OPENNESS OF FIT AND BENEFIT FROM ADAPTIVE FEATURES
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Introduction
Openness of the coupling between the hearing aid and ear modifies the acoustic properties of a hearing aid fitting. As open/occluded fitting offers inherent benefits related to comfort and reduction of perceived occlusion for the patient (Jaspars et al., 2006). Controlling these benefits, the open canal hearing aid fitting inherently limits attainable low-frequency levels in the ear. There is also a greater contribution of direct unamplified sound that enters the ear when compared to more occluded hearing aid fittings.

Traditionally the open canal fitting is reserved for patients with mild-to-normal, low-frequency hearing. In contrast, a review of manufacturers' recommended fitting ranges shows that candidacy may extend to patients with low-frequency thresholds reaching 60 dB HL. Because individuals with moderate low-frequency hearing loss may be regarded as poor candidates for open-canal fittings, it is intended to investigate how the benefit from hearing aid fittings that range in openness of coupling to the ear.

Previous work has shown that increasing vent diameter systematically decreases directivity index (D; Roberts, 2000). Extending this observation to behavioral data, several studies have shown reduced directivity benefit with increased vent diameter (Ock et al., 2004; Galster et al., 2012). A second signal processing strategy, digital noise reduction (DNR), has been shown to improve acceptance of background noise (Roberts & Harner, 2005). The plausible interaction between openness of hearing aid and benefit from digital-noise reduction has not been investigated. It is reasonable to assume that decreased low-frequency levels and increased direct unamplified sounds, associated with increasing openness of fit, may decrease the digital noise reduction benefits.

The present study aimed to document the comparative benefits of digital noise reduction and directional microphones with increasing openness of fit. A sample of participants with low- frequency threshold approaching moderate severity were recruited with the expectation that this sample would be sensitive to changes in low-frequency audibility and the changes in contribution of direct, unamplified sound that occur as openness of fit increases.

Methods
Participants
10 participants (4 female, 6 male) with mild- to- moderate sensorineural hearing loss.
- Ages ranged from 32-81 years (mean = 64 years)
- Both new and experienced users of hearing instruments were included
- All study participants were fit bilaterally and seen for a minimum of 2 laboratory sessions.

Hearing Aid Selection and Programming
Starkey Series 110 hearing aids were chosen for the three earmold configurations and a 50 dB peak gain resolver.
- Open silicon dome
- Silicone custom earmold, fully occluding
- Four membranes were programmed for each device. Within each vent condition, per directional microphones with increasing openness of fit. A sample of participants with low-frequency thresholds approaching moderate severity were recruited with the expectation that this sample would be sensitive to changes in low-frequency audibility and the changes in contribution of direct, unamplified sound that occur as openness of fit increases.

Methods (continued)
Directional microphone with DNR enable
- Omnidirectional mode (DNR disabled)
- Omnidirectional mode with DNR enabled
- Directional mode (DNR disabled)
- Directional mode with DNR enabled

Digital Noise Reduction
A modified version of Starkey’s proprietary noise reduction (DNR; Voice EQ) was used. Modification to the existing algorithm includes removal of a level dependency that affects the amount gain reduction applied as input level increases. In this revised algorithm gain reduction attempts to reach GdB in all ten signal segments.

Results


cST

Table: Summary of post hoc Tukey pairwise comparison between treatment conditions for CST and ANL results. * Indicates significance at the 0.05 level and ** indicates significance at the 0.01 level.

Discussion
The outcomes of the present study demonstrate that a sample of participants with mild-to-moderate, low-frequency hearing loss demonstrate statistically equivalent performance when increasing openness of hearing aid fitting from fully occluded to an open-canal hearing aid fitting.

Specifically, the magnitude of benefit received from directional microphones, as measured with the CST and benefit received from DNR, as measured with a modified ANL, did not vary with increased openness of fitting. The first observation, specific to directional microphones, is in contrast with previous work that has shown decreased directivity and thus decreased performance with increased vent diameter. The second observation of unchanged benefit from DNR had not—to the awareness of the authors—been previously documented.

As illustrated by the follow-up analyses the majority of significant effects were driven by the inclusion of directional microphones in the best condition. It appears that the external features directional microphones were most likely to affect an improvement to speech recognition in noise as well as improved acceptance of background noise.

The selection of participant sample with thresholds approaching moderate low-frequency hearing loss was done as a contrast to previous studies investigating openness of hearing aid fitting that focused on participant samples with normal-to-mild, low-frequency hearing loss. This difference may underlie some of the disagreement between our findings and previous work. While the constraints of this study design, these observations suggest that the candidacy for open canal hearing aid fittings may be reasonably extended to patients with moderate low-frequency hearing loss.

References

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