Preservation of Low-Frequency Hearing is Critical for Localization Abilities

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Outline

• What is localization?
• Localization in patients with acoustic and electric hearing on opposite ears (CI+HA)
• Localization in hybrid users
• Conclusion
• Take-home message
What is Localization?

• Localization is the judgment of direction and distance of a sound source
• It can be vertical or horizontal
• Important for:
  – for locating or steering away from sources of danger
  – for attending to a speaker in background noise
  – quality of life
Cues For Horizontal Localization

- Timing:
  - Later
  - Softer

- Level:
  - Earlier
  - Louder

bang!
Localization in CI+HA

• Some studies have shown improved localization for subjects using CI+HA versus use of either device alone (Ching et al., 2004; Tyler et al., 2002).

• However, other results found that only a few listeners (2 out of 12) showed an improvement in localization despite wearing a cochlear implant and hearing aid in opposite ears (Dunn et al., 2005).
Lower = Better

Cl+HA and Cl+Cl localization

RMS Error in Degrees

Subjects

The University of Iowa
Why the poor performance in CI+HA?

• CI+HA devices might not accurately convey differences in level and timing (Francart et al., 2008; Tyler et al., 2002; Tyler et al., 2006; Ching et al., 2007).

• Due to between-ear differences in:
  1. Place of stimulation
  2. Processing of time delays (Tyler et al., 2002; Ching et al., 2001).
  3. Loudness (Tyler et al., 2002; Ching et al., 2001).
  4. Encoding of fine-structure information (Kong et al., 2005; Grantham et al., 2007)
Potential Benefit of Hybrid for Localization

• Similar signal processing across ears likely results in better coding for level and timing cues
• Preserved low-frequency hearing could provide an advantage to localization
  – Low-frequency timing cues would be similar across ears
Purpose

• Minimal research has focused on localization abilities of users with a hybrid cochlear implant.
  – evaluate localization in hybrid listeners who continue to wear a hearing aid in both ears
Devices

- Eleven adults implanted with a Nucleus Hybrid short-electrode cochlear implant
  - ($M = 61.3$ years; range = 51 to 81 years)
- Ipsilateral Hearing aid: digital, Phonak Aero ITE
- Contralateral Hearing aid: personal HA
- Hearing aids verified using real ear probe measurements
  - No noise reduction or directional microphones were active during testing.
Pure-tone Acoustic Thresholds

Ipsilateral Ear

Contralateral Ear
Test Conditions

1. **Combined**: bilateral HA in addition to the CI

2. **Hybrid**: CI and ipsi HA

3. **Bimodal**: CI and contra HA

- CI is programmed to stimulate frequencies where residual hearing is poorer than ~90 dB HL
  - Lower frequency cut-off between 750-1000 Hz
Test Conditions

4. **Extended Frequency: CI** with 188-7995 Hz and contra HA

5. **Bilateral HA**: ipsi and contra HA

- Testing order of conditions was randomized
- Ear plugs were used when a HA was removed for a test condition
- Subjects were tested acutely with no listening trial
Eight-Loudspeaker Set-up

• An array of eight loudspeakers spanning a horizontal arc of 108°.

• Loudspeaker one and eight were placed 54° to the left and to the right of the (0°) position. (Byrne et al., 1998).
The graph illustrates the RMS Error in Degrees for different cases labeled SE5, A12, A8, A2, SE9, A4, SE8, A7, A9, SE11, A10, and the Average, comparing Combined and Bilateral Hearing Aids. The data indicates that there is no significant difference between the two groups, as represented by the bars for each label. The bar heights are lower for Combined, indicating better performance in this category.
Lower = Better

Significant difference
No significant difference

Lower = Better
Conclusions

- Listeners with a cochlear implant and hearing aid on opposite ears do not benefit from localization.
  - Devices might not accurately convey differences in level and timing
- Functional preservation of acoustic hearing is very important for localization abilities in individuals getting a cochlear implant
- The use of a short-electrode combined with bilateral hearing aids does not cause a decrement to localization.
1. The goal of a cochlear implant is to improve speech perception abilities for individuals with hearing impairment
   - All aspects of hearing should be considered, such as localization

2. If your patient has hearing that can be preserved, a hybrid should be considered
   - It can improve speech perception, but can also preserve localization abilities
   - Ability to localize not only improves quality of life, it provides important benefits to safety
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