NON-CUSTOMIZED GAIN FREQUENCY RESPONSES FOR PRE-CONFIGURED HEARING AIDS: A CLINICAL TRIAL

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INTRODUCTION

- Financial barriers to conventional amplification has driven older adults with hearing loss to cheaper over-the-counter (OTC) hearing aids.
- Most existing OTC hearing devices have low-frequency emphasis[1,2] and hence are inappropriate for age-related hearing losses and could lead to poorer outcomes and reduced satisfaction with amplification.
- Our **long-term goal** is to aid in the development of affordable, evidence-based, pre-configured hearing aids for older adults with hearing loss.
- To achieve this goal, in earlier studies[3,4], our lab developed an evidence-based set of four gain-frequency responses (presets) for pre-configured devices. These gain frequency responses were chosen such that they could provide adequate amplification for 67.9% of older adults with bilateral mild-moderate hearing loss from the National Health and Nutrition Examination Survey database.

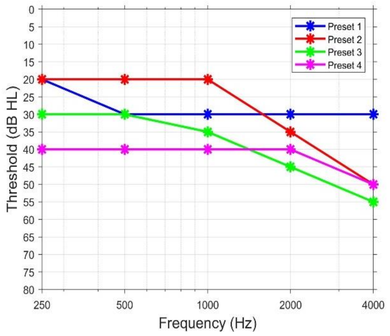

Figure 1. Audiograms associated with the four presets

- The **aim of the present study** was to evaluate the efficacy and effectiveness of the four previously developed presets (denoted as **HAAR**) in the laboratory and real-world to an existing OTC hearing aid (**OTC**) and to traditional fittings completed by an audiologist (**AUD**).
- We **hypothesized** that the outcomes of the presets or HAAR condition will be comparable to AUD condition and will be better than the OTC condition.

METHODS

Participants: 37 older adults (Mean age=70.5, range: 55-88) with bilateral mild-to-moderate sensorineural hearing loss.

Hearing aids: Power BTE with slim tubes: 8 channels, WDRC, 2 automatic programs, DNR and Dir: were left at manufacturer's defaults.

Table 1. Outcome measures

Domain	Laboratory	Real-world
Audibility	Speech Intelligibility Index (SII)[5]	
Speech Understanding	Nonsense Syllable Test (NST)[6]	Speech subscale of Speech, Spatial and Qualities (SSQ) of hearing scale[7]
Sound Quality	Connected Sentence Test[8] (CST) Ratings	Qualities subscale of SSQ
Listening Effort	CST Ratings	Effort Assessment Scale (EAS)[9] Ratings
Subjective preferences and Willingness to Pay (WTP)		

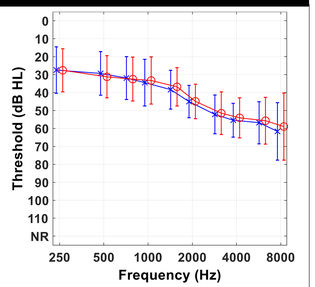

Figure 2. Mean Audiograms of all participants

Unaided testing & Selection-by-trial; Pre-trial condition- 1 week

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First, Second & Third field trial- 4 weeks each. Outcome measures (after each trial)
Subjective preference, WTP: Last visit

Figure 3. Study design. Field trials were randomized

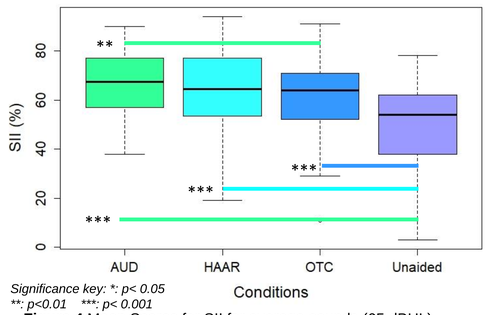
AUD: Hearing aids fit using Audiology best-practices and NAL-NL2 prescriptive formula

HAAR: Participants chose one of the four presets developed by our lab by listening to sentences in quiet and in noise with each of the four presets.

OTC: The gain frequency response of the hearing aids was programmed to match the frequency response of a commercially available PSAP FocusEar RS2 available in the market (mid-frequency emphasis[10]).

RESULTS

Audibility



*Significance key: *: p< 0.05 **: p<0.01 ***: p< 0.001*

Figure 4 Mean Scores for SII for average sounds (65 dBHL)

We used linear mixed effects model to analyze the differences between the unaided and the three aided conditions for the laboratory measures as well as the questionnaires. The different conditions (unaided, HAAR, OTC and AUD) were the independent variables and fixed effect, the outcome measures were the dependent variables and we added a random effect for participants.

We conducted post-hoc testing using Tukey test with correction for multiple comparisons.

Speech Understanding

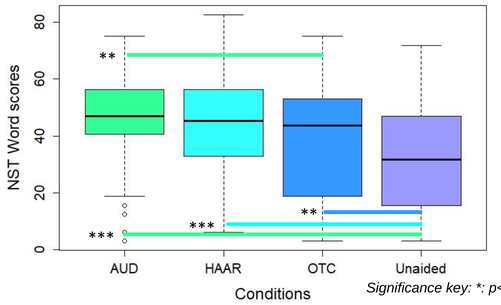


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Figure 5. Scores for Nonsense Syllable Test (NST) in quiet

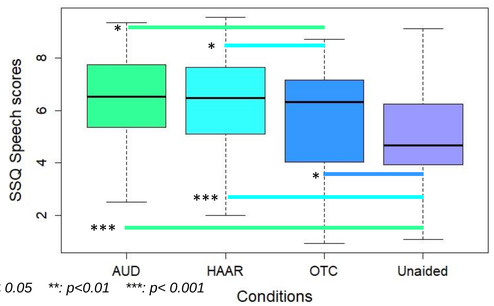
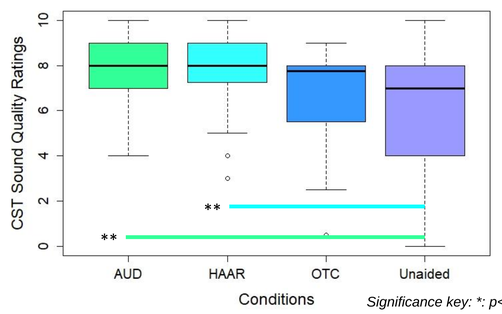


Figure 6. Scores for Speech sub-scale of Speech, Spatial and Qualities of hearing scale

Sound Quality



*Significance key: *: p< 0.05 **: p<0.01 ***: p< 0.001*

Figure 7. Sound quality ratings for connected sentence test in quiet

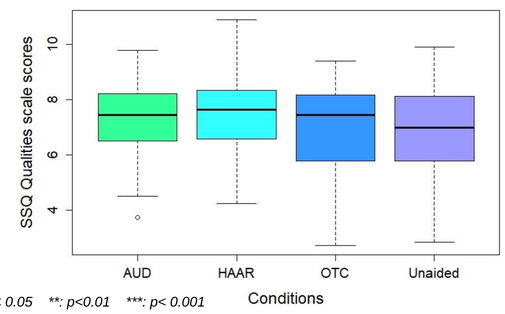
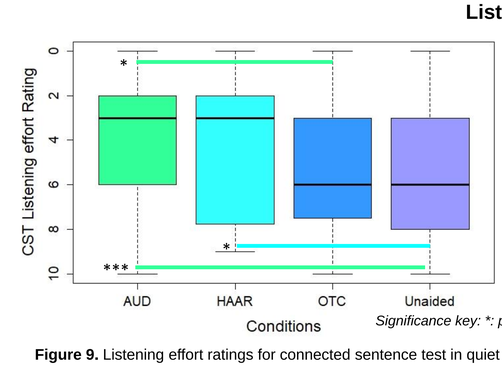


Figure 8. Ratings of Qualities sub-scale of Speech, Spatial and Qualities of hearing scale

Listening Effort



*Significance key: *: p< 0.05 **: p<0.01 ***: p< 0.001*

Figure 9. Listening effort ratings for connected sentence test in quiet

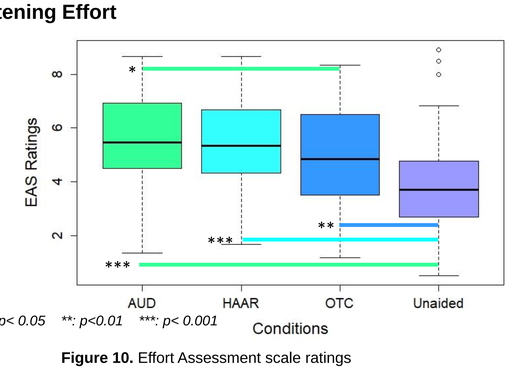


Figure 10. Effort Assessment scale ratings

Subjective preferences

Using Cochran's Q test, there was a statistically significant difference between the preferences (Q = 9.94, *p = 0.007*). We conducted follow-up pairwise testing using Dunn test with Bonferroni correction for multiple comparisons. Results showed that the HAAR configuration was significantly preferable to OTC (*p < 0.001),* while difference between preferences for AUD and HAAR (*p = 0.134*) was not significant.

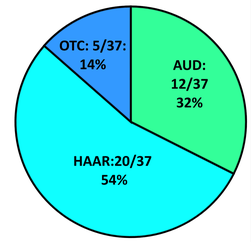


Figure 11. Participants' subjective preferences of hearing aids

Willingness to Pay

The mean dollar amount that participants were willing to pay for AUD model was $1050 (SD=1209.05), HAAR was $1048.58 (SD=1181.67) and OTC was $702 (SD=874.69). The main effect for these price differences was not significant ($F_{(2,69)}$ = 2.72, p = 0.073).

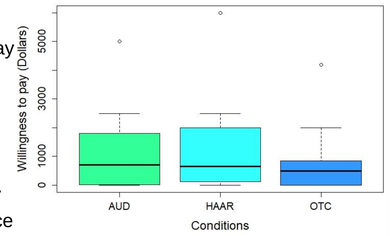


Figure 12. Amount that participants are willing to pay

DISCUSSION AND CONCLUSIONS

- We found our first hypothesis to be true: there was no significant difference between the HAAR and the AUD-based frequency response.
- Our second hypothesis that the HAAR model would perform significantly better than the OTC model was true in the domains of speech understanding in the real-world, and sound quality and listening effort in the laboratory.
- Thus, the gain-frequency responses developed by our lab show improvements in the laboratory (efficacy), real-world (effectiveness), and are also subjectively preferred by hearing aid users. This supports the implementation of these gain-frequency responses in pre-configured hearing aids.
- Further investigating these evidence-based gain-frequency responses will make OTC devices more affordable while maintaining their quality.

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CONTACT

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[1]Cheng et.al. Audiology. 2000, 39(2): 110-116. [2]Urbanski et al, AAS. 2019. [3]Urbanski et al., 2019, AAS. [4]Chan et al. BioMed research international, 2015. [5]ANSI, ANSI S3.5, 1997. [6] Kuk et al., EH, 2010, 31(6): 779-795. [7]Gatehouse et al., IJA, 43(2): 85-99. [8]Cox et al., EH, 1989, 10(1): 29-32. [9]Alhanbali et al., EH, 2017, 38(1), e39-e48. [10]Brody et al., AJA, 2018, 27(4): 581-593.