

Adaptive Assessment of Individualized Annoyance Levels with Ecologically Valid Stimuli



Krishna S. Rodemerck, Au.D.¹, Kamil Wojcicki, Ph.D.², and Jason A. Galster, Ph.D.¹

¹Starkey Hearing Technologies, ²BabbLabs, Inc.

INTRODUCTION

- Hearing aid wearers commonly complain of annoyance when listening to loud, impulsive, or transient sounds. Subjective reports of this nature prompt audiologists to adjust hearing aids in response, often reducing gains applied to loud inputs or adjusting hearing aid output limiting characteristics. This has motivated the development of signal processing for the management of transient sounds.
- The purpose of this study was to investigate a newly developed measure of annoyance, the individualized annoyance level (IAL). The IAL procedure asks participants to adjust soundfield presentation levels of ecologically valid transient stimuli to levels that they judge as annoying but not uncomfortable.
- Of specific interest was the extent of inter-individual and inter-stimulus variability observed during completion of the IAL procedure, as well as the relationship between IALs and traditionally measured loudness discomfort levels.

METHODS

- Fifteen participants with bilateral sensorineural hearing impairment completed this study (see audiogram below).
- Starkey Muse i2400 (size 312 battery) BTE hearing aids with research firmware were prescribed to proprietary (e-STAT) output targets for each participant's hearing loss and verified using in-situ real-ear measures.
- Participants were fit with Lucite, skeleton earmolds with audiologically appropriate venting.

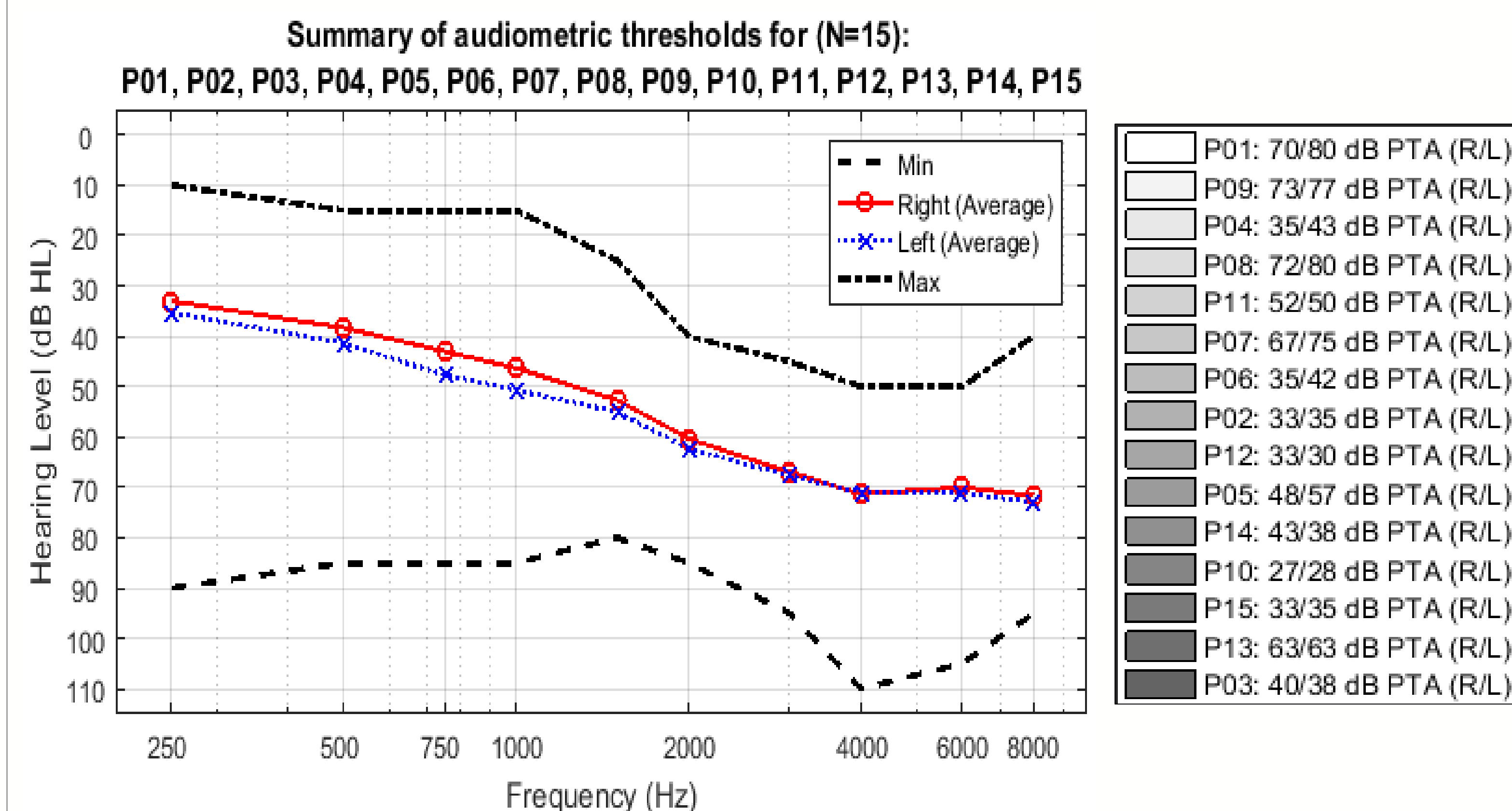


Figure 1: Average hearing thresholds (dB HL) are shown as a function of frequency for fifteen participants. The black dotted lines shows the minimum and maximum (range) of hearing thresholds. The three frequency pure-tone averages (500, 1000 and 2000 Hz) for right and left ears are shown in the figure on the right.

METHODS (CONT.)

- Unaided loudness discomfort levels (LDLs) were collected at 0.5 and 3 kHz.
- Four ecologically valid transient stimuli were presented to participants wearing hearing aids in a sound treated booth:
 - Cutlery drawer slam
 - Cutlery clattering
 - Keys jingling
 - Spoon hitting ceramic

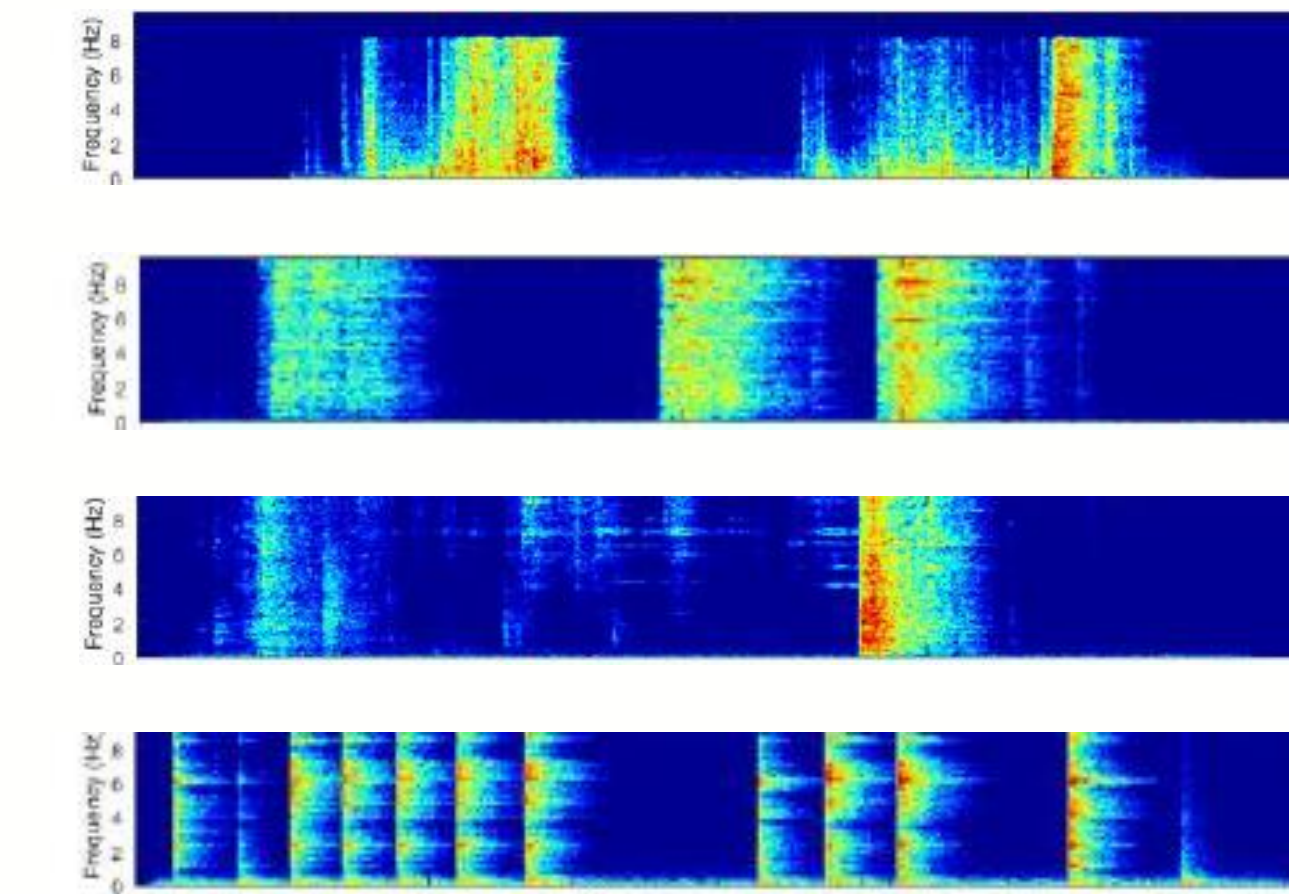


Figure 2: Spectrograms of the cutlery drawer, cutlery clattering, keys jingling, and spoon on ceramic bowl stimuli.

- The recorded stimuli were presented from a loudspeaker at 0° azimuth.
- Participants manually adjusted stimuli levels via a volume control first to a loudness level that was considered **uncomfortable**, second to a **comfortable** level, and then to a level where the stimulus was first judged to be annoying, called the **individualized annoyance level (IAL)**.
- Participants repeated this task three times for each stimulus (36 total measurements per participant) and the levels were averaged over the three trials.

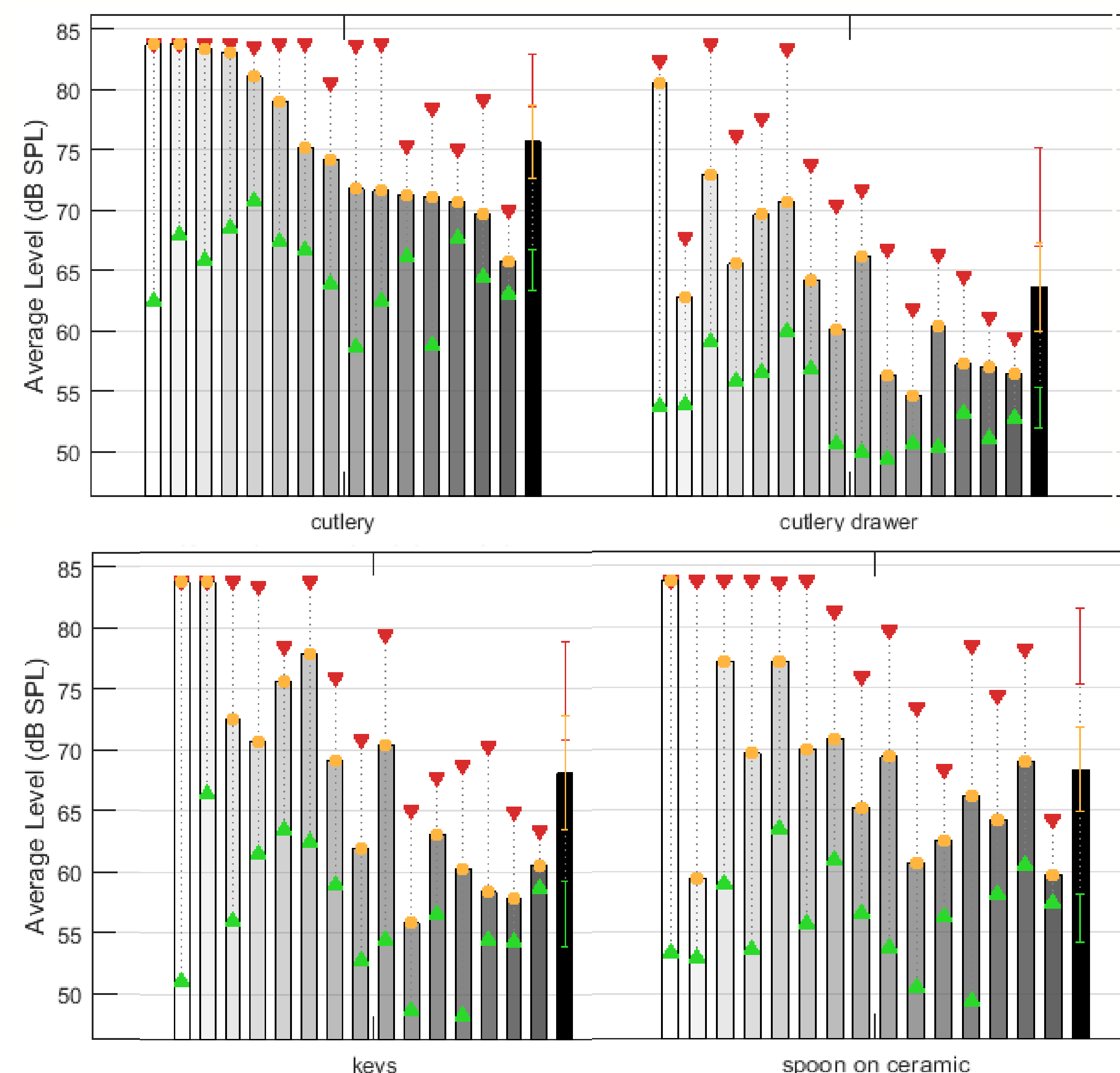


Figure 3: Individualized annoyance levels for each participant per stimulus. The red triangles represent the **uncomfortable** loudness levels, the green triangles represent the **comfortable** loudness levels, and the orange triangles represent the individualized **annoying** levels (IAL). The black bar represents the average across participants for that stimulus. Note that the results are shown in decreasing order, referenced to IALs for the cutlery stimulus. The maximum presentation level was 85 dB SPL.

RESULTS AND CONCLUSIONS

- Individual annoyance levels varied greatly (up to 25 dB SPL) across individuals and across stimuli (noise types). The magnitude of this variance agrees with earlier assessment of LDLs¹.
- Average LDLs (across frequencies) and average IALs (across three trials) were significantly correlated for cutlery clattering, cutlery drawer, and keys jingling.

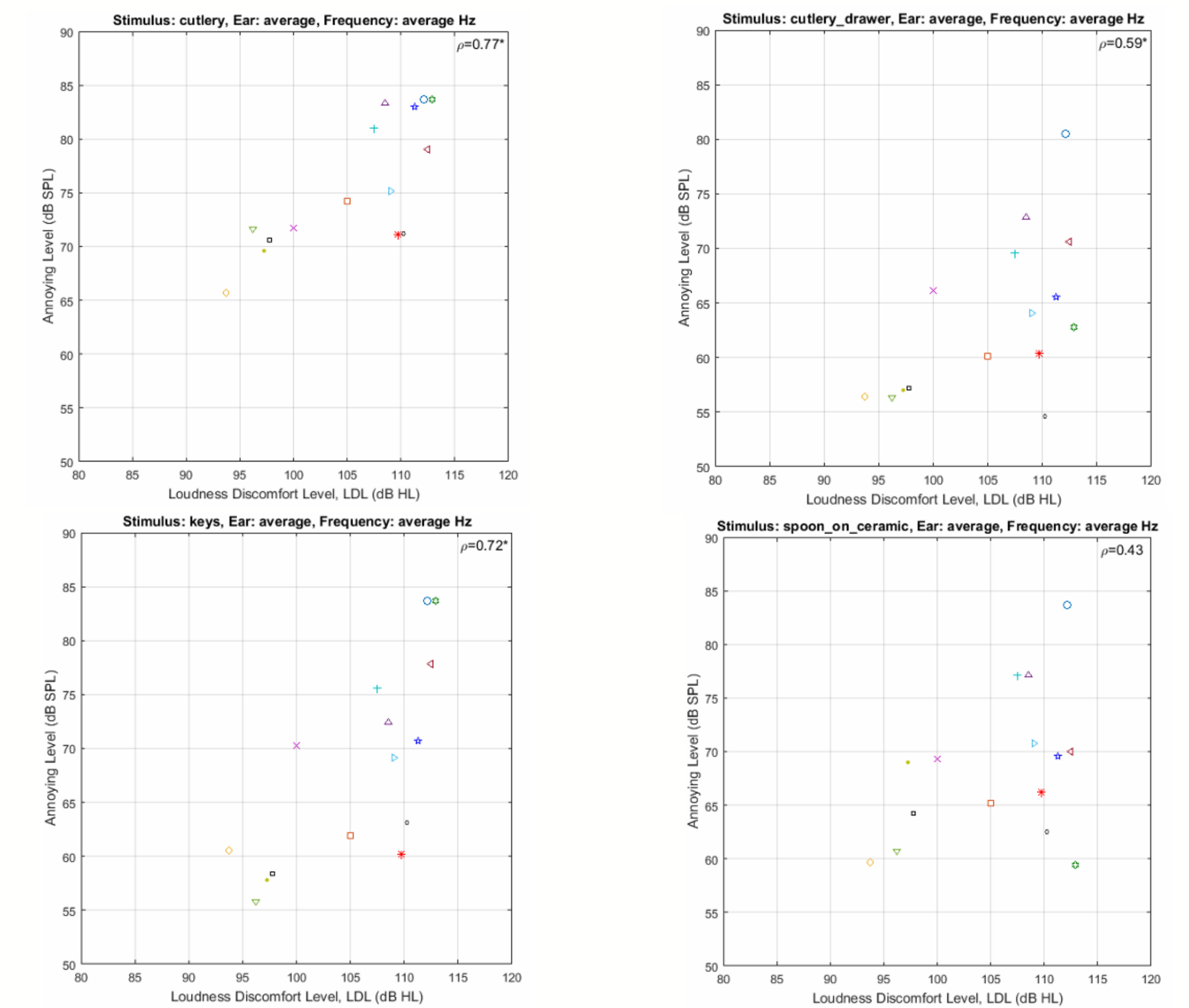


Figure 4: Individualized annoyance levels as a function of average loudness discomfort level (across ears and across both frequencies) for each participant per stimulus (clockwise from top left: cutlery, cutlery drawer, spoon hitting ceramic bowl and keys).

- The IAL is a new measure that uses ecologically valid stimuli to measure the level at which patients find sounds annoying. This procedure shows promise for individualizing the prescription of hearing aid maximum output or other signal processing, with the goal of decreasing loudness discomfort during daily life.
- Further research is necessary to validate the utility of the IAL as an element of the hearing aid fitting routine.

REFERENCES

- Mueller, H.G. & Bentler, R.A. (2005). Fitting hearing aids using clinical measures of loudness discomfort levels: An evidence-based review of effectiveness. *J Am Acad Audiol*, 16(7), 461-472.
- Mackersie, C. (2007). Hearing aid maximum output and loudness discomfort: Are unaided loudness measures needed? *J Am Acad Audiol*, 18(6), 504-514.