



REAL-WORLD AIDED LOUDNESS AND HEARING AID OUTCOMES

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INTRODUCTION

Achieving appropriate loudness perception is essential for successful hearing aid fitting, as it influences comfort, speech understanding, and overall satisfaction^{1,2}. Although some prescriptive fitting methods aim to restore normal loudness growth, real-world loudness perception often varies across individuals and listening environments³.

The present study investigated the relationship between aided loudness perception in everyday settings and self-reported hearing aid outcomes. This insight could help refine fittings to improve outcomes and everyday listening. In this study, real-world loudness perception was assessed using the Cambridge Aided Loudness Profile⁴, while hearing aid outcomes were measured with the Abbreviated Profile of Hearing Aid Benefit⁵ and the Device-Oriented Subjective Outcome scale⁶. We hypothesized that hearing aid users whose aided loudness perception more closely approximates that of normal-hearing listeners would report more favorable outcomes.

METHODS

Participants:

- 16 normal-hearing listeners (NH)
- Age: 23~31 (M=27.5, SD=2.6); Female: n=5
- 35 experienced hearing aid users (HI)
- Age: 44~88 (M=71, SD=9.8); Female: n=11

Hearing aids:

- Starkey Edge AI 24 Receiver-in-Canal devices, programmed to e-STAT 2.0 fitting formula and verified with real-ear measurements using an AudioScan Verifit 2
- Acoustic coupling selection based on degree of hearing loss

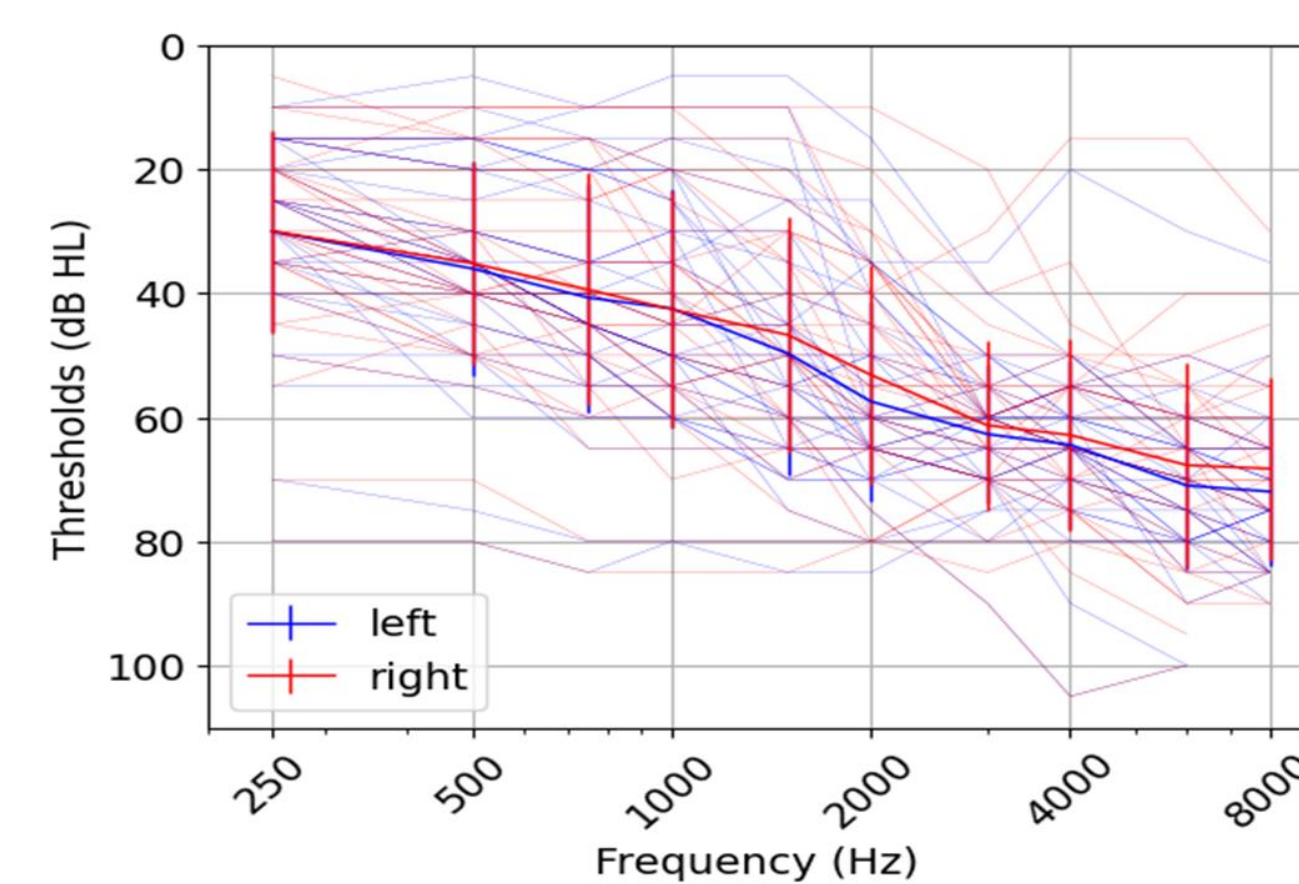


Figure 1. Mean and individual audiograms for HI participants

Cambridge Aided Loudness Profile (CALP):

This questionnaire is a modified version of the Profile of Aided Loudness (PAL)⁷. It assesses the loudness and appropriateness of soft, average, and loud everyday sounds. Example: Soft: "You chewing soft food;" Average: "Sound of cutlery on a plate, when eating;" Loud: "A door slamming, standing a few feet away."

Field outcome measures:

- **Abbreviated Profile of Hearing Aid Benefit (APHAB)** is a standardized questionnaire, in which patients report the amount of difficulty they are having in various everyday situations. It includes subscales for Ease of Communication (EC), Reverberation (RV), Background Noise (BN), and Aversiveness (AV), with scores ranging from 1% to 99%.
- **Device-Oriented Subjective Outcome (DOSO)** is a standardized questionnaire to evaluate perceived device performance. It includes subscales of Speech Cues, Listening Effort, Pleasantness, Quietness and Convenience, and Use, with scores ranging from 1 to 5 for Use and from 1 to 7 for the other subscales.

Procedures:

- Following any necessary fine-tuning, participants wore the hearing aids in real-world settings for at least one week. At the conclusion of the trial, they completed the CALP, APHAB, and DOSO questionnaires. Additionally, CALP data were collected from 16 adults with normal hearing.

RESULTS

Outcome data from the HI participants

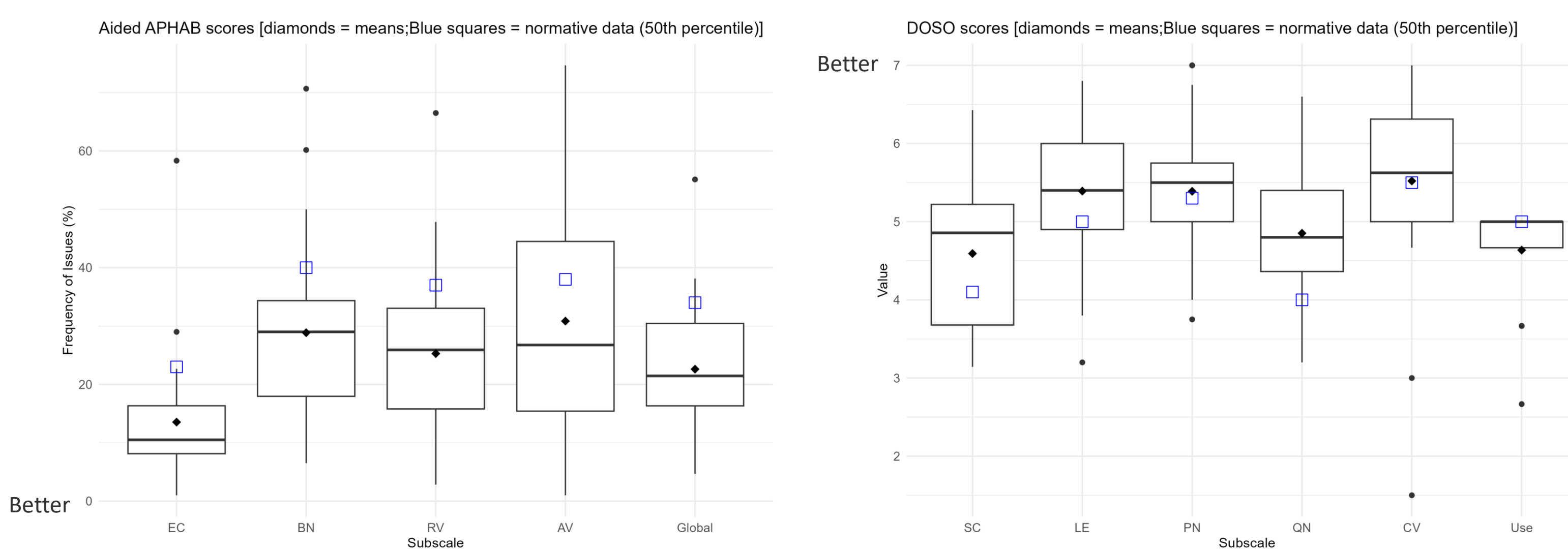


Figure 2. Distributions of APHAB and DOSO subscale scores for the participants (N = 35), presented with 50th-percentile normative values^{8,9}. APHAB: lower scores represent better outcomes. EC=Ease of communication; BN=Background noise; RV=Reverberation; AV=Aversiveness. DOSO: higher scores represent better outcomes. SC=Speech Cue; LE=Listening Effort; PN=Pleasantness; QN=Quietness; CV=Convenience

Outcome data from all 35 HI participants showed that median subscale scores met or exceeded normative 50th-percentile values, indicating adequate gain prescription and benefit from amplification.

Loudness data

Individual loudness ratings for soft, average, and loud sounds were plotted in a three-dimensional space (x = soft, y = average, z = loud) (Figure 3a). Mean ratings from normal-hearing participants served as normative references (Figure 3b).

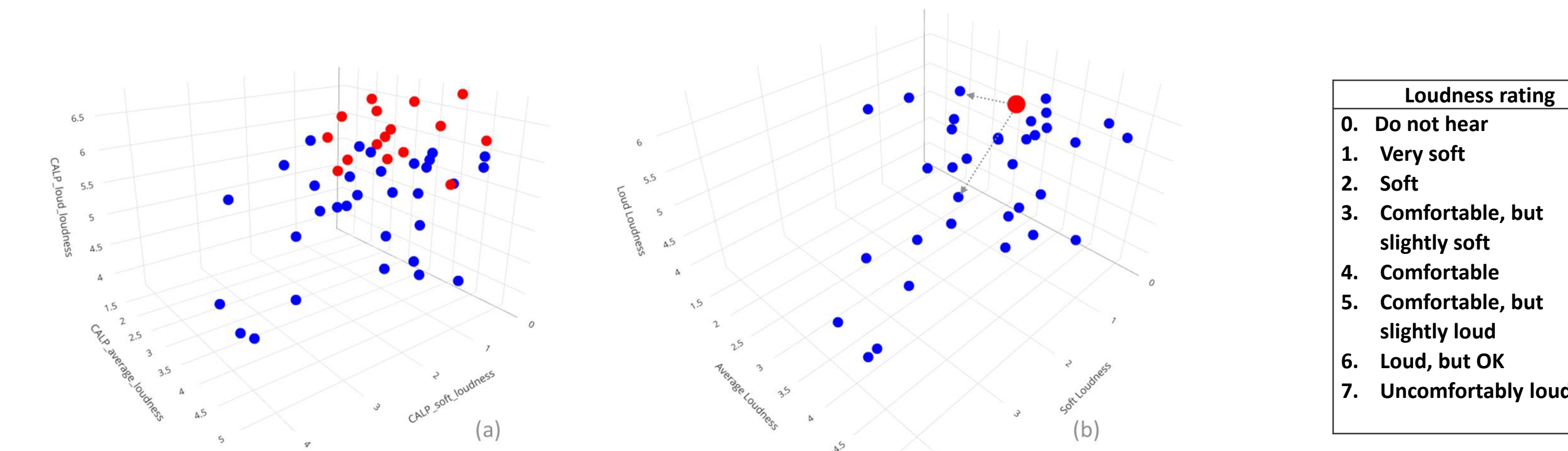


Figure 3. 3D scatter plots of CALP data for NH (red) and HI (blue) participants: (a) all individual data; (b) mean NH and all HI individual data. In panel (b), the arrows demonstrate the Euclidean distances—one smaller and one larger—from the mean NH ratings for two participants.

Aided loudness ratings relative to mean NH loudness perception

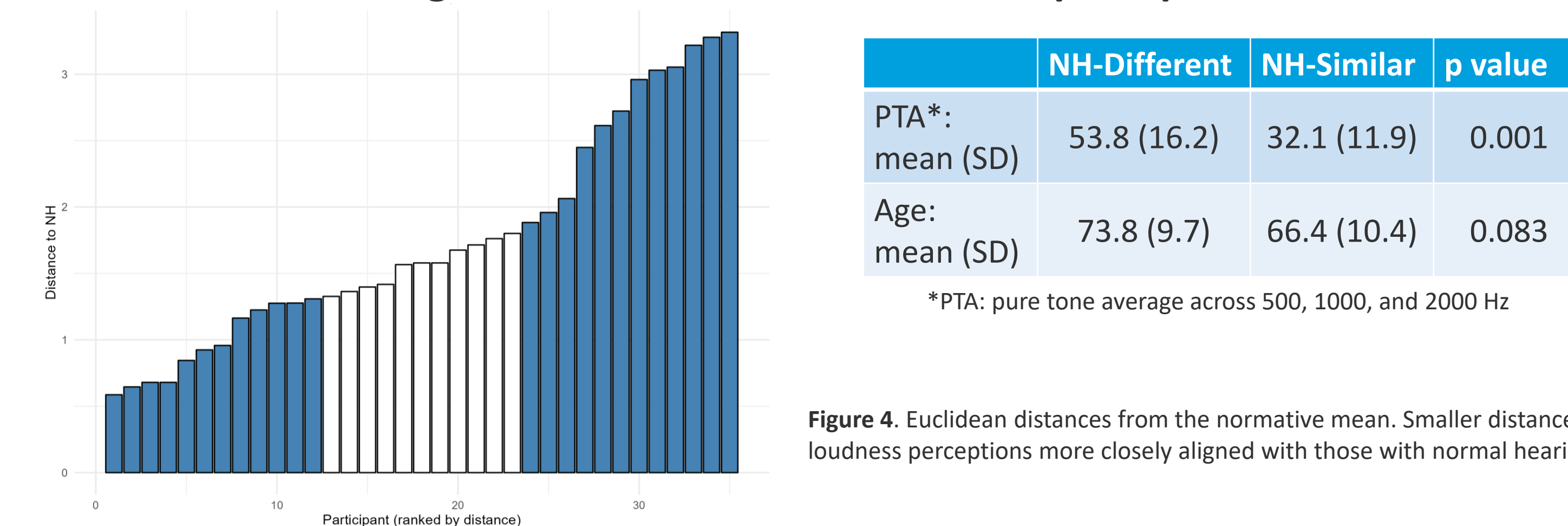


Figure 4. Euclidean distances from the normative mean. Smaller distances reflected loudness perceptions more closely aligned with those with normal hearing.

Participants were ranked according to their Euclidean distances, and the top and bottom tertiles (n = 12 per group) were selected to form two comparison groups: **NH-Similar** (closer to normal-hearing loudness perception) and **NH-Different** (more divergent loudness perception).

RESULTS (CONT.)

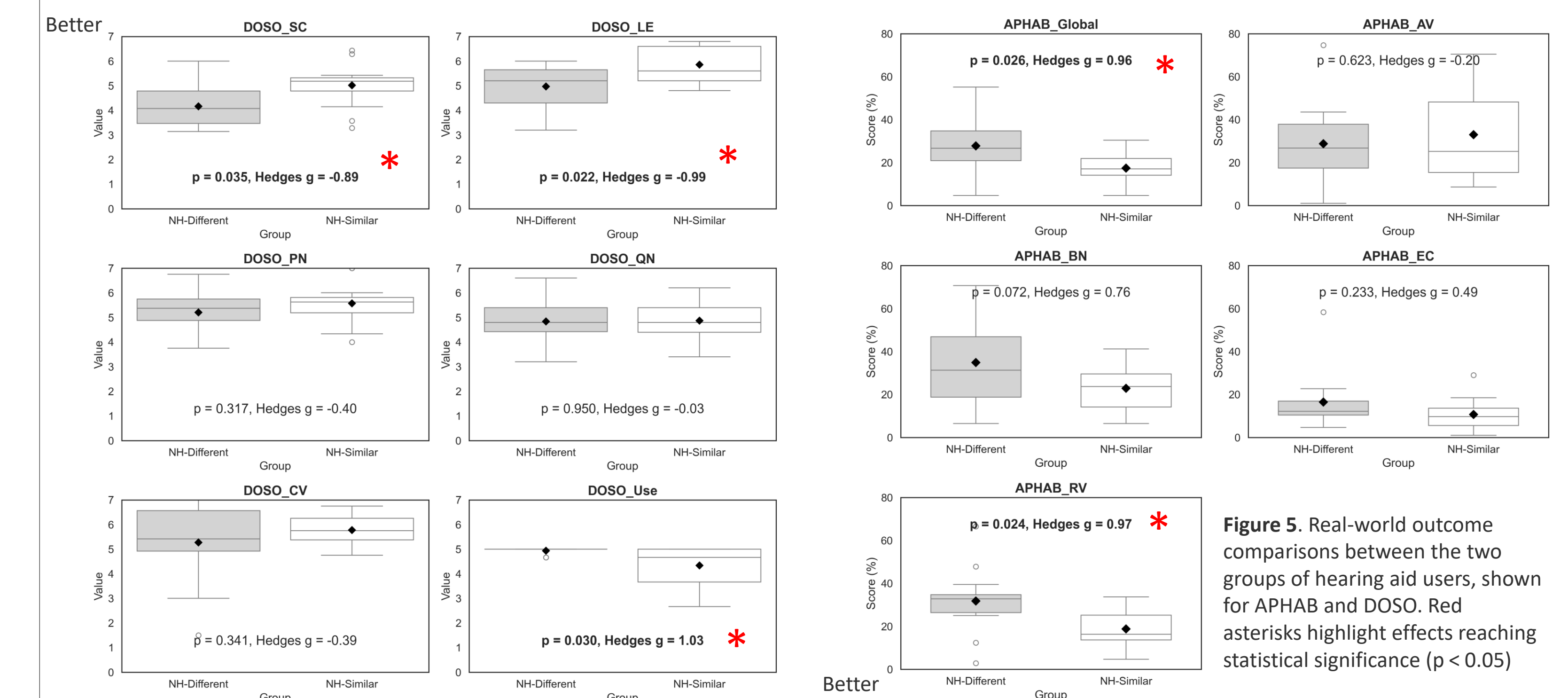


Figure 5. Real-world outcome comparisons between the two groups of hearing aid users, shown for APHAB and DOSO. Red asterisks highlight effects reaching statistical significance (p < 0.05)

Relative to the NH-Different group, the NH-Similar group demonstrated significantly better scores on aided APHAB Global, aided APHAB Reverberation, DOSO Speech Cues, and DOSO Listening Effort, but lower scores on DOSO Use.

CONCLUSIONS

- Loudness perception varies markedly across listeners during everyday listening. It is more homogeneous in normal-hearing listeners than in hearing aid wearers, whose loudness responses vary widely even with best-practice fittings.
- Overall, loudness perception aligned with normal-hearing profiles was associated with better subjective outcomes, especially in speech-related domains.
- Analysis of hearing loss and age indicated that, on average, the NH-Different group had more hearing loss and was older than the NH-Similar group. This aligns with prior findings showing that only about 37% of listeners with severe-to-profound loss showed normal or near-normal aided loudness growth³.
- The findings from this study suggest that real-world loudness perception plays a meaningful role in shaping hearing aid outcomes. Ensuring that loudness perception is appropriately adjusted during hearing aid fitting may enhance everyday listening and communication.
- Aided Loudness assessment may be beneficial when incorporated into hearing aid fitting protocols.

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