Acoustic Considerations in LENA Protocols

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Abstract

In a larger investigation (Moderators of Functional Outcomes in Children with Mild to Severe Hearing Loss*) the LENA is being employed to better quantify the environments of children with hearing loss. We have several objectives: 1) to assess the acoustic impact of extraneous clothing on input level and accuracy of analysis; 2) to generate an acoustic transfer function from the LENA microphone to the hearing aid microphone in an effort to obtain a summed or cumulative audibility measure to be used as a predictive variable in the study.

Introduction

We are involved in a large multi-site (NIH) study* looking at speech, language, educational and psychosocial outcomes from children with hearing loss. One of the largest known contributors to outcomes in children with hearing loss is reduced auditory/linguistic experience. Therefore, the focus of the proposed work is on variations in receipt and effectiveness of early interventions (e.g., hearing aid use, educational programs) that are intended to enhance auditory/linguistic experiences. Although we are gathering "goodness of fit" data relative to the amplification schemes used by these children, we believe it is important to understand the ongoing and typical inputs to their hearing aids. Consequently, the LENA is being employed to better quantify the environments of these children with reduced auditory capacity. We have several objectives: 1) to assess the acoustic impact of extraneous clothing and clothing-generated noise on level and accuracy of the LENA analysis; 2) to generate an acoustic transfer function from the LENA microphone to the hearing aid microphone in an effort to generate a summed audibility measure to be used as a predictive variable in the study.

Methods and Results

For this component of the larger study, we are using a child-size manikin for acoustic research (Figure 1). Measurements are taken in a sound-treated booth with the manikin approximately 1 meter from the sound source.

Relative to the first objective, we have analyzed the impact of multiple layers of clothing over the LENA device. In addition to reduced acoustic input to the analysis algorithm (Figure 2) we have also found errors in the analysis itself, with this acoustic modification. These errors were exacerbated by the fact that a coat, a bib, or any external cover creates microphone noise which will be incorrectly coded as noise in the environment (Figure 3).

Relative to the second objective, we are generating an acoustic transfer function from the chest-placed microphone to the ear-level microphone (as used in an ear-level hearing aid) (Figure 4). By doing so, we are able to derive a summed audibility measure. Using the input to the LENA, we are able to transform the signal to the level at the microphone of the hearing aid, and then apply the gain of the hearing aid. The Speech Intelligibly Index, or SII, will be used to quantify the usefulness – from a speech acoustics standpoint - of the speech input, but over a 12 hour period of time. From these derived values we can ascertain a cumulative effect of audibility over time, rather than at some single point of measure, as is currently done in clinic and research settings.

Figure 1:

The child-size manikin for acoustic research

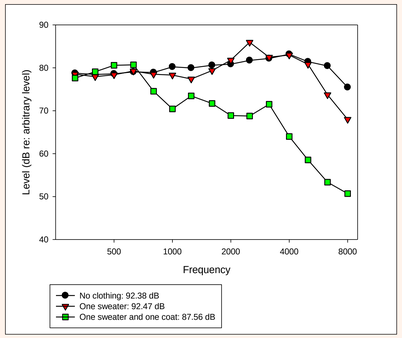


Figure 2:

Effect of clothing on the LENA

Figure 3:

Effect of clothes rubbing on one token (adult words) analysis.

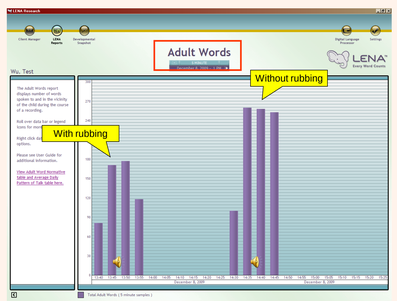
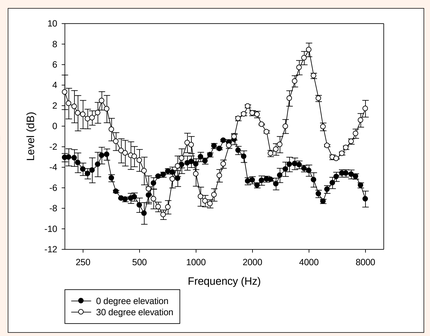


Figure 4:

Chest (LENA position) to ear (hearing aid microphone position) transfer functions



Summary

A primary hypothesis in this large investigation that audibility drives speech and language development (and ultimately educational/ psychosocial success). Through LENA recordings we will have access to type and level of input stimulus. Using the transfer function along with the child's audiogram, and hearing aid amplification characteristics, we will be able to better quantify the audibility accessed over the course of a typical day. Currently, we are reliant upon parent report to assess the amount and content of typical inputs.

Conclusions

1. The use of coats, bibs and other clothing impact both the level into the LENA recorder, as well as the accuracy of the de-coded signals.

2. A transfer function of the measured input to the ear-level input for the hearing-aided subjects allows for derivation of a measure of summed, or cumulative, audibility. This effort is ongoing.

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Outcomes of Children with Hearing Loss

a study of children ages birth to six