Localization and Hearing in Noise: Osseointegrated Device Outcomes

Jake Hillyer B.S., François Cloutier M.D., Elizabeth Harland Au.D., Stacey Watson Au.D., Douglas Backous M.D. & Alexandra Parbery-Clark Au.D./Ph.D.*

Swedish Neuroscience Institute, Seattle, Washington **jake.hillyer@swedish.org*

Abstract

Outcome Objectives: Compare objective and subjective measures of sound source localization and speech-in-noise (SIN) ability.
Methods: 10 Single-sided deafened (SSD) adults with normal contralateral hearing and a minimum of 6 month osseointegrated implant (OI) device usage were recruited from Washington State. Participants localized sounds from an eight speaker array (R-Space), verbally indicating the speaker source of the acoustic stimulus (speech). For SIN testing, participants repeated normed sentences (BKB-SIN) which were presented in background noise. Localization and SIN tests were conducted with both the OI on and the OI off as well as with multiple OI microphone modes to determine benefit of omnidirectional and directional microphone settings. Finally, participants completed questionnaires addressing their subjective perception of sound localization and SIN abilities.
Results: Localization and SIN ability pose significant challenges for OI users with SSD with no global improvement observed in the OI aided conditions. Evaluating error on a per-speaker basis indicates localization accuracy varies, although not consistently, between microphone settings ($p < 0.05$). Lastly, a strong relationship between objective and subjective measures of SIN perception suggests that assessing individuals in simulated real-life environments accurately captures patients' perception of their hearing ability ($p < 0.001$).
Conclusion: Localization, unlike speech-in-noise, ability is modulated by OI microphone modes. Simulating a real-life environment in a clinical setting reliably predicts subjective reports of performance. Future work should assess whether auditory training improves performance of these skills in everyday acoustic environments.

Introduction

Individuals with single sided (sensorineural) deafness (SSD) use osseointegrated implants (OIs) to aid residual hearing.[1, 2]

The chief complaint of SSD individuals is the inability to localize or hear in noise despite patient reports of OI benefit.[1]

Sound localization ability and hearing in noise perception are binaural processing phenomena.[3-5]

Despite potential common mechanisms and clinical relevance, the relationship of localization, hearing in noise, and subjective performance has not been addressed.

Hypothesis

- Localization and hearing in noise are related tasks.
- OI implanted SSD patients indicating better performance in everyday life will achieve greater accuracy for localization and hearing in noise.

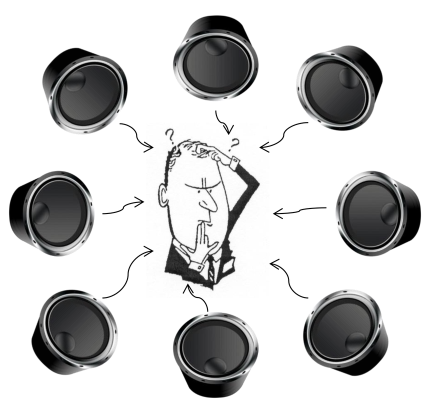
Methods

Participants
- 15 Adults (22-68 yrs)
  - 10 with SSD, normal hearing on contralateral side (38 – 68 yrs, mean age: 56.6 ± 8.57 yrs)

Duration of Hearing Loss	13.80 ± 19.93 years
PTA	93 dB
Time with Device	2.04 ± 0.99 years
Device Usage (per day)	10.50 ± 2.67 hours
Perceived Benefit? (Y/N)	88.8 % (Y)
Device (Oticon:Cochlear)	(3:7)

  - 5 normal-hearing (22-68 yrs, mean age: 42.5 ± 19 yrs)

Loudspeaker Array
- R-Space: 8-surround loudspeakers



Localization Testing
OI Microphone Conditions
- Fixed-Directional
- Omnidirectional
- Adaptive
- OI Device Off

Stimulus
- 1250 msec (*Where am I coming from now*?) 65 dB SPL[3]

Hearing in Noise Testing
- BKB-SIN sentence lists[6]

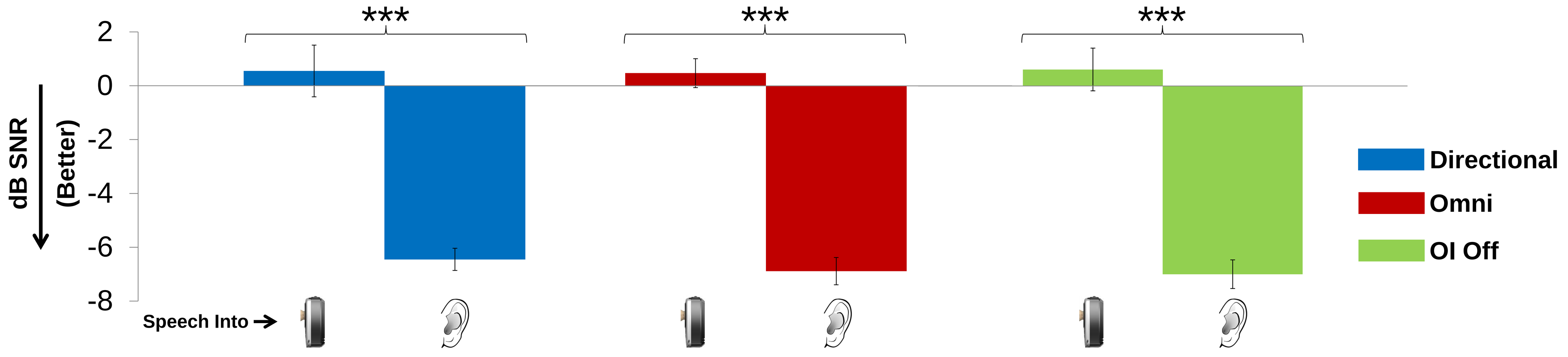
Questionnaires
- Abbreviated Profile of Hearing Aid Benefit (APHAB)[7]

Statistical Analyses
- Nonparametric tests of 2 related samples
- Bivariate correlations

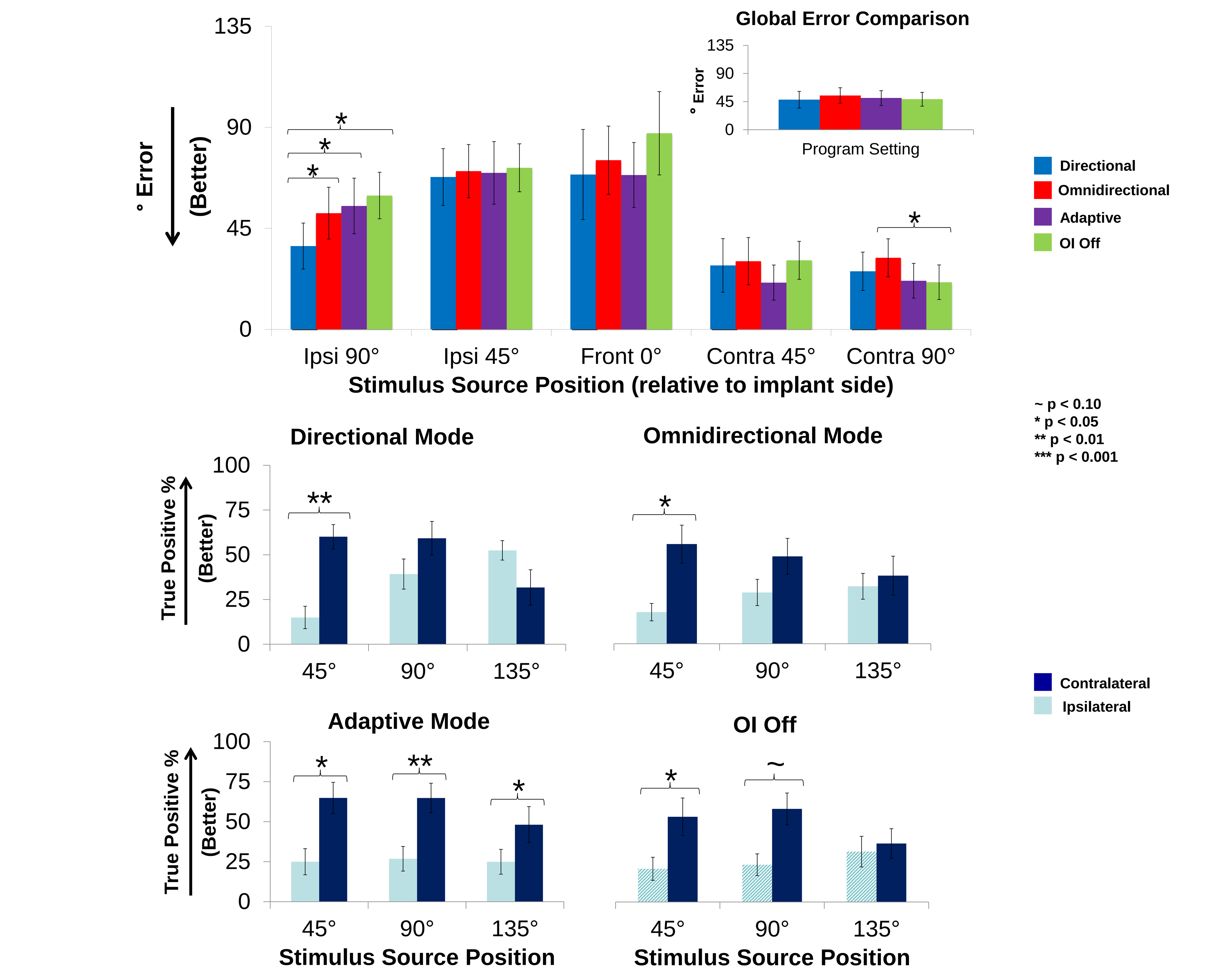
Results

Hearing in Noise

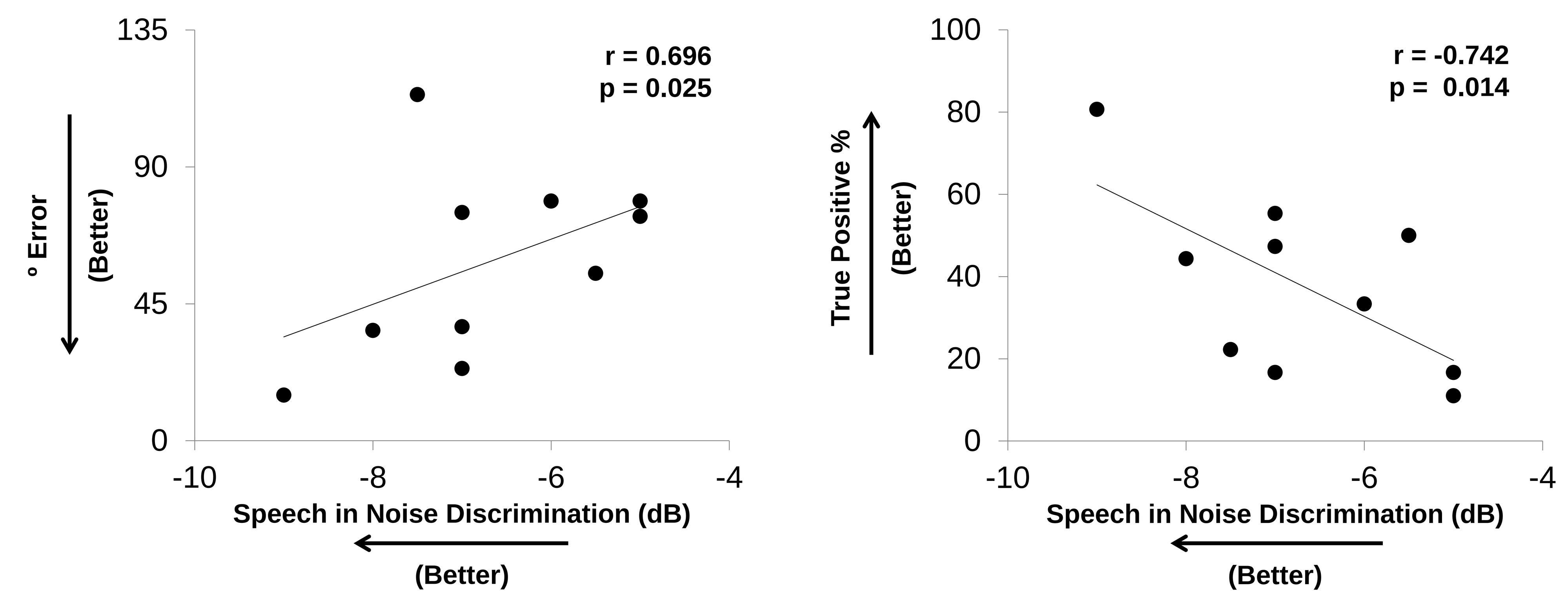
Better hearing in noise when speech presented to normal hearing ear



Localization



Better Frontal Localization: Better Hearing in noise



Acknowledgements

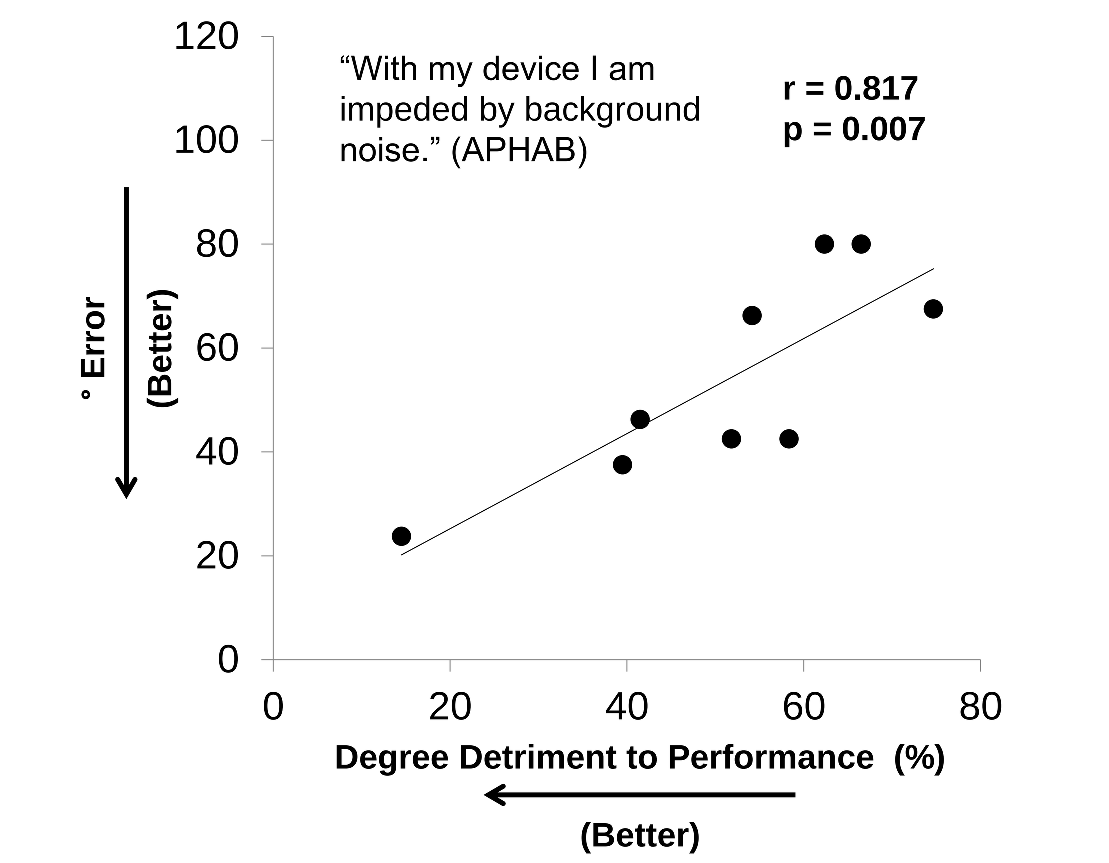
The authors wish to thank members of the Auditory Research Laboratory, the Center for Hearing and Skull Base Surgery at the Swedish Neuroscience Institute, Cochlear™ Americas and Oticon Medical for donating devices, and the patients who donated their valuable time.

Supported by Swedish Neuroscience Institute
www.swedish.org

Results (continued)

Subjective Performance

Better localization ability: Better subjective rating of hearing in noise



Summary of Results

Hearing in noise:
Optimal performance when speech is presented to the normal hearing ear (+6 dB SNR).

Localization:
Per-speaker comparison indicates improved localization for directional microphone settings for 90º.

The normal hearing ear consistently outperforms the OI device side for front sound localization.

Hearing in noise is related to localization ability only when speech is presented to the normal hearing ear.

Subjective reports of OI benefit are strong predictors of localization ability.

Discussion

Normal hearing ear outperforms OI device input for hearing in noise.

Continued difficulty for OI patients to localize sounds: difficulty integrating the OI input into meaningful localization cues.

Patients are accurate in assessing their everyday hearing abilities.

Clinical Implications

For improved SIN ability, patients should position speech to normal hearing ear.

Patients may benefit from multiple program options for various daily settings.

Patient's self-perceived benefit of the OI device in everyday settings is highly predictive of objective localization measures.

Future Work

Extend test population to single sided conductive hearing impaired OI recipients who experience binaural processing. [3]

Can localization ability and hearing in noise perception be improved with auditory training?[8-10]

References

1. Saroul, N., et al. Eur Ann Oto Rhino Laryn., 2011. **128**(3): p. 107-113.
2. Pai, I., et al. Acta Oto-Laryngol., 2012. **132**(7): p. 751-755.
3. Grantham, D.W., et al. Ear Hearing., 2012. **33**(5): p. 595-603.
4. Battista, R.A., et al. JAMA Otolaryngol Head Neck Surg., 2013. **139**(1): p. 64-70.
5. Newman, C.W., et al. Otol Neurotol., 2008. **29**(8): p. 1123-1131.
6. Bench, J., et al. Brit J Audiol., 1979. **13**(3): p. 108-112.
7. Cox, R.M., et al. Ear Hearing., 1995. **16**(2): p. 176-186.
8. Kacelnik, O., et al. Plos Biol., 2006. **4** (4): p. 627-638.
9. Kuk, F., et al. Ear Hearing., 2014. **35** (6): p. 652-666.
10. Nawaz, S., et al. Otol Neurotol., 2014. **35** (2): p. 271-276.