Externalization of speech through hearing aids differing in microphone position and dome type

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BACKGROUND

Survey data suggest that sound image externalization can be disrupted by hearing aids [1,2].

Behavioral data are scarce ([see review in 3]) but a few factors have been implicated:

- occlusion of the ear canal
- unnatural microphone position
- non-linear processing disrupting binaural cues

Here our goal was to obtain sound-externalization ratings for different devices, with a focus on the physical form of the devices.

METHODS

Participants

- 10 adults with normal hearing (NH, 20-31 years) given 10 dB of flat, linear gain
- 8 adults with hearing impairment (HI, 18-33 years) fit according to manufacturer guidelines

Devices

- Commercial devices (GN ReSound One receiver-in-the-canal aids with M&RIE technology) configured to use behind-the-ear (BTE) or in-the-ear (ITE) microphones
- Fitted with closed (power) or open domes
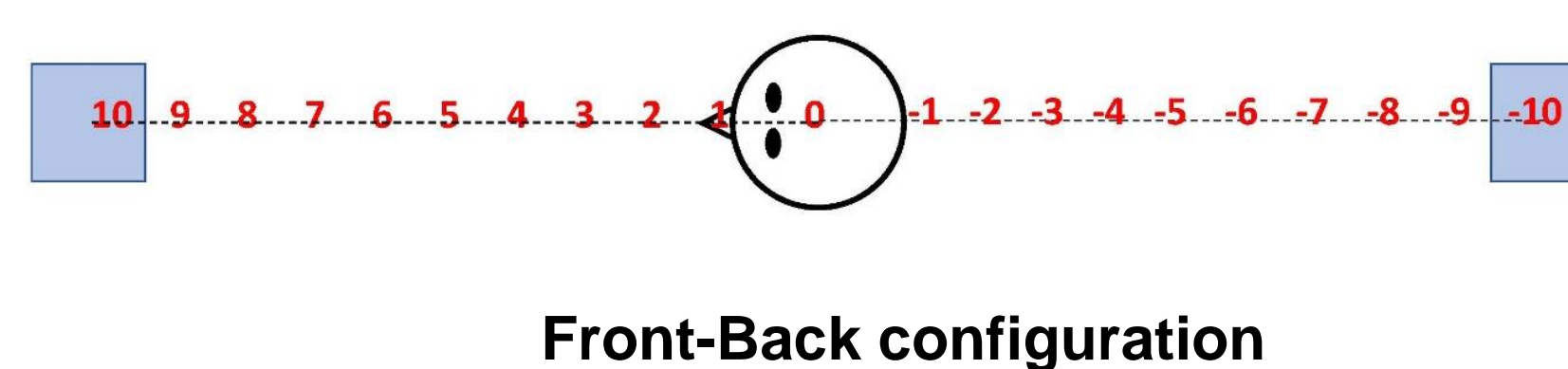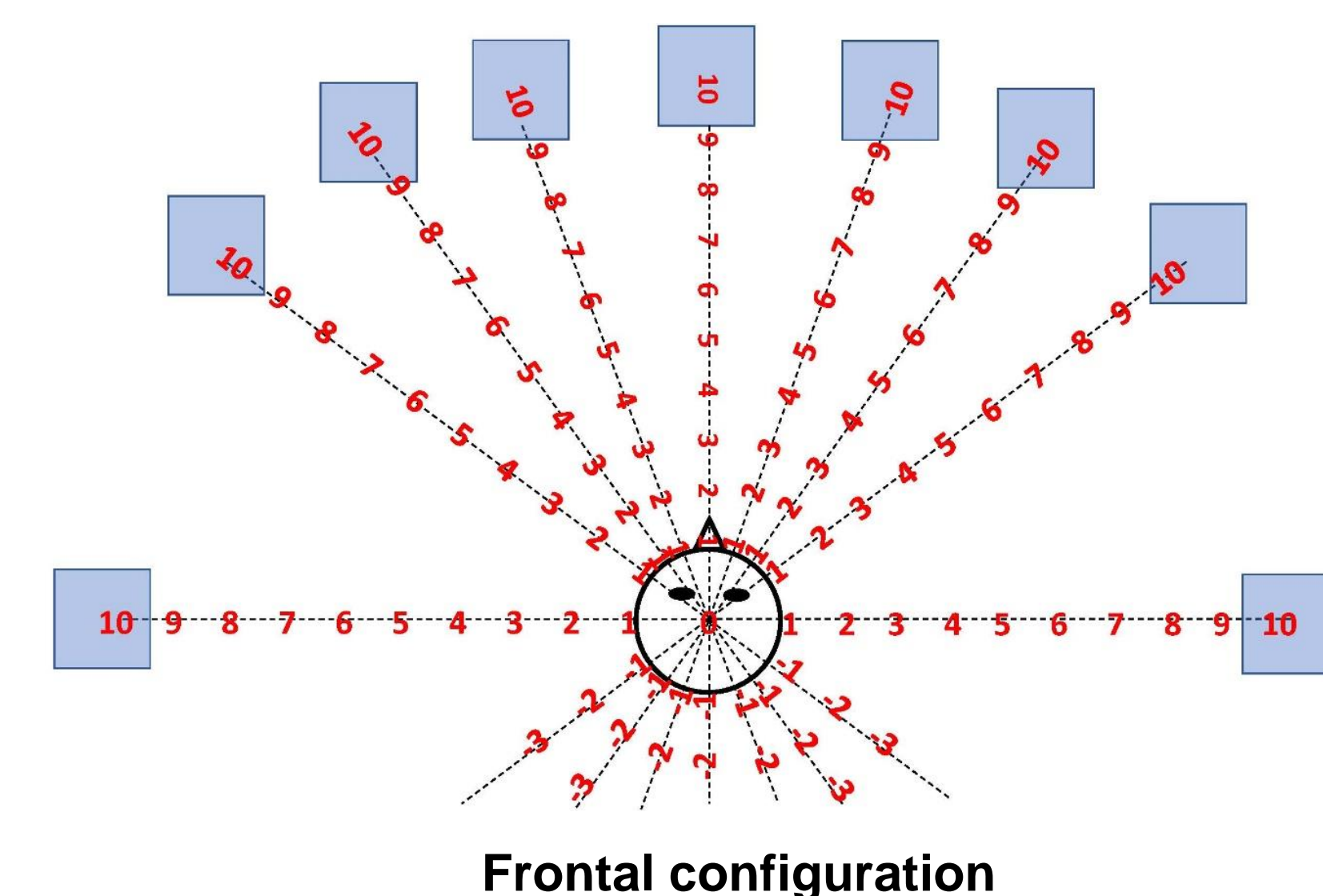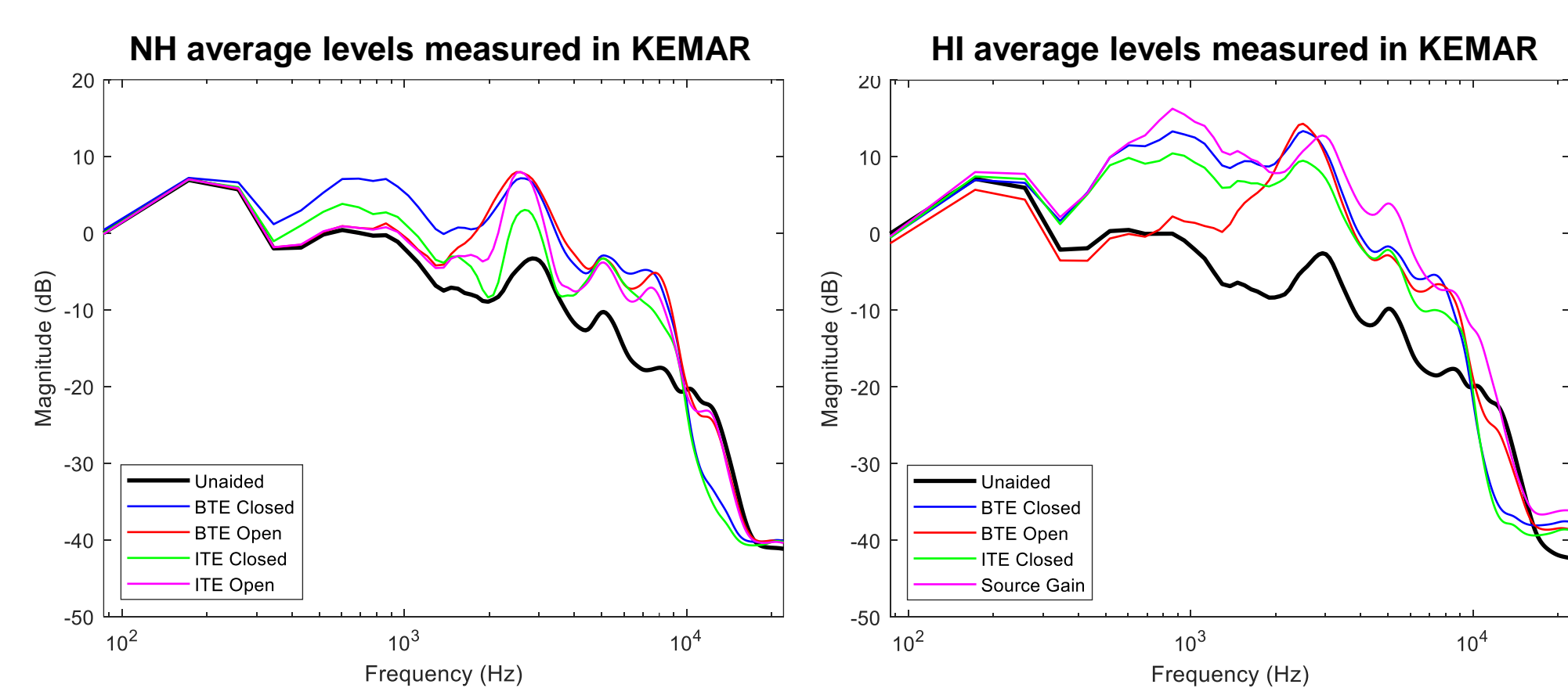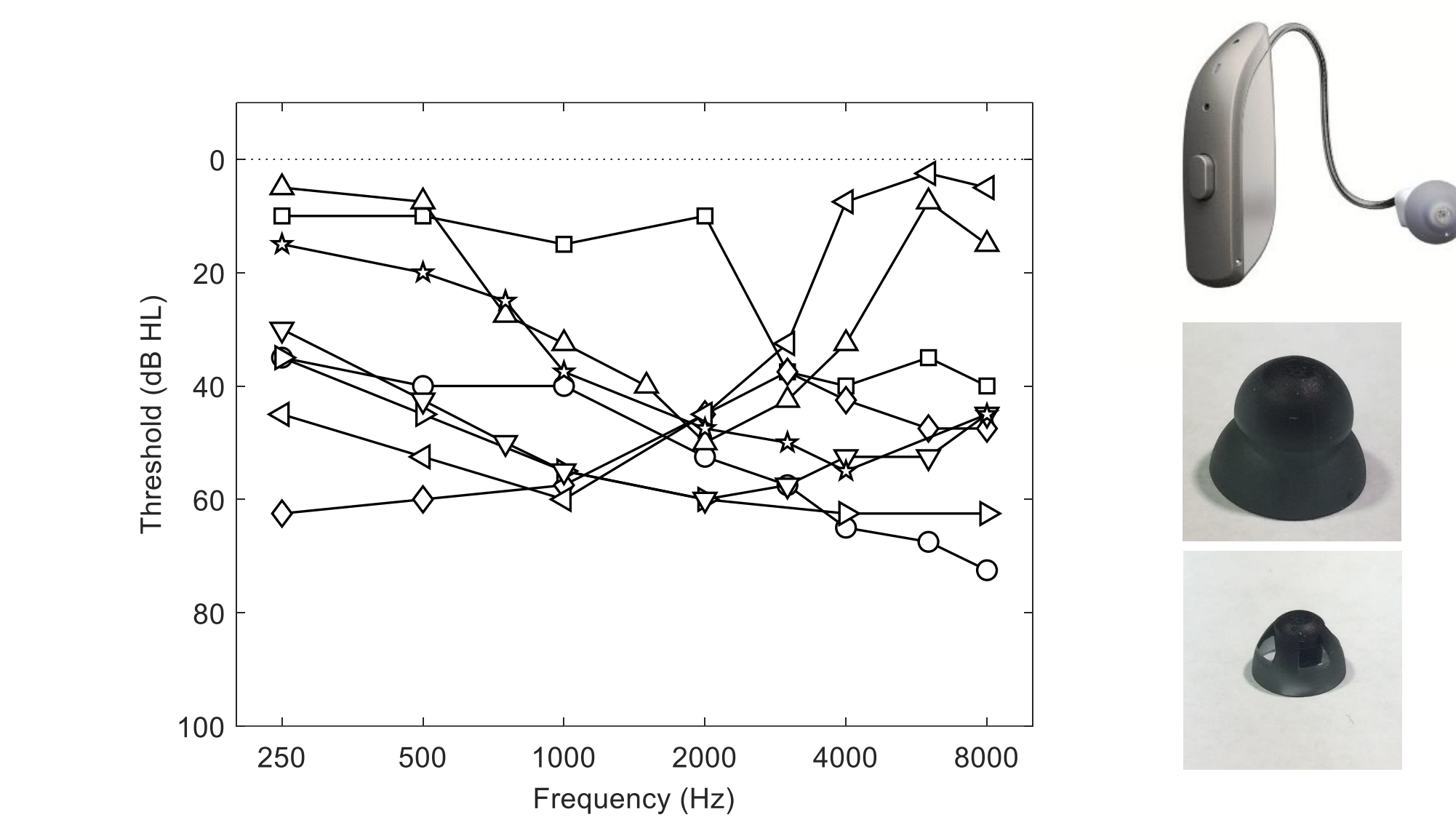
Hearing aid conditions

- Unaided
- BTE Closed
- BTE Open
- ITE Closed
- ITE Open (NH only)
- Source Gain (HI only)
- Own Aids (HI only, 5 of 8)

Stimuli

- Monosyllabic words spoken by 20 talkers
- Presented randomly at 50/55/60 dB SPL
- Frontal configuration: 7 loudspeakers in the frontal hemifield
- Front-Back configuration: 2 loudspeakers in front and behind

Task

- Participants seated in a soundproof booth with head still but not fixed
- Externalization rated via a continuous distance scale (-10 to +10)

Frontal configuration

Front-Back configuration

RESULTS
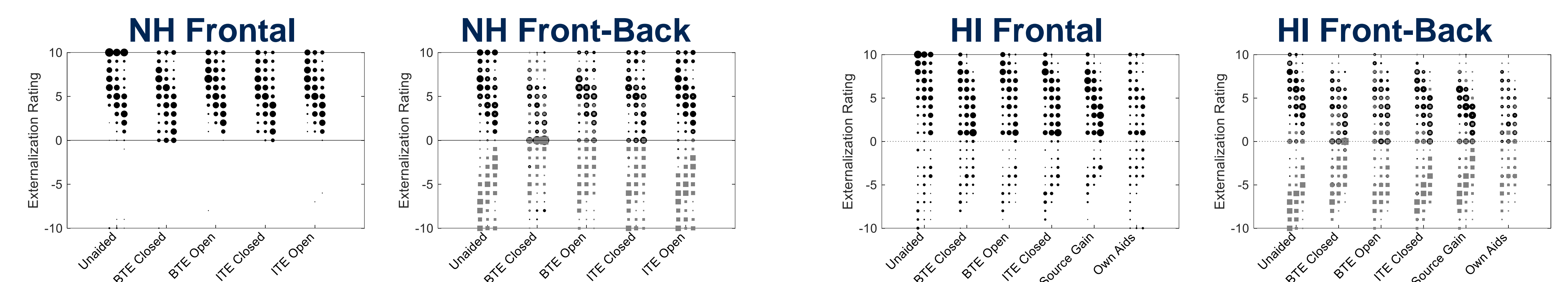
Linear Mixed Effects Models were fit to Absolute Externalization Ratings with fixed effects of Hearing Aid Condition, Level, and Azimuth, and a random intercept for Subject. All models showed significant effects of Hearing Aid Condition and Level. Significant post hoc contrasts of interest are shown as brackets above the bars below.
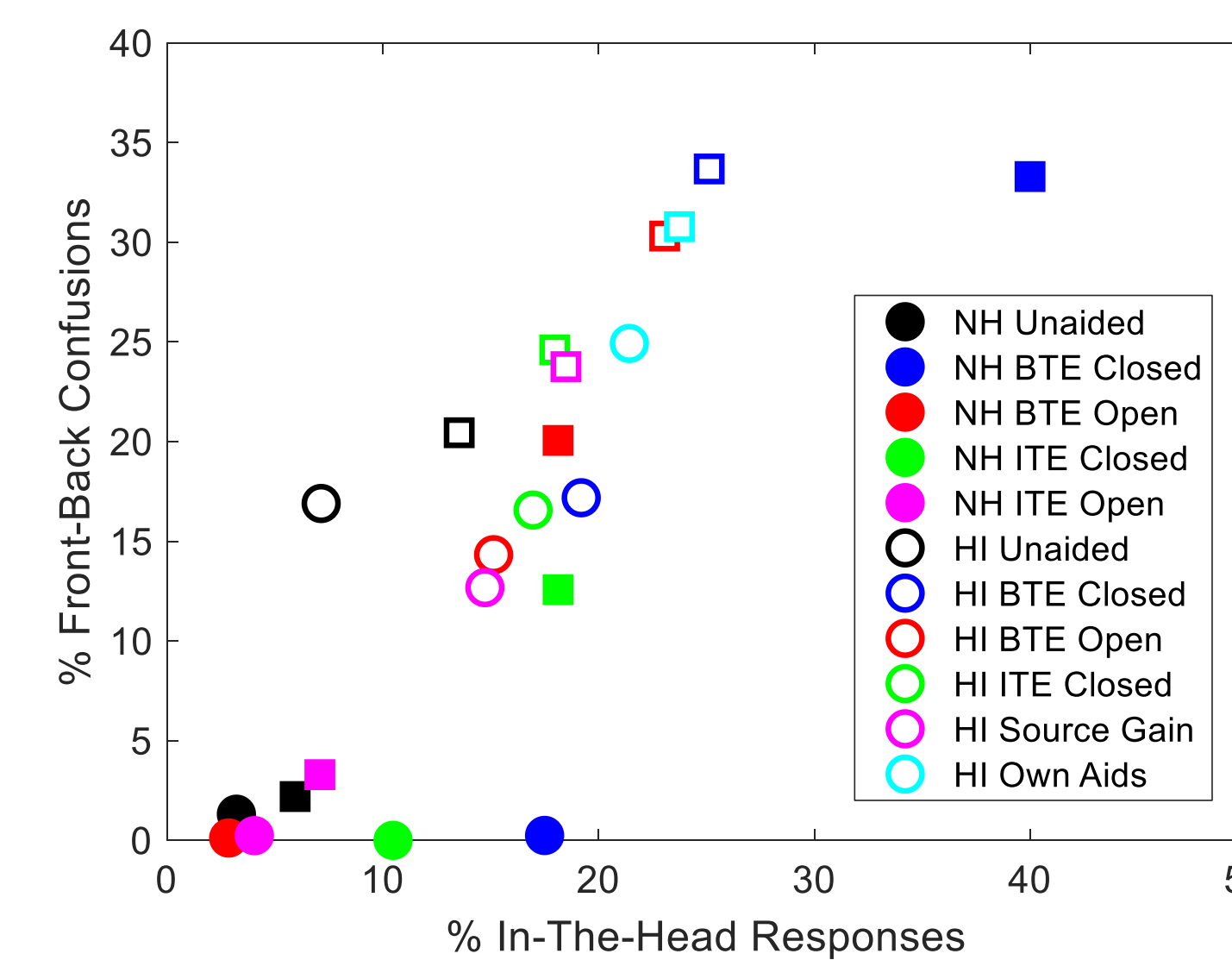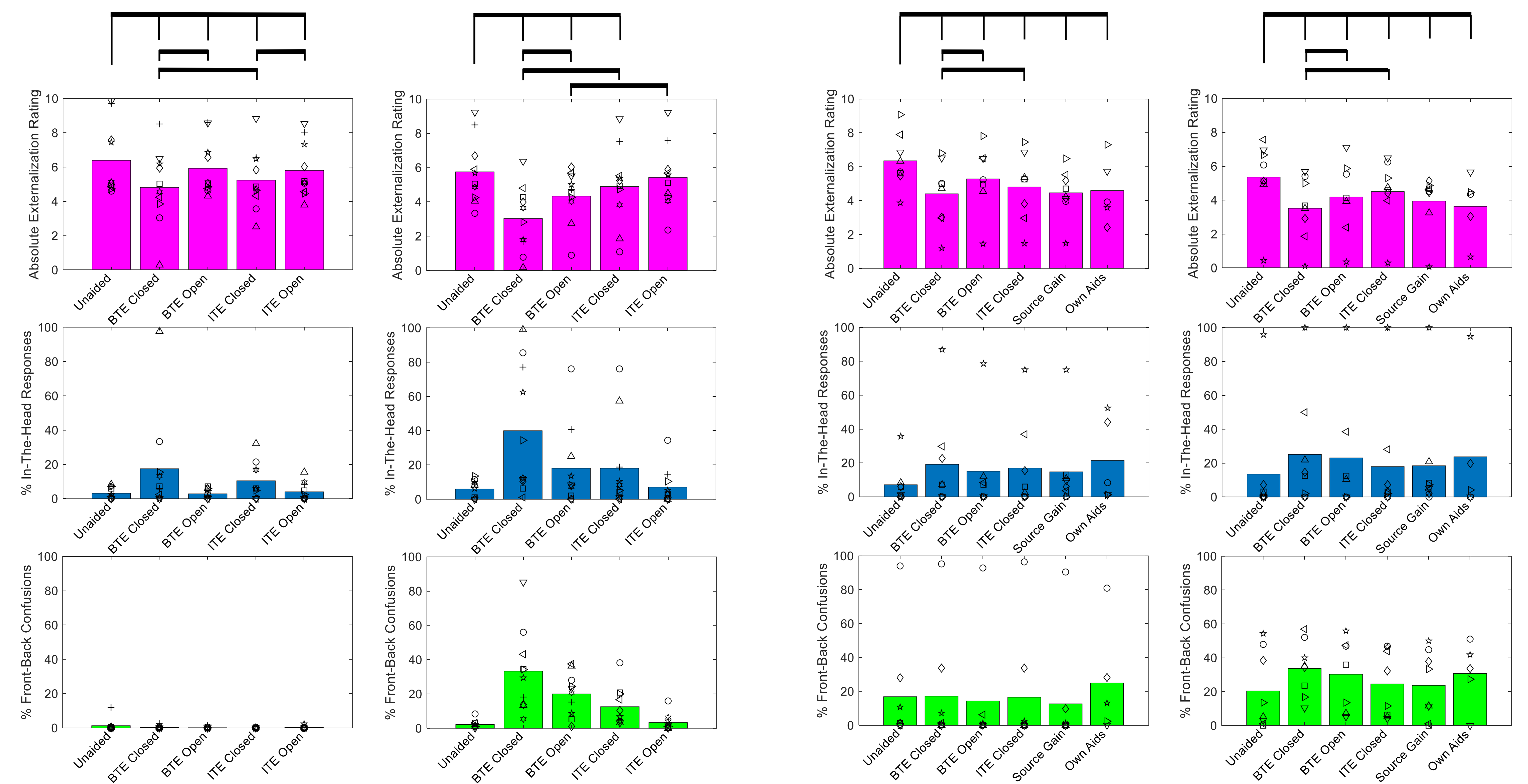
CONCLUSIONS

Hearing aids generally disrupt the externalization of speech, but there are dramatic individual differences.

Closed domes and BTE microphone position appear to be contributing factors.

Poor externalization may be associated with increased front-back confusions.

1. Noble W & Gatehouse S (2006). Effects of bilateral versus unilateral hearing aid fitting on abilities measured by the Speech, Spatial, and Qualities of Hearing Scale (SSQ). Int J Audiol 45:172–181.

2. Boyd AW (2014). Experimental investigations of auditory externalization and the application of head-movement information to hearing-aid signal processing. PhD Thesis, Univ of Strathclyde.

3. Best V, Baumgartner R, Lavandier M, Majdak P & Kopčo N (2020). Sound externalization: a review of recent research. Trends Hear 24:2331216520948390.