Effect of Stimulus Configuration & Response Criterion on Directional Preference

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MOTIVATION

- Directional benefit demonstrated in the laboratory[6,13].
- Success with directionality in everyday life not predictable from laboratory measures of directional advantage[3].
- Although directional benefit is reported in real-world listening situations[8], it is best described as lukewarm ...
  - ✧ Directional mode preferred only ~25% of the time[4],
  - ✧ 25% dissatisfied with hearing aids in noisy situations[10],
  - ✧ Directional microphones are found in only 32% of hearing aids[10].
- Disconnect attributed to acoustics of the environment ...
  - ✧ Presence, location and distance of signal and noise[15],
  - ✧ Reverberation[11,12],
  - ✧ Typical input levels[1,14].
- Aim: To investigate directional preference in the context of the following considerations ...
  - ✧ Location of speech (front, rear) and noise (diffuse, left),
  - ✧ Type of stimuli (standard laboratory, simulated real world), and
  - ✧ Response criterion (speech intelligibility, listening comfort).

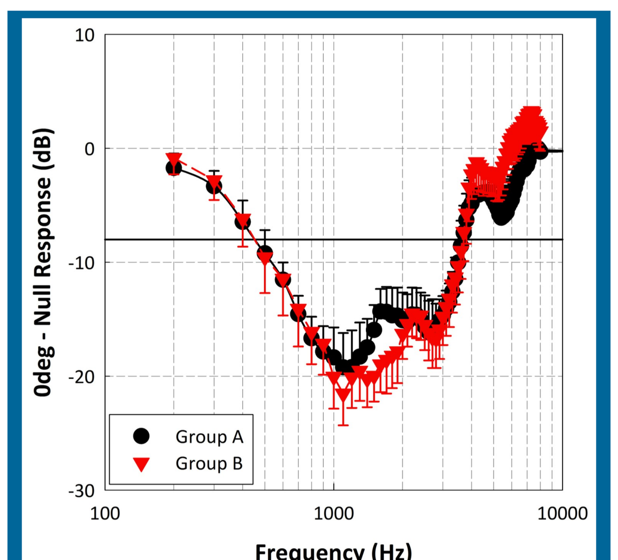
METHODS

Participants

- 20 adults with mild-to-moderate hearing loss
  - ✧ 9 females, 11 males,
  - ✧ Age: Mean 70 years, range 55-83 years.
- Experienced hearing aid users.
- Participants divided into 2 groups.
  - ✧ Group A (n=11): Standard stimuli,
  - ✧ Group B (n=9): Simulated real-world stimuli.

Hearing Aids & Fittings

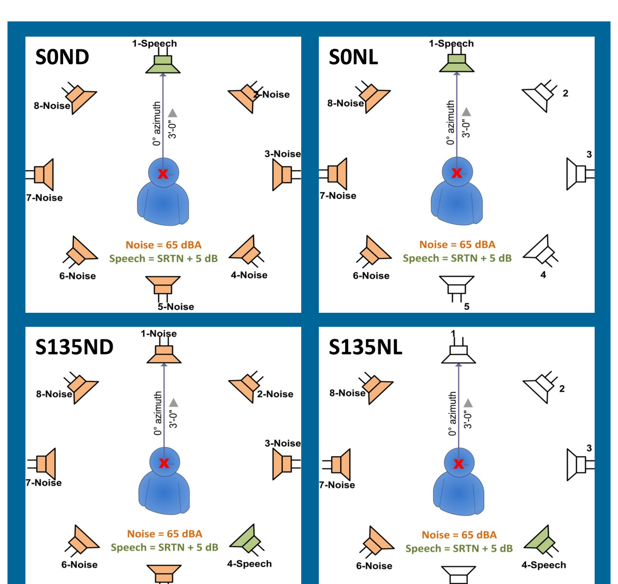
- Bilateral BTEs.
  - ✧ Occluded molds, 2mm SAV.
- Hearing aid gains matched to eSTAT.
- Expansion and adaptive feedback cancellation on; noise reduction off.
- M1=omnidirectional, M2=directional.



Static directionality: Mean ± 2 standard errors. Goal: ≤ -8 dB between 500 and 3000 Hz.

Procedure

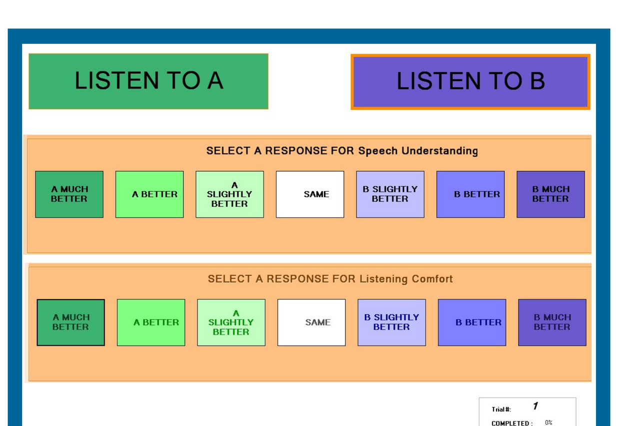
- Stimuli
  - ✧ Standard: Laboratory stimuli using speech-shaped noise and concatenated HINT sentences. SNR fixed at 5 dB above omnidirectional HINT threshold.
  - ✧ Real-world: Real-world scenarios simulated via 5.1 surround sound. Various signals and background noises. Scenarios judged to be realistic by 3 normal-hearing listeners.



Standard laboratory test conditions.

Simulated real-world scenarios — restaurant, theater, home, car.

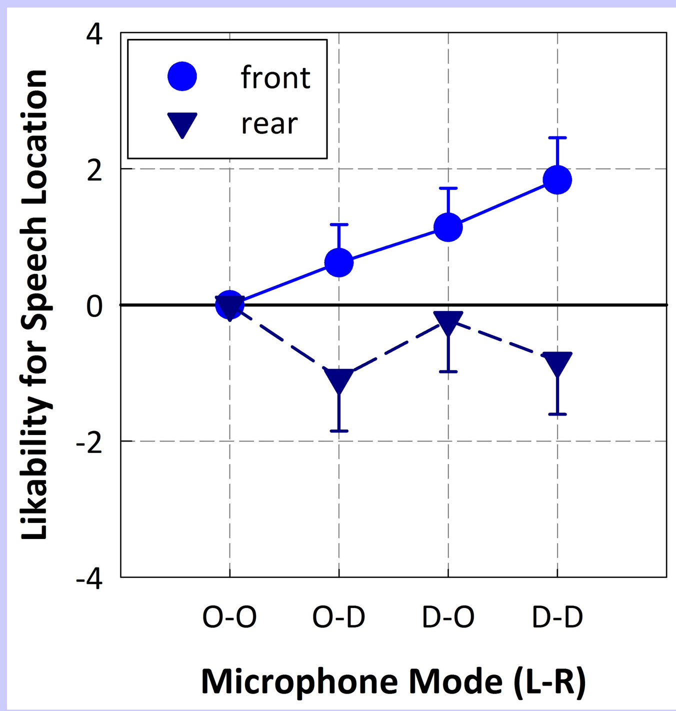
- Benefit evaluated as patient's response to "Which program is better?"
- HA settings evaluated in pairwise comparisons.
  - ✧ Selection of Setting A and Setting B randomized.
- Task: Select setting with better speech intelligibility or comfort.



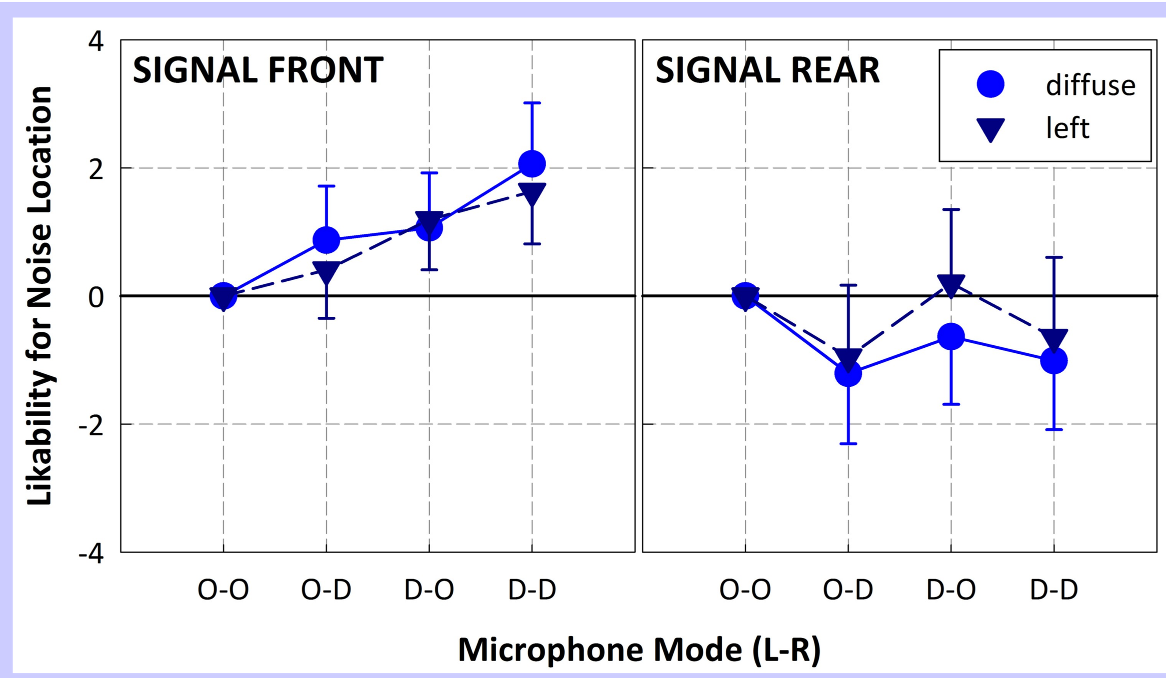
User interface for evaluation of subjective preference in a paired comparison format.

RESULTS

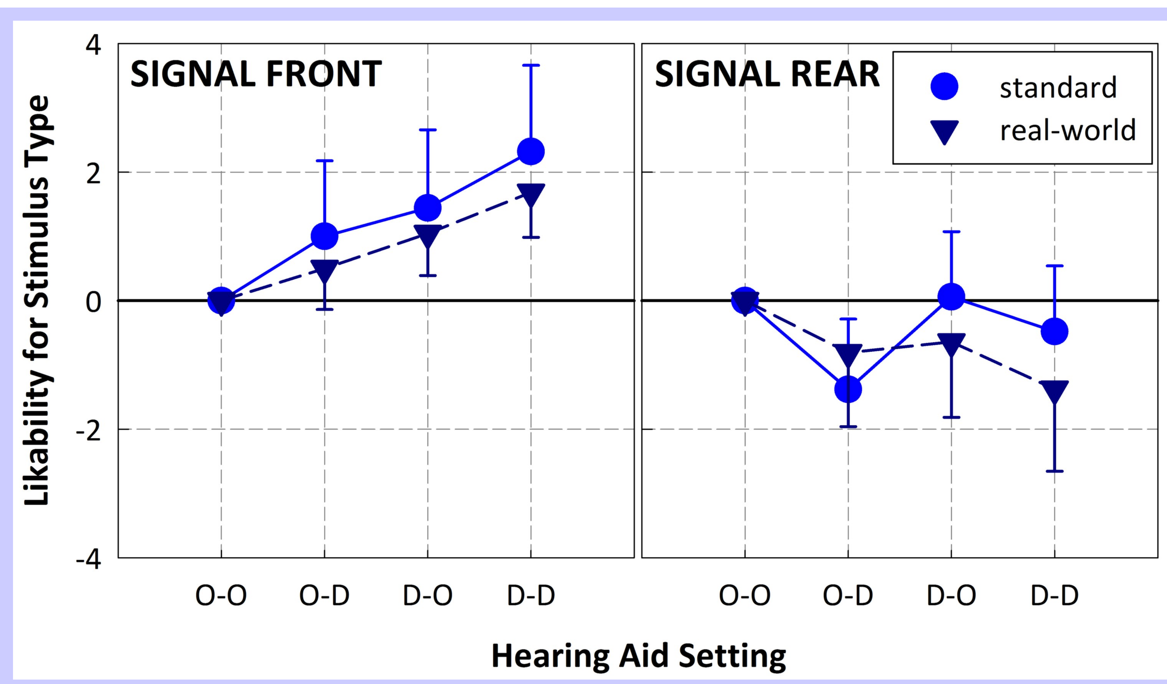
Data analysis: Relative likability coefficients (Bradley-Terry model[5]) for omnidirectional (O) and directional (D) microphone modes. Likability of reference (O-O setting) arbitrarily set to 0. For significance, α=0.05. Figures show mean (symbols) ± 2 standard errors of the mean.



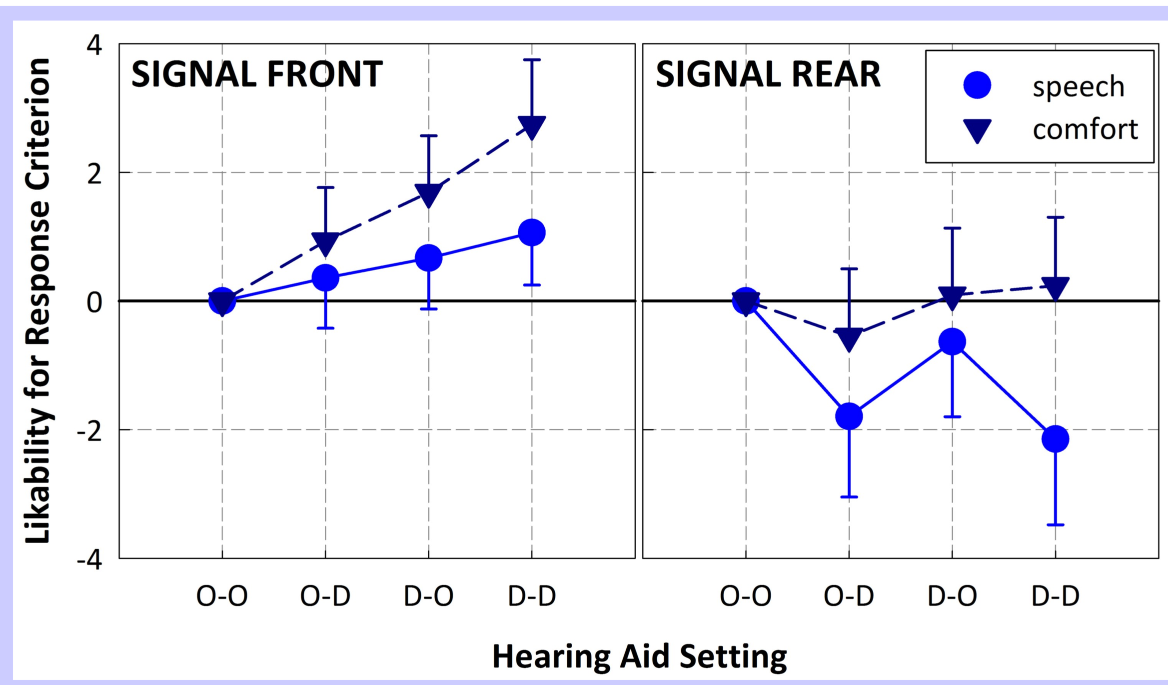
- ✧ ***Signal front***: Significant difference in likability across settings, with D-D setting most preferred.
- ✧ ***Signal rear***: Significant aversion to directionality in right ear; no difference in likability based on left ear status.
- ✧ Different patterns of directional preference based on signal location.



- ✧ ***Signal front***: Significant difference in likability across settings, with D-D best. Similar patterns of preference between diffuse noise and noise located on left side.
- ✧ ***Signal rear***: Significant aversion to any directionality in diffuse noise, but only to directionality in right ear for noise located on left side. Generally similar patterns of directional preference in both noise conditions.



- ✧ ***Signal front***: Significant difference in likability across settings, with D-D best. Similar patterns of directional preference between standard and real-world stimuli.
- ✧ ***Signal rear***: Significant aversion to directionality in right ear for standard stimuli, especially O-D setting; significant aversion to any directionality with real-world stimuli, particularly D-D setting. Similar patterns of preference in both types of stimuli, except for D-O setting.



- ✧ ***Signal front***: Significant difference in likability across settings, with D-D best. Similar patterns of directional preference between speech understanding and listening comfort criteria, but large difference in magnitude of preference.
- ✧ ***Signal rear***: Significant aversion to directionality in right ear for speech understanding; significant aversion to the O-D setting for listening comfort. Different patterns of directional preference depending on response criterion.

SUMMARY & DISCUSSION

- **Directional microphones in hearing aids are designed to reduce sensitivity to sounds located to the side and/or behind the listener, without compromising sensitivity to sound located in front.**
- **Speech location affects directional preference? Yes.**
  - ✧ When speech is located in front, it is expected that directionality will be preferred over omnidirectional. The results demonstrate this effect; D-D is preferred the most.
  - ✧ When speech is located behind the listener, participants demonstrate an aversion to directionality, preferring the omnidirectional microphone mode.
    - ✪ The greater preference for D-O over O–D is related to speech located on the right side.
- **Noise location affects directional preference? Sort of.**
  - ✧ The patterns of directional preference are very similar for both noise configurations.
    - ✪ For speech in the rear, D-O is an acceptable alternative to O-O when noise is on the left side, but not for diffuse noise. This is likely related speech location — at ~135° for both noise left scenarios, but at 135° or 225° for the noise diffuse scenarios.
- **Stimulus type affects directional preference? Sort of.**
  - ✧ When the signal is located in front, the patterns of directional preference are very similar for standard and real-world stimuli, with the D-D setting most preferred.
    - ✪ On average, SNRs for the standard laboratory scenarios were ~5 dB higher than those for the real-world scenarios — i.e., better speech intelligibility and greater listening comfort in the standard scenarios.
    - ✪ SNRs for the standard scenarios were based on the individual's omnidirectional speech reception threshold in noise (SRTN), whereas SNRs for the real-world scenarios were fixed (much like the real world). The greater uniformity in difficulty across participants for the standard scenarios was expected to result in greater uniformity in directional preference.
    - ✪ Noise in the *restaurant* and *theater* included competing speech and music, respectively, which might otherwise be considered a signal. Informational masking can occur when signal characteristics are similar to that of the noise[2]. Although the effect did not achieve statistical significance, Hornsby & Ricketts[6] showed ~1 dB lower directional benefit for speech than for speech-shaped noise masker.
  - ✧ For signals located in the rear, O-O is most preferred.
    - ✪ In standard scenarios, any setting with the right ear in omnidirectional was acceptable, regardless of the status of the left ear, because the signal was always located at 135° azimuth (rear right); the rear signal location was not fixed across real-world scenarios.
- **Response criterion affects directional preference? Yes.**
  - ✧ As expected, similar patterns of preference are obtained for speech understanding and listening comfort, when the signal is located in front.
    - ✪ Like the real world, the background noise for *restaurant* and *theater* was dynamic. The possibility of listening in the dips in noise may make directionality less salient for speech understanding.
    - ✪ Pilot testing revealed ~3 dB directional advantage for speech understanding in the *S0ND* scenario. Killion[7] has suggested that hearing aid wearers are unlikely to notice improvements up to ~2 dB.
  - ✧ For signals located in the rear, listeners are averse to directionality for speech understanding whereas no difference in preference is seen across settings for comfort.
    - ✪ Aversion to directionality for speech understanding appears to outweigh the increased comfort that it provides. Directionality was preferred for comfort only in the *S135NL* scenario.
- **What are the clinical implications of these findings?**
  - ✧ Bilateral symmetry in microphone mode may not always be desired or necessary.
  - ✧ Exact noise location relatively inconsequential in determining directional preference.
  - ✧ Ask the right questions to ascertain efficacy of directionality based on patient report.
    - ✪ Listeners more aware of increased listening comfort when signal located in front, and of loss of audibility when signal located in the rear.

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