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# Performance Testing of Open Ear Devices in Noise

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## Abstract

Questions have arisen regarding the use of advanced signal processing techniques in Open-Ear Devices which do not occlude the ear or provide amplification at low frequencies. If the devices are designed to allow low-frequency information freely in and out of the ear, and many environmental noises are low-frequency in nature, can advanced signal processing features provide any benefit? HINT thresholds were measured on 11 subjects in unaided and aided conditions including a traditional Custom as well as an Open Ear Device. Data indicate advanced signal processing and directionality can contribute to performance in open-style devices.

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# INTRODUCTION

Open Devices have many advantages when recommending hearing aids: comfort, convenience, sound quality, and a 'high-tech' perception different from hearing aids. The acoustics of the fitting allow low-frequency information un-obstructed access to the canal, while high-frequency amplification can be provided to compensate for audibility in mild, high-frequency losses. Advanced signal processing features, which affect the response across a wide bandwidth and may therefore be limited in their impact in such open devices, need to be evaluated to understand any interactions with this open configuration. Subjects were fit with two devices currently used to treat mild hearing losses: CIC and Open Ear Devices (OED).

# METHODS

**Subjects:** 5 subjects originally fit with OED devices and 6 subjects originally fit with CIC devices. Mean Audiograms in Figure 1 show differences in hearing loss which differentiate the choice of initial device fit.

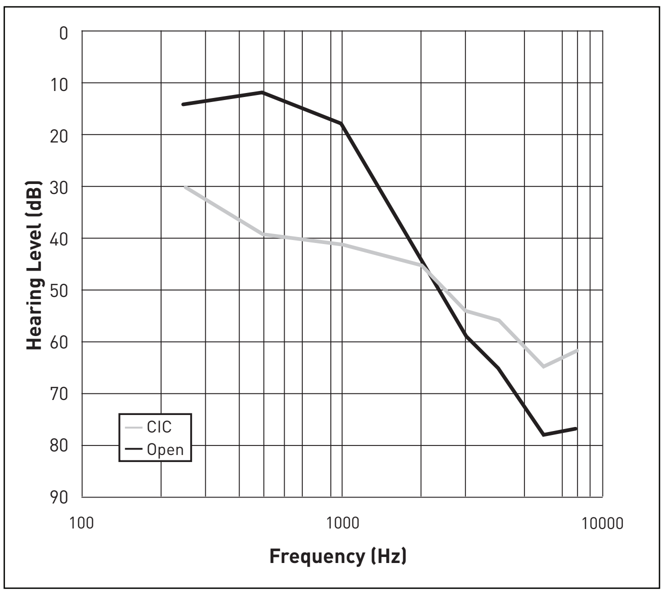


Figure 1: Mean Audiograms

**Devices:** All subjects were fit with Multi-channel digital CIC devices (Innova) and OED (ION) with the same signal processing chip. Both sets of devices included a program button which gave access to multiple settings. The OED devices included dual microphones which could be configured as omni or directional. Fittings were optimized for the patients' hearing loss. Because of differences in insertion loss between styles, fitting targets were different (Figure 2).

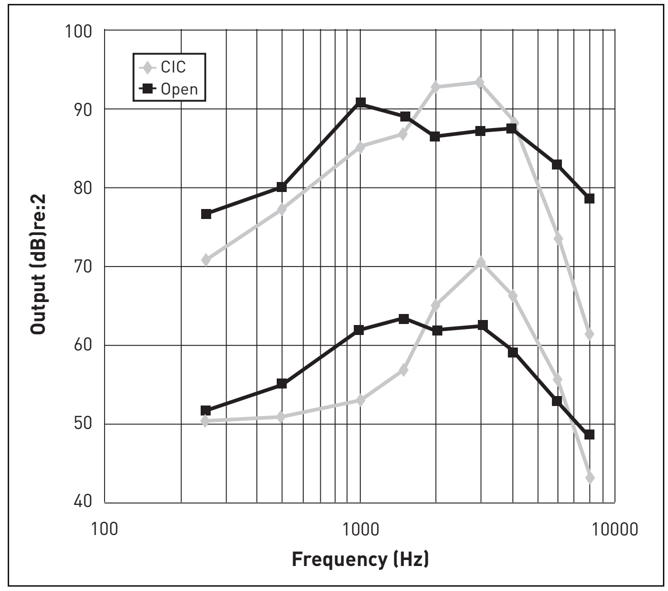


Figure 2: Fitting Targets

**Test Materials:** All subjects were tested with the HINT1 using 20 sentence lists and the spectrally matched steady-state noise designed for the HINT. Presentation was made in the two-dimensionally diffuse (2DD) sound field shown in Figure 3 using four uncorrelated noise tracks2.

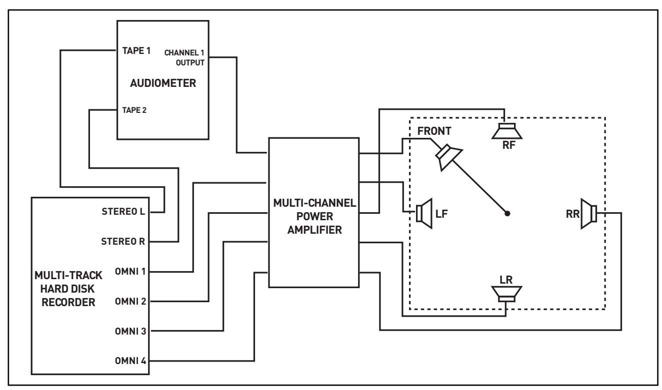


Figure 3: Test Environment

**Protocol:** All subjects were tested with their own devices in Quiet and Noise and then fit with the alternate (CIC to Open or Open to CIC) and then testing was repeated.

# RESULTS

Analysis was performed separately for the Quiet and Noise test conditions.

In Quiet, a main effect of noise reduction was found [F(1,9) = 5.95, p=0.037] showing lower (better) thresholds with noise reduction off (33.98 dBA) than noise reduction on (35.50 dBA). A main effect of model was also found [F(2,18)=9.36, p=.002] with CIC thresholds lower (32.96 dBA) than Open Omni (35.65 dBA) or Open Directional (35.60 dBA) thresholds. Finally, a significant interaction between noise reduction and model was found [F(2,18)=6.38, p=.008] and is shown in Figure 4.

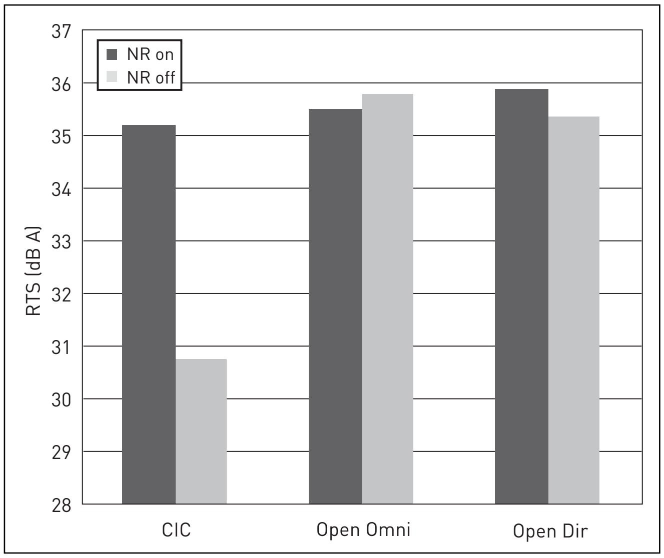


Figure 4: Quiet Thresholds

In Noise, a main effect of noise reduction was found [F(1,9)=17.49, p=.002] with lower thresholds with noise reduction on (-7.38 dB SNR) compared to noise reduction off (-6.78 dB SNR). A main effect of model was also found [F(2,18)=6.61, p=.007] with lower threshold in Open Directional (-8.02 dB SNR) than CIC (-7.40 dB SNR) which was lower than Open Omni (-5.83 dB SNR). Finally, a significant interaction between noise reduction and model was found [F(2,18)=9.95, p=.001] and is shown in Figure 5.

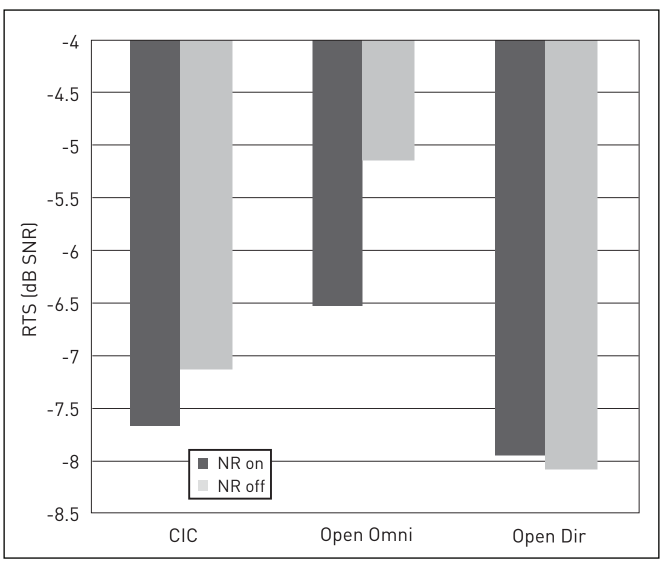


Figure 5: Noise Threshold

## CONCLUSIONS

Two sets of subjects evaluated the traditional treatment for mild hearing losses, the CIC, and the newest platform, the OED. Performance was measured in various configurations of each, including both an omni and directional microphone in the OED. Noise reduction was also included as a variable.

In quiet, the CIC without noise reduction provided the lowest threshold, with all other conditions not significantly different (see Figure 3). The ability to amplify low-frequency information was valuable for performance, but could be counteracted with signal processing features such as noise reduction.

In noise, microphone placement had a significant impact (the degradation in performance going from CIC to Open Omni with its unnatural microphone placement) but could be counteracted with a directional microphone. Noise reduction had a positive impact in both omni microphone conditions, but made no difference in the directional microphone condition.

It is interesting to note that no significant effect or interaction with group was found, even though audiograms were very different and would be considered best suited for the devices subjects began with. This would suggest that a significant component of speech recognition benefit from amplification is from the High Frequencies, which are those amplified with both CIC and OEDs.

## REFERENCES

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2. Nilsson, M., Ghent, R., Bray, V., & Harris, R. (2005). Development of a Test Environment to Evaluate Performance of Modern Hearing Aid Features. J. Am. Acad. Aud., 1 6, 27-41.

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