Effect of signal-to-noise ratio on microphone preferences and benefit

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This study is a follow-up to *Walden* et al. (2004) that identified distance from the signal as a critical environmental variable in listener preferences for omnidirectional versus directional microphone processing. Because distance cannot be measured directly by the hearing aid, it must be inferred from some acoustic measure. The present study sought to determine whether the signal-to-noise ratio (SNR) might be used to represent distance between talker and listener in automatic directionality algorithms. Additionally, the role of possible loudness differences between the two microphone modes in listener preferences was explored. Speech intelligibility, preferences, and loudness comparisons of omnidirectional and directional microphone hearing aid processing were evaluated across a range of signal-to-noise ratios (SNRs).

Participants were 31 current hearing aid users who either had experience with omnidirectional microphone hearing aids only, or with manually switchable omnidirectional/directional hearing aids. Using IEEE/Harvard sentences from a front loudspeaker and speech-shaped noise from three loudspeakers located behind and to the sides of the listener, the directional advantage (DA) was obtained at eleven SNRs ranging from -15 dB to +15 dB in 3-dB steps. The speech signal coming from the front loudspeaker was held constant at 65 dB SPL and the level of the speech-shaped noise varied to create the eleven SNR test conditions. Preferences for the two microphone modes at each of the eleven SNRs were also obtained using concatenated IEEE sentences presented in the speech-shaped noise. Loudness comparisons between the two microphone modes were also obtained at each SNR, using speech-shaped noise coming from all four loudspeaker locations.

Mean speech recognition for each microphone mode and SNR is shown in fig 1. Speech recognition was higher for the DIR mode than for the OMNI mode, except at the most unfavourable and the most favourable SNRs. Despite the systematic variation in mean DA across SNRs, there was substantial individual variability in the maximum DA obtained and the SNR at which it was observed.

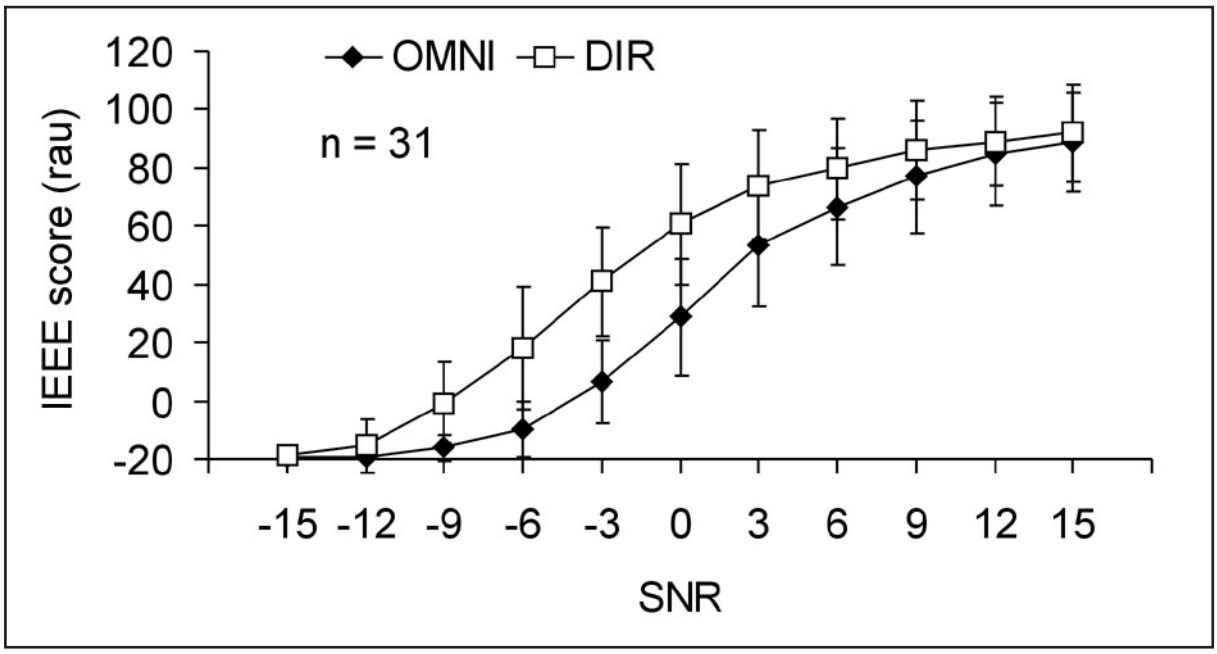

Fig. 1: Mean speech recognition rau scores for the OMNI and DIR modes at each SNR test condition. The error bars show one standard deviation.

Microphone preferences are shown in fig. 2, which gives the percentage of OMNI, DIR, and no preference ratings at each SNR. Preference for DIR processing increased systematically as the SNR improved from the most unfavourable SNRs, where "no preference" ratings were most common, through the mid-range of SNRs where there was a rather consistent preference for DIR processing. At the more favourable SNRs, preferences were approximately equally divided between DIR processing and no preference. Notably, few preferences for OMNI processing were observed, regardless of SNR.

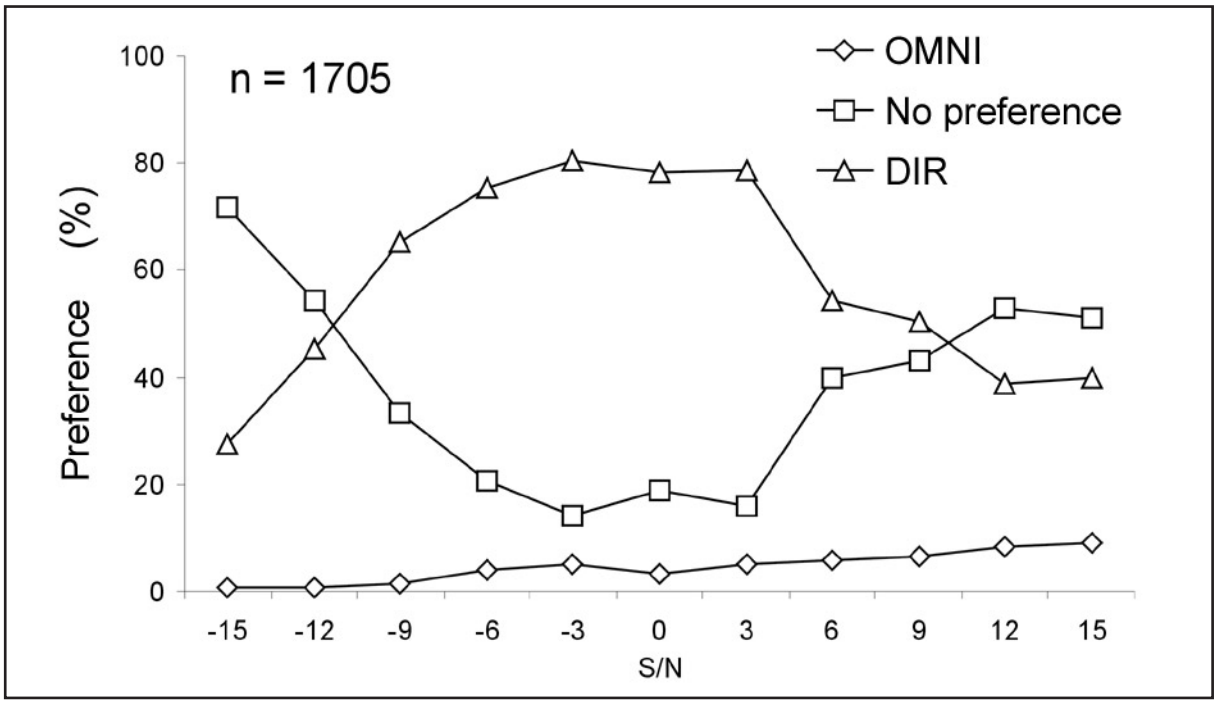

Fig. 2: Distribution of preference ratings by response category at each SNR test condition

The (normalised) preference ratings and DA are plotted together in fig. 3, which shows the mean DA and mean microphone preferences, expressed as z-scores, for each of the eleven SNRs. These mean data suggest that microphone preferences were determined largely by the relative intelligibility of speech through each microphone mode.

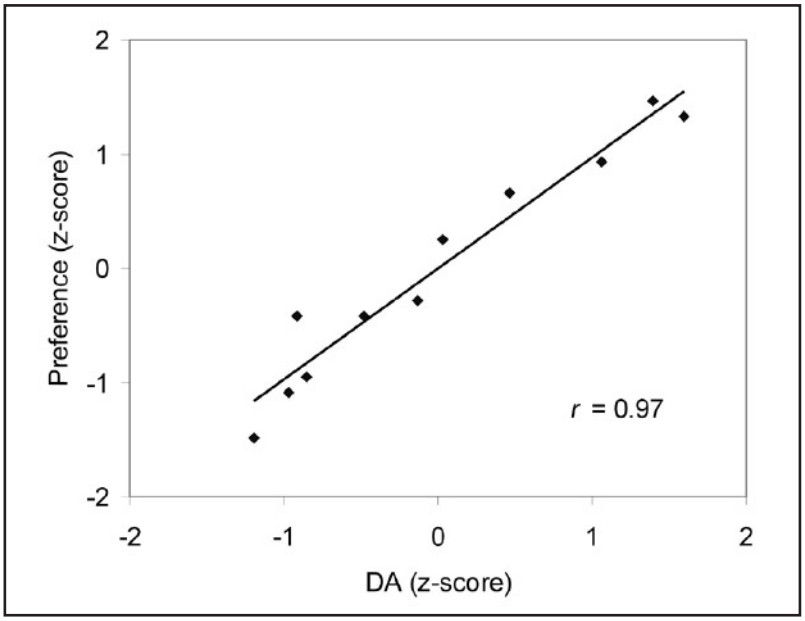

Fig. 3: Normalised mean preference rating and directional advantage for each of the eleven SNR test conditions

Results of the loudness comparisons are shown in fig. 4. Loudness differences between the two microphone modes tended to be relatively small. At unfavourable SNRs, there was a tendency for the OMNI mode to be rated louder, whereas the DIR mode tended to be rated louder at the more favourable SNRs.

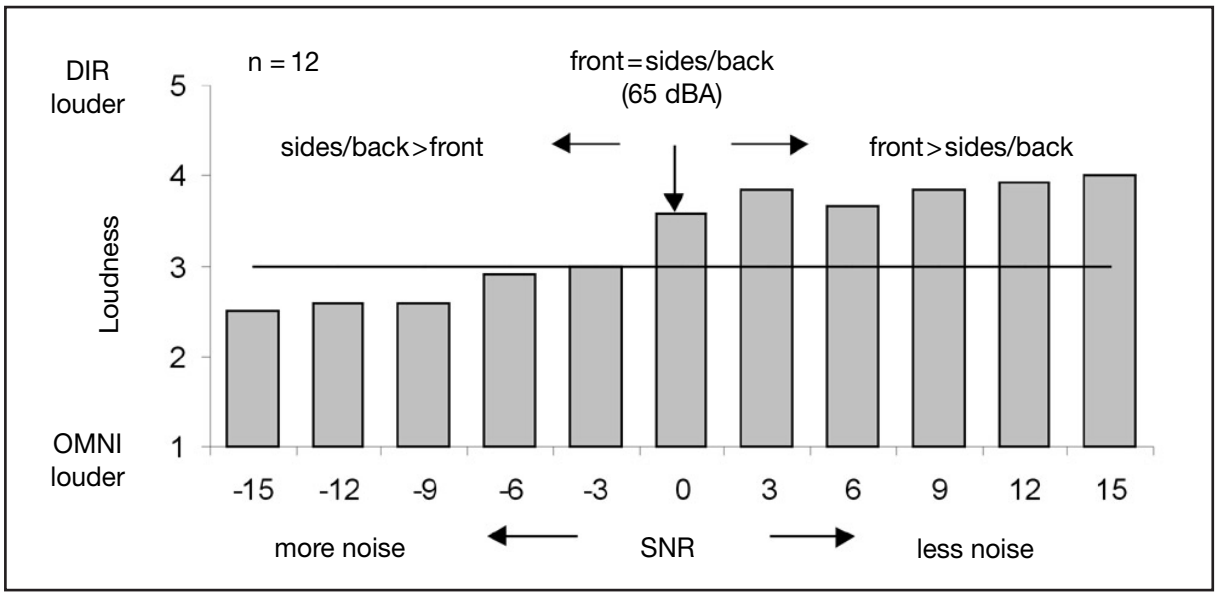

Fig. 4: Mean loudness rating at each SNR test condition. The horizontal line indicates a rating of equal loudness.

Overall, the results of this study provide little insight regarding why omnidirectional microphones appear to be preferred in some everyday listening situations where background noise is present, as was observed in *Walden* et al. (2004). Further, specific to the primary motivation for this study, these data provide little support for using SNR to estimate distance in automatic switching algorithms, because omnidirectional processing was not consistently preferred to directional processing at any SNR. In this regard, these results provide additional caution against generalising the findings of directional microphones in a controlled laboratory test environment to their performance in everyday listening situations.

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References

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