Development of Evidence-Based Gain-Frequency Responses for Preconfigured OTC Hearing Aids

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BACKGROUND

- Over-the-counter (OTC) hearing aids are intended to promote affordability and accessibility of amplification for older adults with mild-to-moderate age-related hearing loss; however, they must provide sufficient audibility in order to achieve quality outcomes.
- Non-customized hearing aid fittings may be a viable option for making amplification more affordable.
- However, most currently available non-custom devices have inappropriate gain characteristics for age-related hearing loss. Evidence shows these devices provide excessive low-frequency gain and insufficient high-frequency gain. Many are most suitable for reverse slope hearing losses.[1,2]
- **Study Aim:** Use population-based audiometric data to develop a set of hearing aid gain-frequency responses that can fit a large percentage of older adults with age-related hearing loss.

METHODS

Step 1: Gather NHANES Audiograms

- The National Health and Nutrition Examination Survey (NHANES) audiometry database was searched for the following criteria:
  - Age 55+
  - Bilaterally:
    - PTA ≥ 25 & ≤ 55
    - 250 Hz- 6 kHz ≤ 65
    - Tympanograms within normal limits
- For each NHANES audiogram, NAL-NL2 REAR targets 250 Hz-4 kHz for unilateral and bilateral fitting were obtained using an Audioscan Verifit
- Note that the NHANES audiometry database does not provide thresholds at 250 Hz. For the purpose of this analysis, the 500 Hz threshold was duplicated at 250 Hz.

NHANES Mean Audiometric Thresholds
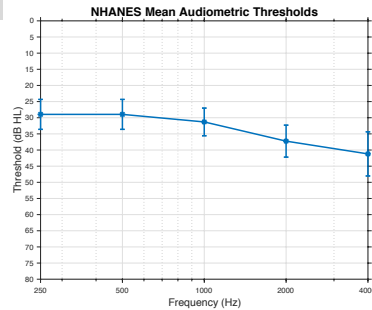
Mean audiometric thresholds of NHANES audiograms (n= 267 individuals, 534 ears, , 181 females, mean age= 70.1.

Step 2: Create Candidate Gain-Frequency Responses

- Generated 642 base audiograms by placing nodes on the audiogram and connecting them in all possible combinations
  - The nodes were placed to represent the range of mild-to-moderate hearing loss
- For each base audiogram, obtained NAL-NL2 REAR targets 250 Hz-4kHz using an Audioscan Verifit
- This resulted in 642 sets of REAR targets
- These REAR targets comprised **642 candidate gain-frequency responses**
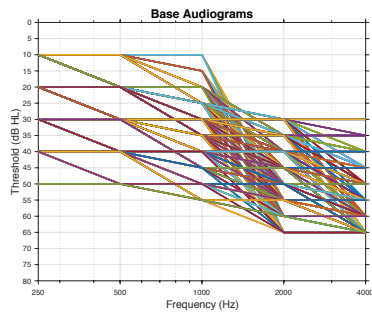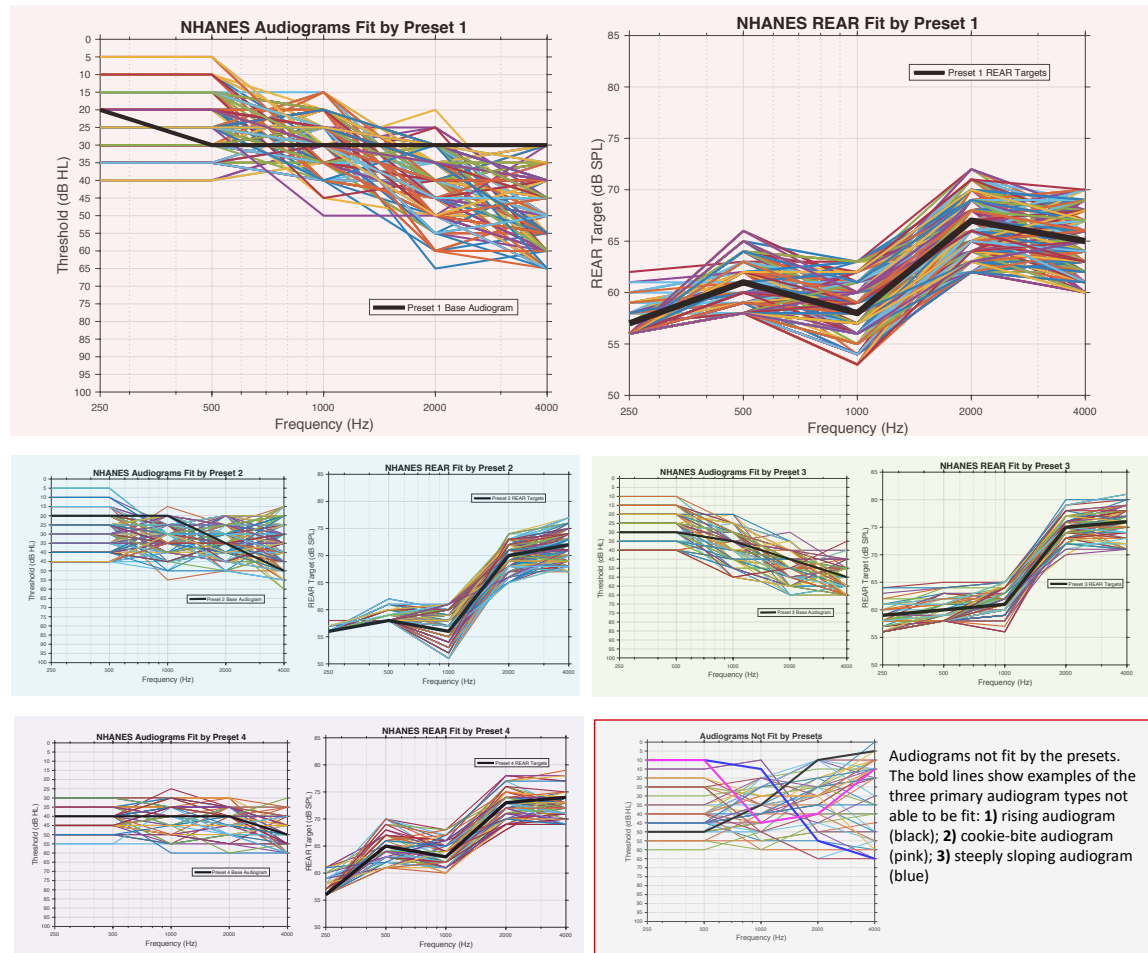

Base Audiograms

642 base audiograms used to create 642 candidate gain-frequency responses.

Step 3: Use Candidate Gain-Frequency Responses to Fit NHANES Audiograms

- Developed an algorithm to find the set of four candidate gain-frequency responses that will fit the maximum number of NHANES individuals
- For a given NHANES audiogram, a candidate gain-frequency response was considered a good fit if its REAR targets were within +/- 5 dB of the NHANES REAR targets from 250Hz-4kHz
- The algorithm exhausted all possible combinations of four presets from the set of 642 candidate responses
  - For each set of four, calculated the percentage of NHANES individuals fit in **all 3 fit conditions**: 1) unilateral right fitting; 2) unilateral left fitting; 3) bilateral right and left fitting
- The winning set of four was the set that fit the highest percentage of NHANES individuals

RESULTS

- The winning set of four presets fit 67.9% of NHANES individuals in **all three fit conditions**; unilateral fitting left and right and bilateral
- The remaining audiograms were primarily composed of 1) rising audiograms; 2) notched audiograms; 3) steeply sloping audiograms
- Shown below are the audiograms fit by each preset and their associated REAR targets, along with the audiograms that could not be fit

NHANES Audiograms Fit by Preset 1

NHANES REAR Fit by Preset 1

NHANES Audiograms Fit by Preset 2

NHANES REAR Fit by Preset 2

NHANES Audiograms Fit by Preset 3

NHANES REAR Fit by Preset 3

NHANES Audiograms Fit by Preset 4

NHANES REAR Fit by Preset 4

Audiograms Not Fit by Presets

Audiograms not fit by the presets. The bold lines show examples of the three primary audiogram types not able to be fit: **1)** rising audiogram (black); **2)** cookie-bite audiogram (pink); **3)** steeply sloping audiogram (blue)

REFERENCES

1. Chan, Z. Y. T., & McPherson, B. (2015). Over-the-Counter Hearing Aids: A Lost Decade for Change. *BioMed Research International, 2015*, 1-15.
2. Cheng, C. M., & McPherson, B. (2000). Over-the-Counter Hearing Aids: Electroacoustic Characteristics and Possible Target Client Groups. *Audiology, 39*(2), 110-116.

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DISCUSSION

- The results demonstrate that a set of 4 gain-frequency responses can fit approximately 70% of older adults with mild-to-moderate hearing loss, regardless of whether the individual selects a unilateral or bilateral fitting.
- These non-custom gain-frequency responses may be used in future service delivery models in support of public health initiatives aimed at promoting affordable, accessible amplification