LINKING SIGNAL-TO-NOISE RATIO TO HEARING AID SUCCESS

Gina Hone[1], B.S., Christi Miller[1], Ph.D., Michael Lee[1], PhD., Yu-Hsiang Wu[2], M.D., Ph.D., Ruth Bentler[2], Ph.D., Kelly Tremblay[1], Ph.D.

[1]Department of Speech and Hearing Sciences, University of Washington, Seattle [2]Department of Communication Sciences and Disorders, University of Iowa, Iowa City

INTRODUCTION

Purpose of Study:

- To identify new variables contributing to hearing aid success and to develop more sensitive clinical tools & protocols to maximize outcomes for HA users.
- Listeners with hearing loss need a more favorable signal-to-noise ratio (SNR) to perform at the same level as normal hearing listeners; yet HA processing often reduces the SNR from the input to the output.[1] Further, studies have shown that neural codes responsible for conveying speech information are sensitive to changes in SNR.[2,3]
- The **device-centered SNR** is the SNR at the HA output (e.g., extracted SNR via phase-inversion) . An individual's **intrinsic SNR** is a trait unique to, and required by, that individual to perform a particular listening task (e.g. acceptable noise level; SNR required to understand 50% of speech; performance-perceptual discrepancy).

Hypothesis: A person will report greater HA success if their HA produces a more favorable output SNR (e.g., +5) , and if the listener has a low intrinsic SNR (e.g., 0).

PARTICIPANTS

- 175 adult subjects recruited at UW and UI
- Bilateral, symmetrical, mild to moderately-severe sensorineural hearing loss
- Montreal Cognitive Assessment screening indicating adequate cognitive function for testing (> 21/30)
- Fluent speakers of American English
- Bilateral HA user (min of 8 hours/week)

Gender	Age (years)		Binaural PTA (dB HL)		MoCA (Total Score)	
98 F 77 M	Mean	SD	Mean	SD	Mean	SD
	67.06	10.76	40.53	11.81	26.82	2.18

Table 1. Demographics of participants.

METHODS

	Known Predictors	Experimental Predictors
Patient-Centered Variables	• Age (self-reported; years) • Personality (NEO Five-Factor Inventory-3)[4]: Neuroticism, Extraversion, Openness to Experience, Agreeableness, Conscientiousness • Gender (self-reported; categorical) • Self-Efficacy (Listening Self Efficacy Questionnaire; LSEQ)[5] • Auditory Lifestyle and Demand Questionnaire (ALDQ)[6] • Working Memory (WM; Word Auditory and Recognition Recall Measure)[7] • Pure-tone average, binaural (dB HL; PTA)	• Acceptable Noise Level (ANL)[8] • SNR for 50% correct (Hearing in Noise Test, SNR-50)[9] • SNR for 80% correct (Hearing in Noise Test, SNR-80) • Performance-Perceptual Discrepancy (PPDIS)[10]
Device-Centered Variables	• Audibility (Speech Intelligibility Index; SII; 65 dB speech input using real-ear measures) • Directionality (dB separation between mics across frequencies; 70 dB SPL/0 dB SNR input) • Noise Reduction (dB reduction in gain across frequencies; 70 dB SPL vacuum noise)	• SNR at the HA output (dB SNR; Hagerman's phase-inversion technique for sentences in 4-talker babble; speech at 65 dB SPL and noise from 4-speakers at SNRs from -10 to +15 dB)*

Table 2. Variables considered in this study. Predictors are categorized into either known or experimental, and patient- or device-centered.
*Excluded from analysis due to low validity of results.

Outcomes

- Hearing Aid Daily Use (self-reported; hours)
- Multimodal Lexical Sentence Test (MLST)[11]: Speech at 65dB SPL with visual cues and speech-shaped noise at +8dB SNR
- Abbreviated Profile of Hearing Aid Benefit (APHAB)[12]: Global Aided Score
- Hearing Handicap Inventory for the Elderly/Adults (HHIE/A)[13]
- Speech, Spatial, and Qualities of Hearing, v12 (SSQ)[14]
- Satisfaction with Amplification in Daily Life (SADL)[15]

Statistical Analysis: A series of stepwise, multiple linear regression models were used to evaluate the significance of predictors on each outcome. In the first model, experimental variables were entered and evaluated for significance. In the second model, a hierarchical procedure was used with known predictors entered into the first block of the model, followed by the experimental predictors.

RESULTS

Model 1: Experimental Predictors

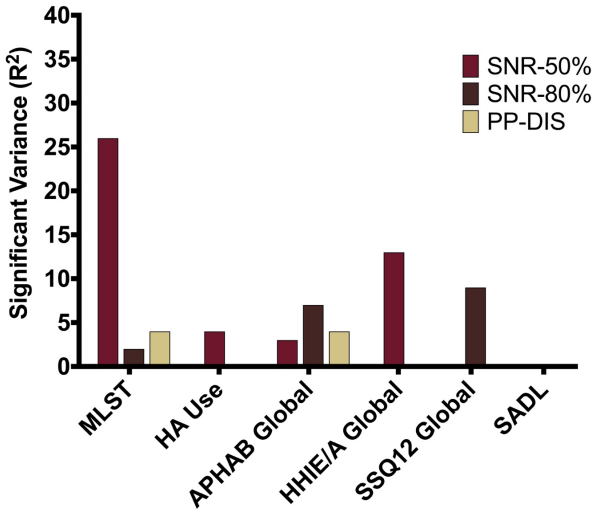

Figure 1. Significant variance explained by experimental predictors across outcomes at p=.05.
Overall ANOVAs for each outcome:
Speech-in-Noise [F (3,156) =24.243; p<0.0001; total R^2 =.32]
HA Use [F(1,133) =5.955; p=.016; total R^2 = .04]
APHAB Global [F (2,159) =12.821; p<0.0001; total R^2 =.14]
HHIE/A Global [F(1,161) =23.322; p<0.0001; total R^2 =.13]
SSQ12 Global [F(1,162) =15.258; p<0001; total R^2 = .09]
SADL Global [ns]

Model 2: Known and Experimental Predictors

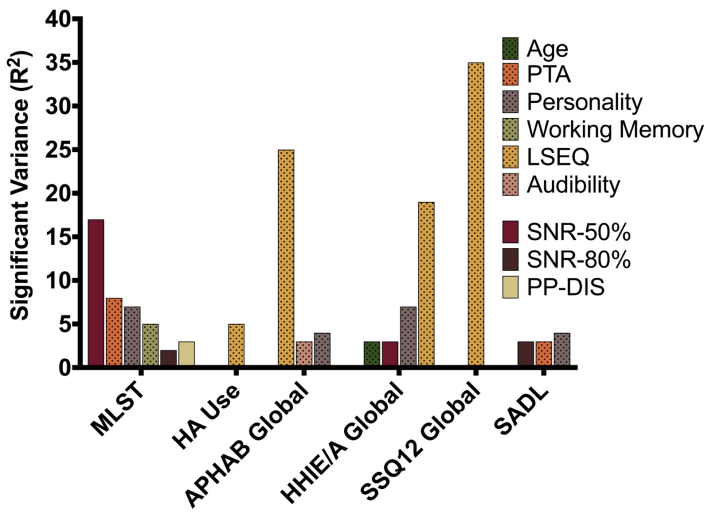

Figure 2. Significant variance explained by known and experimental predictors across outcomes at p=.05.
Overall ANOVAs for each outcome:
Speech-in-Noise [F (7,134) =13.293; p<0.0001; total R^2 =.41]
HA Use [F(1,117) =6.345; p=.013; total R^2 = .05]
APHAB Global [F (3,138) =21.057; p<0.0001; total R^2 =.31]
HHIE/A Global [F(4,385) =15.622; p<0.0001; total R^2 =.31]
SSQ12 Global [F(1,141) =76.002; p<0001; total R^2 =.35]
SADL Global [F (3,139) =4.711; p=.004; total R^2 =.09]

CONCLUSIONS

- Output SNR, as measured in this study, did not yield valid results for a majority of subjects. Explanations for this result are being explored.
- Intrinsic SNR (SNR-50, SNR-80, PPDIS) was informative to outcomes; however, once we controlled for known predictors, the contribution was minimized.
- The most consistent predictor across self-reported HA outcomes was listening self-efficacy. Although previous work suggests that self-reported outcomes (e.g., APHAB, HHIE) measure different underlying constructs than listening self-efficacy[11], they were highly correlated in this study. It is possible that rehabilitation focus on improving listening self-efficacy (e.g. role playing therapy) could improve other domains of success.

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