

# Importance of Relationships Between Signal to Noise Ratio, Auditory Environment, and Hearing Assistive Technology Use In Young Children



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## Objective

To explore the diverse relationships between signal to noise ratio, rich auditory environment, and parental perspective on the use of hearing assistive technology (HAT) in order to understand the best possible listening environments for young children with hearing loss.

## Background

Background noise is a continuous challenge which children with hearing loss face when it comes to listening and learning. There is well-documented evidence demonstrating that signal-to-noise ratio (SNR), or the loudness of speech above noise, can be improved when using hearing assistive technology (HAT) that specifically employs a remote microphone and direct streaming to hearing or cochlear implants (FM or Roger technology). Traditionally, this technology has been used for classroom use however, the benefit is also seen in everyday listening environments (Crandell, 1993; Flynn, Flynn, & Gregory, 2005). Challenging listening environments can impact parent-child relationships, speech, language and auditory development, and can reduce learning opportunities. With a greater, improved signal-to-noise ratio, hearing aid and cochlear implant users demonstrate improved speech understanding abilities (Thibodeau, 2010).

Any degree of hearing loss in children can result in compromised speech intelligibility in noise. The degree of hearing loss does not predict the amount of difficulty a child may face in these situations (Gabbard, 2004). This is important, because critical incidental listening takes place when a child hears and learns from what is happening around them (Akhtar, Jipson, & Callanan, 2001). This learning is significantly reduced for children with hearing loss because they have less access to meaningful distance listening (Moeller et al., 1996). Children with all degrees of hearing loss using HAT technology have better access to meaningful adult speech (Benitez-Barrera, Angley, & Tharpe, 2018).

## Methods

Marion's Way Preschool at the Marion Down Center began providing services to children and families in 2010. This 6-week language intensive program for children with hearing loss uses HAT (FM/Roger) technology which is loaned to families for use at home, and in the classroom to enhance speech intelligibility. In addition, personal amplification (hearing aids &/or cochlear implants) is optimized to the child's needs using verification and validation strategies. Every parent receives counseling, education and guided observations of the classroom to help them best understand technology benefits and techniques to improve communication access for their children.

**Results of three assessments are analyzed in this study:**

- ❖ **Aided speech-in-noise testing with and without HAT:** The PINT (Phrases In Noise Test) was administered to establish a SNR threshold using adaptive noise levels. The SNR threshold is used as a value to understand the level of background noise that impacts the child's ability to best understand speech (Schafer, 2010).
- ❖ **The FM/Roger Parent Questionnaire** (Johnson, 2012): the surveys were completed by parents both prior to and at the conclusion of preschool
- ❖ **A LENA SP recording and analysis:** the LENA electronic device was worn by the child and captured and recorded a full day of speech and environmental input. Pre-program and post-intervention LENA recordings were made and analyzed. The LENA software analysis provided detailed information regarding the child's auditory environment including adult words, child vocalizations and conversational turns.

Data collected from 2014-2019 were used for this project. Analysis included:

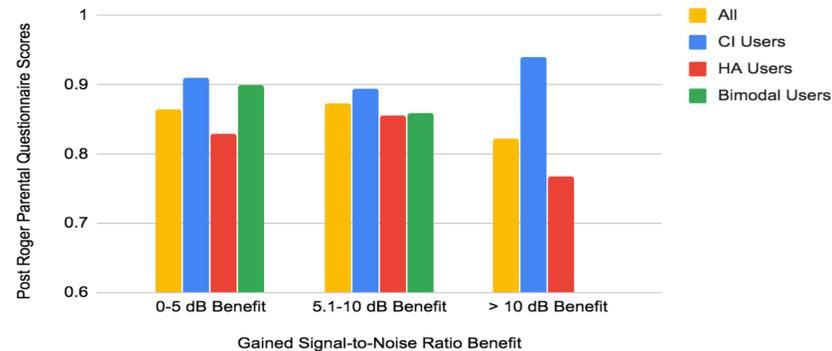
- ❖ Post-Roger parent questionnaires scores and the signal-to-noise ratio benefit scores broken down into groups by amplification type used by the child (HA, CI, or bimodal).
- ❖ Pre- and Post LENA data (average adult words, average conversational turns and time spent in meaningful auditory environments) analyzed by the type of amplification used.

## Results

**Post-Roger parent scores and SNR Benefit:**

- ❖ Children who used cochlear implants had the highest correlation with post-Roger scores in all SNR benefit groups.
- ❖ The Highest correlation was seen in the greater than 10 dB benefit group
  - Bimodal users did not receive greater than 10 dB SNR benefit
- ❖ There was a close to even distribution of children who scored in the variety of SNR benefit ranges
  - 34% (10/29) of children scored in the 0-5 dB Benefit range
  - 28% (8/29) of children scored in the 5.1-10 dB Benefit range
  - 38% (11/29) of children scored in the >10 dB Benefit range

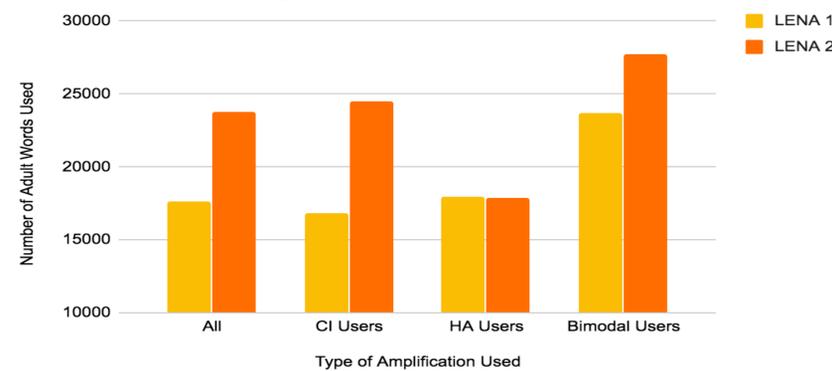
SNR Benefit by Post Roger Parental Performance Scores for Various Amplification Users



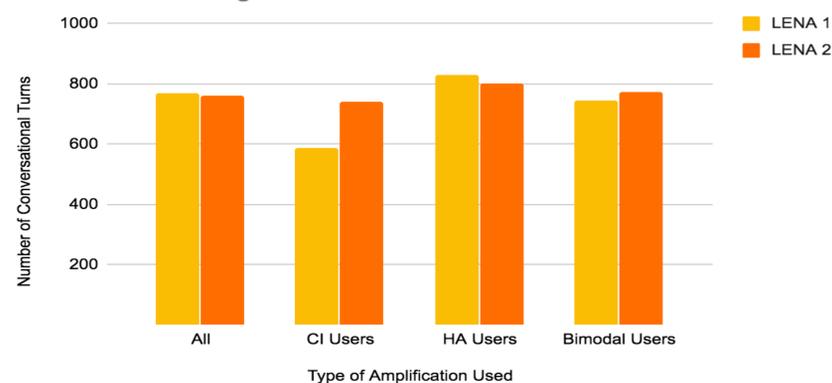
**Pre- and post- LENA data by type of amplification used:**

- ❖ Similar increase in scores for all amplification users except for bimodal users which remained the same after counseling on the importance of meaning auditory environments for learning.
- ❖ Cochlear implant users made the most significant gain in adult word use and conversational turns.
- ❖ Hearing aid users made no significant changes in adult word use or conversational turns.

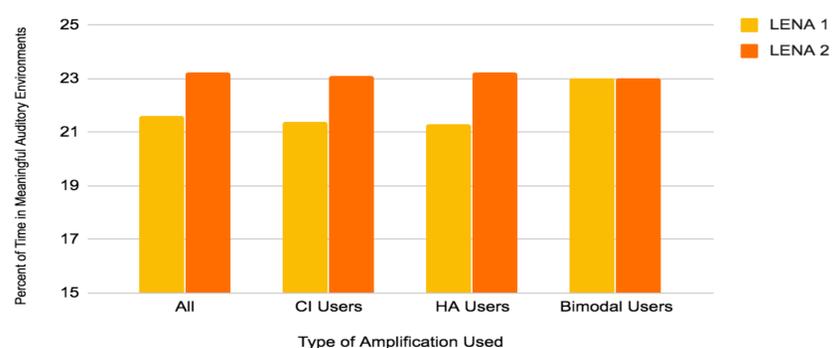
Average Recorded Adult Word Use



Average Recorded Conversational Turns



Average Recorded Time Spent in Meaningful Auditory Environments



## Discussion

The use of HAT technology in addition to personal amplification has clear advantages in adverse listening environments. When used with young children, advantages can be clearly documented in both educational and everyday environments. Speech-in-noise testing, an objective assessment that can be done in a soundroom by an audiologist on children beginning at about age 3 years, is a valuable measure, but not the only one to be considered. Parents can evaluate the impact on communication using a pre- and post- treatment questionnaire.

All amplification users of hearing aids, cochlear implants, or both (bimodal) gained benefit in speech-in-noise understanding and listening. This analysis indicates a plateau in benefit at 10 dB for all children regardless of amplification technology. This is to be predicted because Roger technology is designed to give 10 dB of SNR benefit ("Phonak", 2020). SNR benefit varies by child, amplification used, and likely attention at the time of the testing.

Additionally, the fact that no observed bimodal users gained more than 10 dB of SNR benefit, may have resulted from the low number of bimodal participants. One important factor which could be a determinant of success when using HAT technology is parental counseling on the importance of meaningful auditory environments and optimizing listening settings for their children. All parents were counseled as a group and individually on the use of this technology at home. The similar measurements of meaningful auditory environment between amplification users was a positive indicator that all parents and children benefited from the technology and training. Additionally, when examining adult word use and conversational turns, there are a variety of factors which may have affected why cochlear implant children made greater improvements than other amplification groups. Cochlear implant and bimodal children are more likely to receive increased individualized intervention or therapy which may have impacted them outside of the program impact. The children who do participate in Marion's Way Preschool have a variety of language and literacy abilities, levels of intervention, and up to a third are estimated to potentially have other learning challenges. Any of these factors could have an effect on the results.



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