Effect of Stimulus Configuration & Response Criterion on Directional Preference
Shilpi Banerjee, Starkey Laboratories, Inc.

MOTIVATION
- Directional benefit demonstrated in the laboratory.  
- Success with directionality in everyday life not predictable from laboratory measures of directional advantage.
- Although directional benefit is reported in real-world listening situations, it is best described as lukewarm...
- Directional preference mode only 25% of the time...
- 25% dissatisfied with hearing aids in noisy situations.
- Directional microphones are found in only 32% of hearing aids.
- Disconnect attributed to acoustics of the environment...
- Presence, location, and distance of signal and noise.

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 B (n=9): Simulated real-world stimuli.

Hearing Aids & Fittings
- Bilateral BTEs.
- Occluded molds, 2mm SAW.
- Hearing aid gains matched to eSTAT.
- Expansion and adaptive feedback cancellation on; noise reduction off.
- M110monidirectional, M212irectional.

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 vs. 5.1 surround sound. Various signals and background noises. Scenarios judged to be realistic by 3 normal-hearing listeners.

RESULTS
- Data analysis: Relative likability coefficients (Bradley-Terry model) for omnidirectional (O) and directional (D) microphone modes. Likelihood 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.

SUMMARY & DISCUSSION
- Directional microphones in hearing aid designs 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.
  - The greater preference for D-O over O-O 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 D-D when noise is on the left side, but not for diffuse noise. This is likely related speech location – at 135° for both noise left earscen, but at 135° or 225° for the noise diffuse scenarios.
- Stimulus type affects directional preference? Sort of.
  - The signal located in the 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 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 pre-stimuli 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 for participants for the standard scenarios is expected to result in greater uniformity in directional preference.
- Noise in the restaurant and theater included a 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.
  - Although the effect did not achieve statistical significance, Hornsey & Roberts showed ~3 dB lower directional benefit for speech than for speech-shaped noise masks.
  - For signals located in the rear, O-D is most preferred. In any setting, 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.
- For testing revealed ~5 dB directional advantage for speech understanding in the sind scenarios. Killion has suggested that hearing aid wearers are unlikely to make great 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.
- Aton for directionality for speech understanding appears to outweigh the increased comfort that it provides. Directionality was preferred for comfort only in the 120°/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 less of availability when signal located in the rear.

REFERENCES

Workshop on Speech in Noise: Intelligibility & Quality, Lyon, France, 2013