The Effect of Low-Frequency Acoustic Cues on Speech Perception in Noise for EAS Recipients

UNC DEPARTMENT OF OTOLARYNGOLOGY/ HEAD AND NECK SURGERY

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Background

The development of atraumatic surgical techniques and shorter, more flexible electrode arrays has resulted in postoperative residual hearing preservation in the implanted ear, presumably due to preservation of cochlear structures[1,2]. As a result, these cochlear implant (CI) recipients have access to low-frequency acoustic cues either naturally or through the use of a hearing aid (HA), while receiving audibility of mid-to-high frequency information through electric stimulation provided by the CI in the same ear. This ipsilateral combination of technologies is known as electric-acoustic stimulation (EAS).

Having access to low-frequency cues such as the fundamental frequency and timing cues helps the listener separate targets from background maskers in complex listening environments[3,4] and can also help improve speech perception in quiet[3,4]. Bimodal recipients, who listen with a CI in one ear and a HA in the contralateral ear, demonstrate an improvement in speech perception when listening with combined stimulation[3,4,5]. EAS listeners who also have residual hearing in the contralateral ear have the added benefit of bilateral acoustic low-frequency input. Research has shown that these EAS listeners are able to utilize bilateral acoustic cues such as inter-aural time differences (ITD) to further assist them in speech perception as well as localization[6].

The objective of the current report is to compare the speech perception in noise scores of EAS recipients in a CI-alone versus an EAS listening condition. Comparison of the CI-alone and EAS listening conditions allows for the review of whether the addition of acoustic low-frequency information improves speech perception in a challenging noise condition.

Aim

Review the benefit of low-frequency acoustic cues in participants listening with EAS

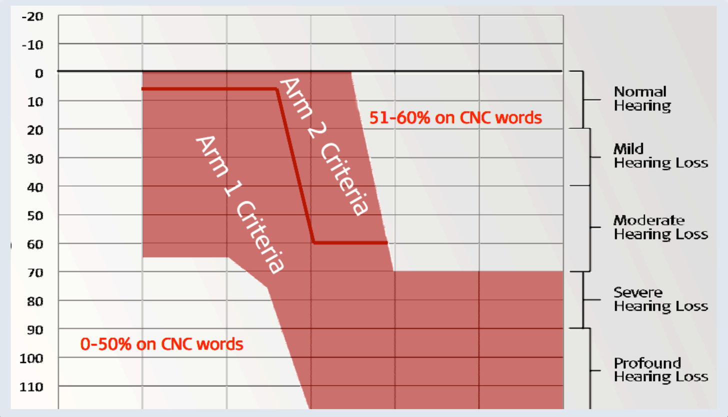
Methods

Retrospective Review

Inclusion Criteria:

- Participants in EAS clinical trial
  - Unaided criteria (Figure 1)
  - ≤ 60% on CNC words
- Residual hearing in the implanted ear

Figure 1: Inclusion criteria for the EAS clinical trial



Listening Conditions:

- CI-alone (ear plugged/masked)
- EAS

Test Battery:

- AzBio Sentences in 10-talker babble (+10 dB SNR at 60 dB SPL)
- BKB-SIN (60 dB SPL)

Speech Processor:

- DUET speech processor (MED-EL Corporation)
  - Acoustic settings programmed to meet NAL-NL1 prescriptive targets

Results

Fourteen (14) participants completed the test battery assessing the benefit of adding the acoustic component to electric stimulation when listening in a multi-talker background noise. Participants received their CI as part of the U.S. multi-center EAS clinical trial[7]. Participants were implanted with the FlexEAS electrode array and fit with the DUET speech processor. At the time of evaluation, participants had a range of 3.7 to 9.4 years of device listening experience (mean: 5.3 years). All participants presented with residual hearing in the implanted ear (defined as ≤ 75 dB HL at 125 Hz). The low-frequency pure tone average (LFPTA: 125, 250 & 500 Hz) ranged from 12 to 90 dB HL (mean: 60 dB HL). All participants reported consistent use of the EAS device. Participants completed speech perception testing with the CI-alone (unfamiliar, full-frequency map) and EAS (familiar, everyday map plus acoustic component). The output of the acoustic component was verified using the NAL-NL1 prescriptive method prior to evaluation.

Data were analyzed using a paired-samples t-test (SPSS, v24), with significance defined as $\alpha < 0.05$. Figure 2 plots the AzBio sentences in noise scores for the EAS and CI-alone listening conditions. One participant did not complete this measure due to time limitations. There was a significant difference in speech perception scores ($t_{(12)}=4.63$, $p<0.001$), indicating better performance with EAS as compared to the CI-alone listening condition.

Figure 3: Speech perception performance on the BKB-SIN test for the EAS and CI-alone listening conditions. Results are reported as the dB SNR where the participant understands 50% correct; therefore, a lower value indicates better performance.

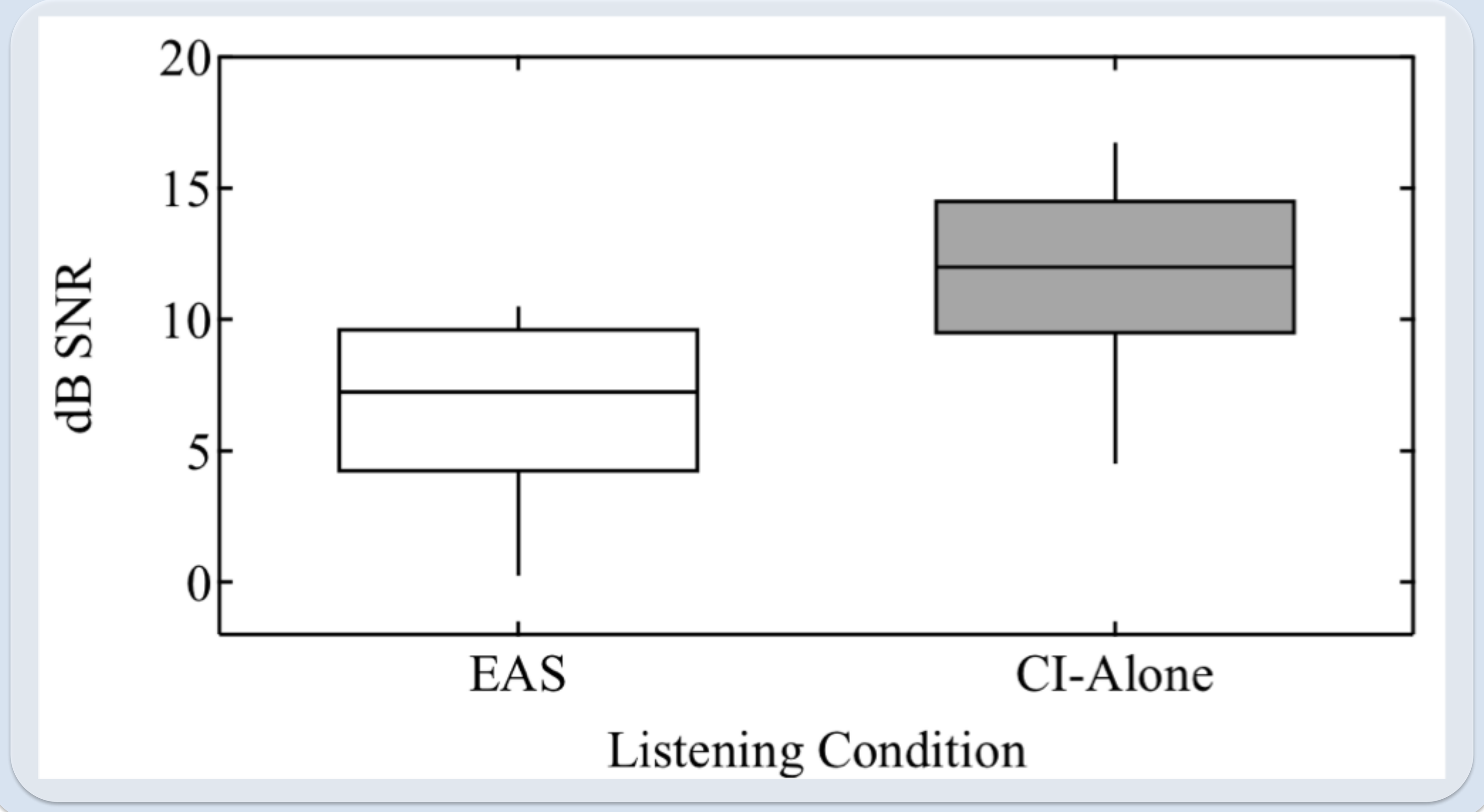
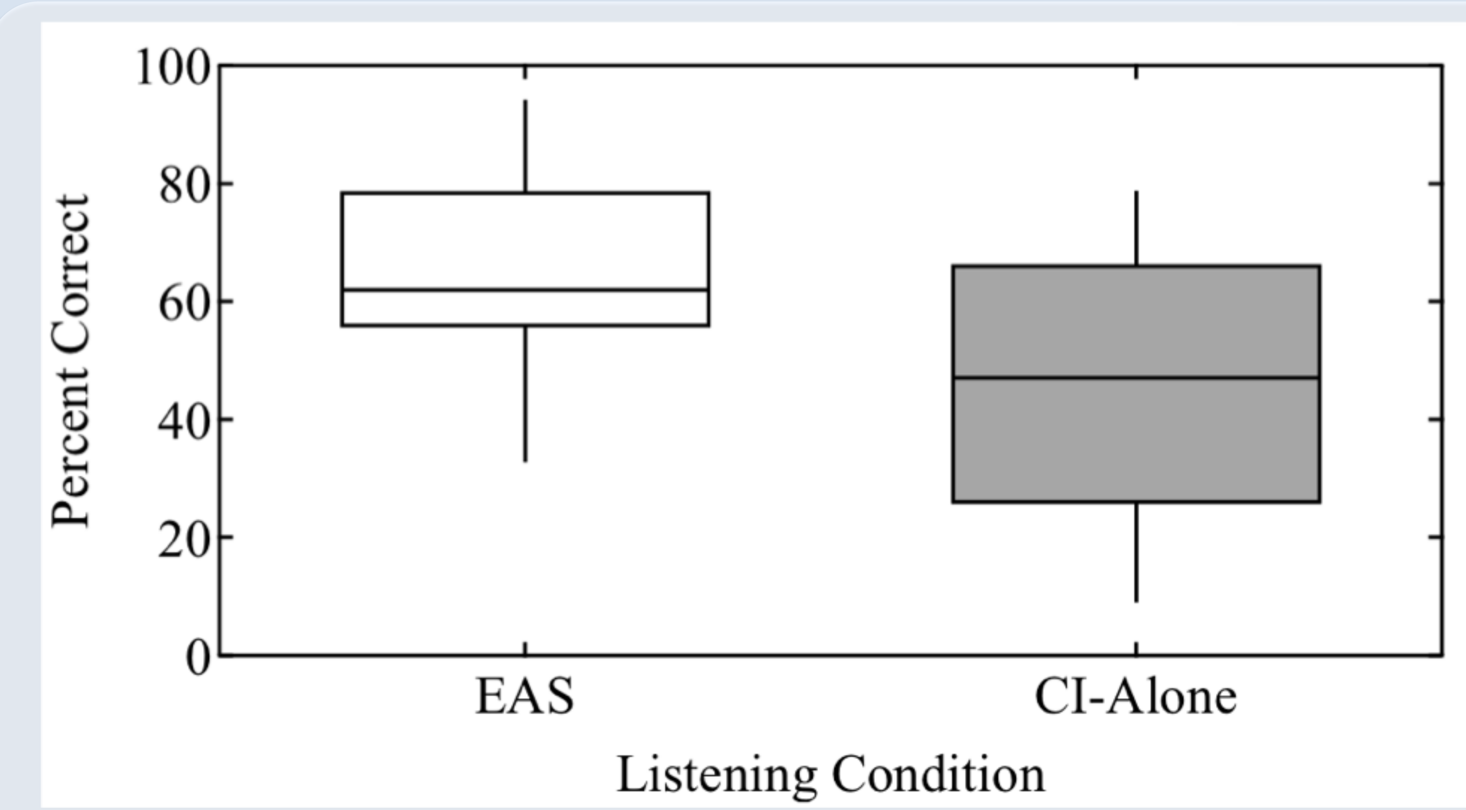


Figure 2: Speech perception performance on the AzBio sentences in a 10-talker babble (10 dB SNR) for the EAS and CI-alone listening conditions. Results are reported in percent correct.



Results on the BKB-SIN test for the EAS and CI-alone listening conditions are plotted in Figure 3. A lower value indicates better performance. Again, there was a significant difference in speech perception scores ($t_{(13)}=-7.19$, $p<0.001$), indicating better speech perception in multi-talker noise with EAS as compared to the CI-alone listening condition. These data suggest the addition of the acoustic component provides a benefit for speech perception in a challenging noise environment.

Conclusions

Participants demonstrated better speech perception in noise when listening in the EAS condition as compared to the CI-alone condition. This benefit is presumably due to the addition of acoustic low-frequency information. In the multi-center EAS clinical, speech perception in noise was tested using a steady masker. The present data were obtained in a fluctuating masker, highlighting the benefit of low-frequency acoustic cues in a challenging background noise.

A consideration of this dataset is that testing in the CI-alone condition was conducted using an unfamiliar, full frequency map. While this provided participants with a electric representation of the full speech spectrum, changes to electric frequency filter assignments can impact speech[8]. Thus, performance in the CI-alone condition may be underestimated.

Participants with residual hearing in the implanted ear experience a benefit with EAS as compared to a CI-alone listening condition. In the future, we plan to investigate the amount of residual hearing necessary to experience such benefit.

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