Insert earphones for more interaural attenuation

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Masking presented to an ear with a moderate-to-severe conductive loss often will mask both ears simultaneously. One solution to this well-known masking dilemma has been to use an insert earphone instead of the traditional supra-aural headphone.[3] To test the across-head isolation of a recently introduced ER-3 insert earphone (HEARING INSTRUMENTS, Vol. 35, No. 7, p. 28) supplied with foam earplugs, the interaural attenuation was measured for six subjects who had unilateral losses (normal hearing in one ear and a profound hearing loss in the other). With this earphone, an average interaural attenuation of 98 dB at 500 Hz was achieved with deeply inserted earplugs, compared to 59 dB for the TDH-39.

In the first experiment, a comparison was made of the interaural attenuation (as measured by the difference between the good-ear and bad-ear unmasked thresholds) obtained with TDH-39/MX41-AR supra-aural headphones and with ER-3 TUBEPHONE™ insert earphones. The TDH-39 headphones were supplied with the freshly calibrated Zenith ZA-112 audiometer used for these experiments. The ER-3 earphones were used as simple plug-in substitutes for the TDH-39, without audiometer recalibration. (The new earphones were designed to approximate the eardrum pressure response of the typical TDH-39, and in most cases between 500 and 4000 Hz the individual good-ear thresholds measured with either phone were within 5 dB of each other.)

The interaural attenuation obtained with the new insert earphones in the first experiment was less than expected based on the classic Zwislocki study.[3] On one subject, Zwislocki measured 105 dB at 500 Hz and 100 dB at 1000 Hz. In retrospect, there were two clear differences between the experiments: Zwislocki left one ear open (in this test, both ears were occluded regardless of earphone type), and he presented the signal to the other ear through a deeply inserted earplug. In this case, the earplugs often had been given shallow insertions.

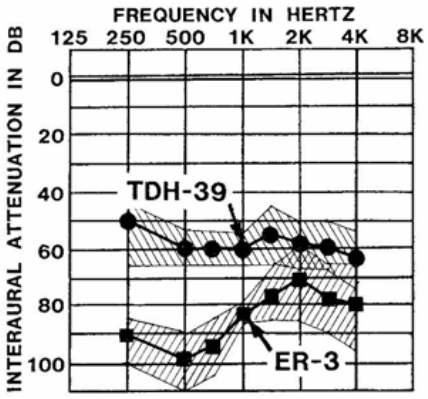

Fig. 1. Average and range of interaural attenuation obtained on six subjects with two earphones: TDH-39 (●) and ER-3 with deeply inserted plugs (■).

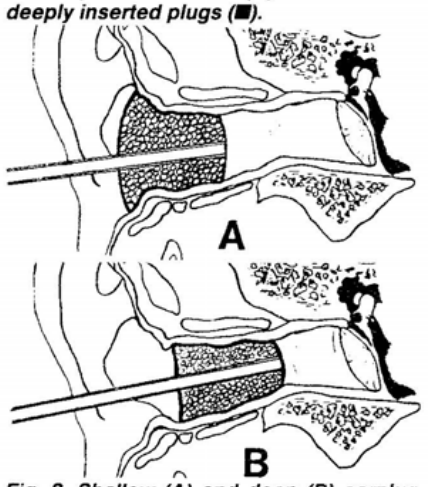

Fig. 2. Shallow (A) and deep (B) earplug insertion.

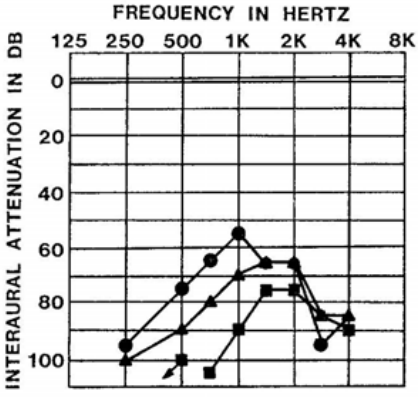

Fig. 3. Interaural attenuation obtained on subject ER with deep earplug insertion in both ears (■), with shallow insertion in dead ear only (▲) and with shallow insertion in both ears (●).

In this experiment, each of the subjects was available for a second experiment where interaural attenuation was measured with one ear open, as well as with both ears occluded with deeply inserted earplugs. Under these conditions, attenuations were obtained consistent with those reported on Zwislocki's subject. With their good ears open, three of the subjects showed an interaural attenuation of 110+ dB at 500 Hz and 95 dB at 1000 Hz when they were asked to respond only if they heard the tone. (One reported feeling a tickle and one a mechanical "shock" with a 105-110 dB HL 500 Hz tone, but they reported hearing nothing.)

Fig. 1 shows the results of the second experiment with the insert earphones, using deeply inserted plugs in both ears, compared to the results obtained on the same subjects with the supra-aural headphones. The average interaural attenuation obtained with one ear open was generally as good or better than the values shown in Fig. 1.

Bone conduction or flesh conduction?

The sketches in Fig. 2 show the earplug insertions called "shallow" and "deep." Note that in the shallow insertion condition, the soft cartilage of the ear canal wall is exposed, while in the deep insertion condition, the soft cartilage is mostly shielded. In the occluded ear, the dominance of the air conduction path to the eardrum in determining what is commonly called "bone conduction" has been demonstrated by others.[1,2] In particular, the most important "bone conduction" path from one ear to the other in experiments such as this first experiment may be a flesh conduction path: the sound in one ear canal enters the flesh through the exposed soft cartilage, appears to be transmitted through the flesh and jaw to the other ear canal and re-enters that ear canal through the exposed soft cartilage on that side.

Fig. 3 shows the result of measure

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ments on one subject that confirm the importance of a deeply inserted earplug in both ears if maximum interaural attenuation is desired at low frequencies. These data indicate that an additional 15-20 dB of interaural attenuation is obtained for each ear canal in which the earplug is deeply seated, regardless of whether it is the "sending" ear or "receiving" ear.

Applications

The use of an insert earphone with this increased interaural attenuation can not only circumvent the masking dilemma, but often can eliminate the need for masking in the first place. Even when masking is still needed, a much lower masking level is required, reducing the chance for error. □

References

1. Khanna SM, Tonndorf J and Queller JE: Mechanical parameters of hearing by bone conduction. *J Acous Soc Amer* 60:139-154, 1976.
2. Tonndorf J: Bone conduction. In *Foundations of Modern Auditory Theory, Vol. II* Tobias J (ed), 1972.
3. Zwislocki J: Acoustic attenuation between the ears. *J Acous Soc Amer* 25:752-759, 1953.

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