IMPROVED COMPREHENSION BEHIND THE LISTENER

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INTRODUCTION

Most listening situations involve the listener looking at the person to whom they are speaking. Therefore, hearing aid performance has been evaluated over the years in quiet and in noise with the speech presented from in front of the listener. It has been documented that speech understanding in noise ability has been improved with the use of directional microphones. However, special circumstances may arise where the speaker is located behind the listener; such as being in a car and listening to a passenger in the back seat. The presumptions of today's algorithms in advanced hearing instruments do not consider this situation.

Purpose

A new algorithm was developed that changes direction of the focus from in front of the listener to behind the listener. The algorithm has a reverse cardioid directional pattern that can be accessed through a separate program. This study was conducted to compare the performance of this new algorithm [reverse directional] to more conventional programs [omni directional and fixed directional] . Comparisons were made when listening to speech in quiet and in noise with the speech originating from the front and from the back. Audibility to sounds from the front and from the back was also examined.

METHODS

Participants

- Twenty participants
- All native English speakers
- Ages 63-82 years
- Average age of 72 years
- 14 experienced hearing aid wearers
- 6 new hearing aid wearers
- Average right/left audiograms shown in Figure 1

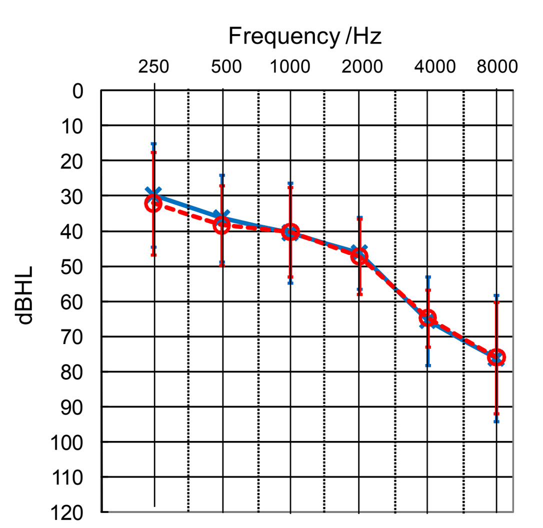

Figure 1: Average right/left audiograms for participants

Hearing instrument

- Widex Clear 440 Passion; Receiver in Canal
- 15 channel instrument with low compression threshold
- Instant-fit ear tips with the following venting recommendations:
- <30 dB HL was open fit tips; 30-40 dB HL used a 1.7mm vent; 40-50 dB HL used a 1mm vent; and 50 dB HL and above used no venting

Hearing aid programs:

1. Omnidirectional microphone
2. Fixed directional
3. Reverse directional [activation level 55 dB SPL]

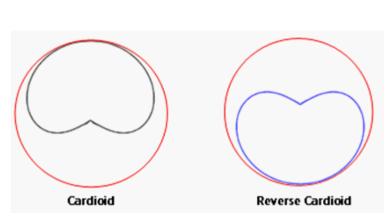

Figure 2: A cardioid and reverse cardioid pattern

Hearing aid features:

- Noise reduction: off
- Impulse sound management: off
- Feedback: SuperGain
- In-situ vent effect compensation (AISA): on

METHODS [cont.]

Procedures

1. Audibility Testing [warbled tones from 250 Hz through 8000 Hz]
   a. Sound field thresholds obtained from 0°
   b. Sound Field thresholds obtained from 180°
2. Speech Understanding in Quiet [50 dB SPL presentation level]
   a. ORCA nonsense syllable test from 0°
   b. ORCA nonsense syllable test from 180°
3. Speech Understanding in Noise using HINT [overall noise level of 68 dB SPL]
   a. Speech from 0° and continuous speech-shaped noise from 90°, 180°, and 270°
   b. Speech from 180° and continuous speech-shaped noise from 90°, 0°, and 270°

RESULTS

Sound-field thresholds

Thresholds from 0° Azimuth [Figure 3]

- Thresholds approximately 20 dB HL at 250 Hz through 2000 Hz.
- Thresholds were within 1 dB between the omni directional mic and reverse directional mic due to activation level.
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed similar performance [p>0.05].
- Thresholds for fixed directional mic were 3-5 dB poorer at 250 Hz through 1500 Hz; expected due to higher circuit noise with a fixed directional microphone.

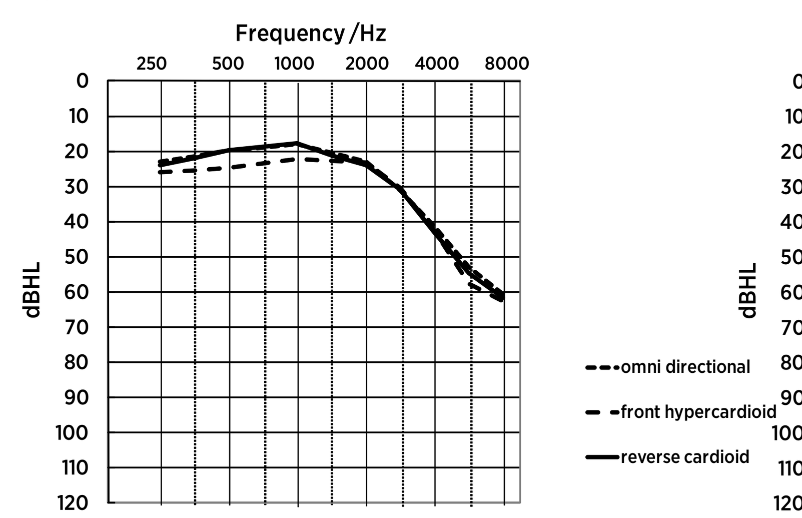

Figure 3: Sound-field aided threshold results with warbled tones from 0°

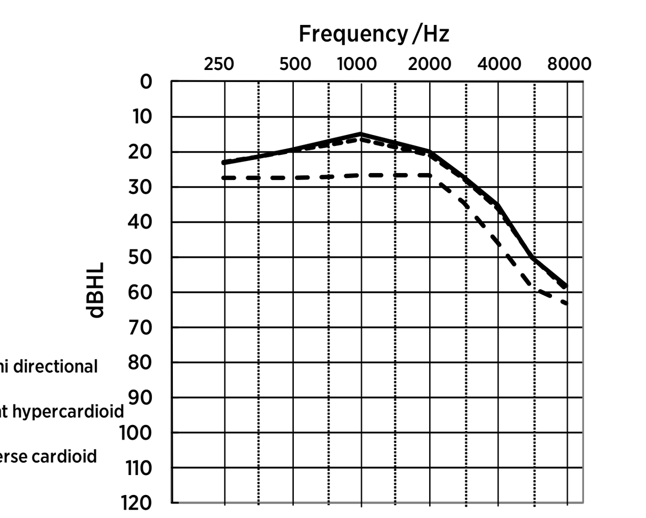

Figure 4: Sound-field aided threshold results with warbled tones from 180°

Thresholds from 180° Azimuth [Figure 4]

- Thresholds approximately 20 dB HL at 250 Hz through 2000 Hz.
- Thresholds were within 1 dB between the omni directional mic and reverse directional mic.
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed similar performance [p>0.05].
- Thresholds for fixed directional mic were 4-10 dB poorer across all frequencies; expected due to lower sensitivity at the null of the polar pattern.
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed poorer performance [p<0.05] than omni or reverse directional.

RESULTS [cont.]

Speech understanding in quiet

Speech from 0° Azimuth [Figure 5]

- Total phoneme scores on the ORCA NST were within 3% among the omni and fixed directional mode and reverse directional mode.
- Total phoneme scores on the ORCA NST were within 1% between the omni directional and fixed directional modes.
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed similar performance [p>0.05].

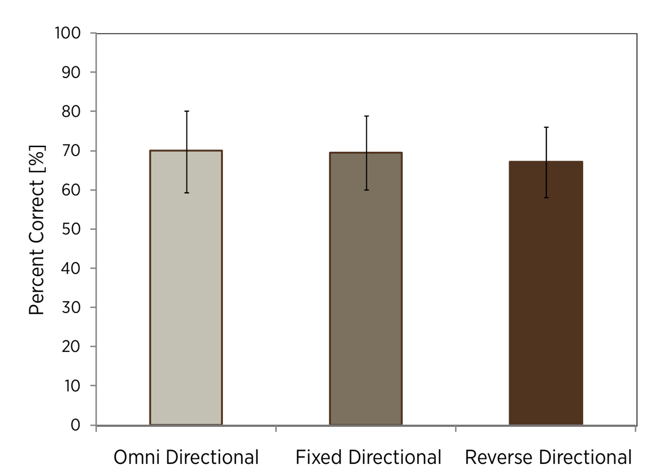

Figure 5: Total phoneme score with speech presented from 0° at 50 dB SPL

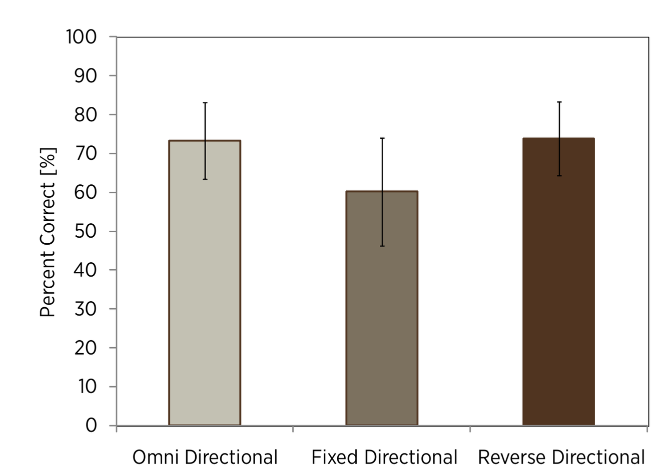

Figure 6: Total phoneme score with speech presented from 180° at 50 dB SPL

Speech from 180° Azimuth [Figure 6]

- Total phoneme scores on the ORCA NST were essentially the same between the omni directional [73% correct] and reverse directional [74% correct].
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed similar performance [p>0.05].
- Results for the fixed directional were 14% poorer than the omni or reverse directional; expected due to lower sensitivity at the null of the directional polar pattern.
  - Post-hoc analysis with Bonferroni adjustment for multiple comparisons showed poorer performance [p<0.05] than omni or reverse directional.

Speech understanding in noise

Speech from 0° and noise from 90°, 180°, and 270° [Figure 7]

- With speech from the front and noise from the sides and back, the best signal-to-noise ratio was obtained with the fixed directional microphone [-1 dB SNR].
- The poorest signal-to-noise ratio was obtained with the reverse directional [7 dB SNR].
- Omni was 6 dB poorer than fixed directional and 2 dB better than reverse directional.
- Fixed directional was 6 dB better than omni and 8 dB better than reverse directional.
  - Post-hoc analysis with Bonferroni adjustment showed all 3 microphone modes to be different from each other [p<0.05].

RESULTS [cont.]

Speech understanding in noise [cont.]

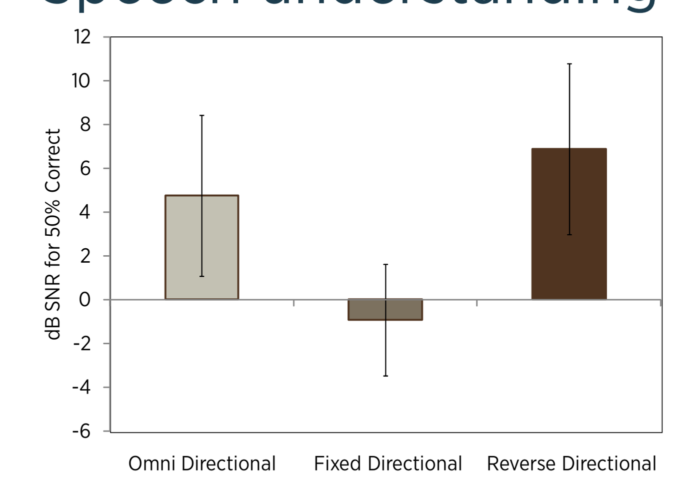

Figure 7: Absolute HINT score [dB SNR for 50% correct] with speech from 0° and noise from 90°, 180°, and 270°

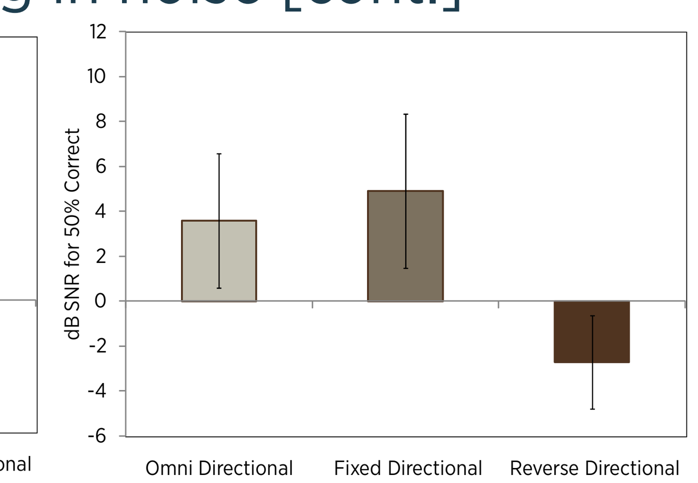

Figure 8: Absolute HINT score [dB SNR for 50% correct] with speech from 180° and noise from 90°, 0°, and 270°

Speech from 180° and noise from 90°, 0°, and 270° [Figure 8]

- With speech presented behind the listener and noise from the sides and front, the best results were obtained with the reverse directional microphone [-3 dB SNR].
- The poorest results were obtained with the fixed directional mic [5 dB SNR].
- Omni was 1.5 dB better than fixed directional and 6.5 dB poorer than reverse directional.
- Reverse Directional was 6.5 dB better than omni and 8 dB better than fixed directional.
  - Post-hoc analysis with Bonferroni adjustment showed the reverse directional was different from the omni and fixed directional [p<0.05].
  - Omni and fixed directional were similar [p>0.05].

CONCLUSIONS

- Aided sound field thresholds and speech understanding in quiet were similar between the omni directional microphone and reverse directional microphone regardless of presentation azimuth [0° and 180°].
- Similarity was due to the activation level of the reverse directional microphone.
- For speech understanding in noise, the reverse directional microphone performed the best with speech from behind [180°] and had the poorest results with speech from the front [0°].
- When stimuli were presented from behind the listener [180°], poorest results were obtained with the fixed directional microphone due to lower sensitivity in the null of the polar pattern.

IMPLICATIONS

- Results emphasize utility of the reverse directional microphone. It should be used in situations when the main speaker is behind the listener [e.g. sitting in car listening to passenger in the back].
- In quiet, the reverse directional microphone would be in an omni directional mode and not have detrimental effects on speech from the front.
- Results support the concept that a fixed directional microphone can be detrimental to speech understanding in quiet and in noise when the speaker is behind the listener.

**references available upon request