

Maintaining the Directional Advantage in Open Fittings

by Mark C. Flynn, PhD

The provision of directional microphones and larger vent diameters (ie, open fittings) are not mutually exclusive concepts. However, the design of the complete hearing system can make a difference in the overall directional performance of the hearing instrument.

For users of modern hearing instruments, one of the unexpected disappointments is the distortion of the user's own voice (ie, the occlusion effect).¹ Recently, the introduction of various dynamic feedback cancellation circuits in digital hearing instruments has allowed feedback to be cancelled without loss of gain or distortion through phase cancellation. This advancement has allowed the implementation of larger-diameter vents than was otherwise thought possible.

Open fittings are crucial to increasing hearing instrument acceptance, as they remain the most effective method of decreasing the occlusion effect. Occlusion is reduced or avoided by allowing an escape of built-up sound pressure in the low frequencies through the increased vent size.^{2,3} Importantly, to implement open fittings, the dynamic feedback cancellation system needs to be combined with a short digital processing time^{4,5} and a verified vent compensation strategy.⁶

While large vent diameters are a solution for the occlusion effect and hearing instrument acceptance, some concern has been raised recently about the impact of increasing the vent size on directionality—so much so that some researchers have suggested that a larger vent will compromise the benefits of directional microphones.^{7,8} In a directional microphone, sounds from the side and the rear are attenuated in preference to sounds from the front. The concern is that the vent will allow low-frequency sound from the rear to pass through the vent without attenuation, thus reducing the directional benefit.

It is crucial that, when attempting to solve the problem of occlusion, we do not compromise the signal-enhancing features, such as directionality and noise reduction, that are available in premium digital hearing instruments. The issue with directional benefit is crucial; directional microphones remain the only way to improve speech understanding in noise. Therefore, it is essential that research investigates the degree of directional benefit obtained with modern hearing instruments that were designed for the purpose of offering open solutions. The purpose of the present study was to evaluate the effect of increased vent size on directionality for both canal (ITE/ITC) and behind the ear (BTE) hearing aid styles.

Assessing the Effect of Vent Size

A total of 49 experienced hearing aid users participated in this study. All participants had a mild-to-moderate sensorineural hearing impairment and were fitted with either Oticon Syncro ITE/ITC (n=38) or BTE (n=11) hearing instruments using the Genie 5.0 fitting software. Fitting was conducted according to manufacturer specification using the vent diameter recommended for the degree of hearing loss and style. Oticon Syncro combines Dynamic Feedback Cancellation, short digital processing times, vent compensation strategy, and large vent sizes to enable OpenEar Acoustics.

For the BTE instruments a standard vent was used which allowed an average vent size of 3.9 mm (range: 3.0 mm-open). For ITC/ITE instruments, a collection vent was used to allow the largest possible effective vent size.⁹ This resulted in an average collection vent size of 2.32 mm (collection vent faceplate diameter range: 0.8 mm-3.0 mm).

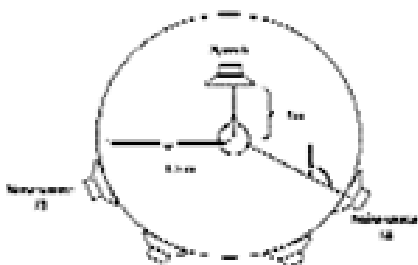
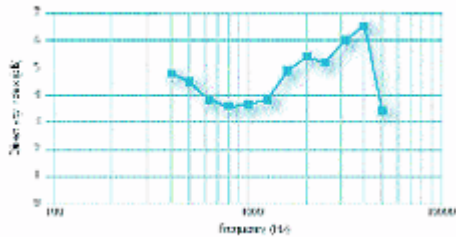


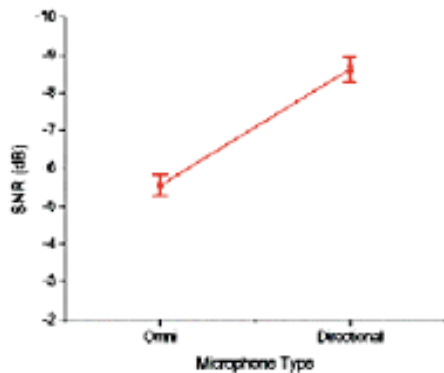
Figure 1. Set-up of the Dantale-II speech perception test.¹⁰

Speech understanding was measured using the Dantale-II speech test¹⁰ in an acoustically treated room. For each participant, speech was presented at 70 dB SPL and noise adjusted to provide the 50% level in speech understanding and the SNR calculated. The resulting SNR was calculated

Directivity Index of Directional ITE



under two microphone conditions: omni-directional and full-directional. For each condition, the microphone was fixed in each mode (omni or full) using the Genie fitting software. Speech was presented at 1 meter from a loudspeaker at 0° azimuth. To ensure a realistic sound scene, a broadband unmodulated noise was presented simultaneously from four loudspeakers located behind the participant at 1.5 m distance (Figure 1).



Results

Figure 2. Signal-to-noise improvement in speech understanding between an omnidirectional and direction microphone for the hearing instrument.

Figure 2 illustrates the improvement in speech understanding between an omni-directional and a directional microphone. The results of the study indicated a statistically and clinically significant improvement in directionality of 3.07 dB ($F[1,96]=49.84, p<.00001$). There were no statistically significant differences ($F[1,47]=0.2246, p=0.63$) between the BTE and ITE/ITC styles indicating that the same directional benefit is obtained irrespective of hearing aid style. Comparison of the vent diameter versus the

improvement in directionality indicated that there was no significant correlation ($r=-0.008$) between vent size and directional benefit.

Conclusions

The improvement in speech understanding from a directional microphone found in the present study was equivalent to that demonstrated in previous studies with hearing instruments without large vents.^{11,12} This indicates that the provision of directional microphones and increased vent diameter are not mutually exclusive concepts. Similarly, there was no significant correlation between vent size and directional benefit. This indicates that directional considerations should not be a factor when selecting the maximum vent size, as long as the directional system is designed to work seamlessly with open fittings.

The present study demonstrates the need to design hearing systems so that all features work together in synergy. It is crucial that, when providing a relief from occlusion through increased vent size, the anti-occlusion system does not negatively act on another system such as directionality. Previous research^{8,13} has put into question the efficacy of combining directional microphones with large vents. The primary concern was that the unprocessed omnidirectional sound coming through the vent will dominate and mask the processed directional sound.

Figure 3. Directivity Index for the open ear instrument, which demonstrates the high-frequency emphasis of the directional microphone.

To overcome this limitation, it is crucial to: 1) design the microphone specifically to work in combination with larger vents, and 2) to provide a vent compensation strategy. The microphones used in Oticon Syncro, for example, are optimized to work together with large vent sizes. Figure 3 illustrates that largest DI of the directional system used in this study is in the mid-to-high frequencies where vent size has no effect on directionality.

As different directional microphones have different frequency responses, the use of directional microphones with a low-frequency emphasis may have been the reason for the loss of directionality reported in previous studies. In the study by Ricketts,¹³ no vent compensation was applied. Vent compensation of approximately 50% is required to compensate for the “leakage” of processed directional sound.¹⁴ The combination of the correct directional microphone with a clinically verified vent compensation strategy ensures that directional benefit can be maintained while providing open fittings.

Consequently, when implementing open ear acoustics in an advanced digital hearing instrument, the directivity sensitivity of the directional microphone should complement the open fitting so that the hearing

aid user will not have to make a choice between relief from occlusion or improved speech understanding in noise.

Importantly, the results of the current study were tested on a hearing instrument with an advanced directional solution. In this instrument, decision-making is driven by a system designed to incorporate artificial intelligence, where the directional system can be split into multiple bands.¹⁵ The splitting into multiple bands allows a number of advantages over traditional directional solutions, such as the ability to cancel multiple noise sources simultaneously and to have a hybrid split-directionality mode where both omnidirectional and directional polar responses are available simultaneously. The results presented here indicate that, despite the further evolution of directional systems, it is possible to ensure that directional benefit will be maintained with open fittings. The critical issue is that the system needs to be designed so as to accommodate the leakage of low frequency sounds from the vent while maintaining directional benefit.

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