suggested that early intervention services assisted parents of children with hearing loss in providing stimulating learning environments.

In addition to measurement in the home environment, LENA has the potential to be used in a variety of other settings by different caregivers interacting with the child. LENA can also be used to help measure the effectiveness of a treatment program in increasing the child's vocalization and in improving the learning environment, for example, by collecting pre- and post- therapy language samples. It also provides a tool for clinicians to explore the optimal time of day for treatment, and to identify settings and times of the day in which the child is most engaged in language and listening. As a tool to guide parents of children with hearing loss, LENA offers opportunities to teach parents about optimal acoustic environments and to encourage and reinforce parents' efforts in providing enriched language settings for their children's learning.

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