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Effect of Microphone Location in ITE versus BTE Hearing Aids

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Abstract

Sound pressure measurements were made at the hearing aid microphones of 20 subjects with their in-the-ear (ITE) hearing aids and a behind-the-ear (BTE) hearing aid to determine the influence of microphone location on hearing aid input. A probe tube microphone was used to measure the difference in dB SPL between the ITE and BTE microphone locations. ITE microphone location resulted in a maximum high frequency advantage of 9.2 dB in the 2500 to 5000 Hz range. However, the frequency location of this maximal advantage varied a great deal between individuals, precluding the use of a standard ITE microphone correction factor for 2cc coupler to functional gain conversions.

Key Words: In-the-ear hearing aids, behind-the-ear hearing aids, functional gain, probe tube microphone measures, pinna

Few studies have attempted to determine the amount of acoustic emphasis achieved by placing a microphone within the partially filled concha as is done with an ITE (in-the-ear) hearing aid. Lybarger and Teder (1986) found up to a 3 dB advantage in the high frequencies with an ITE as compared to a BTE (behind-the-ear) microphone location using a KEMAR manikin. Similarly, Hoke (1976) reported a peak gain of 14 dB at 6 kHz measured with a microphone location near the helix of the pinna on a KEMAR manikin. Cox and Risberg (1986) compared the effects of microphone location using real ear measurements on a group of subjects using putty to simulate ITE hearing aids. They found up to a 6 dB advantage at 4 kHz for the average ITE microphone location.

Although the reported amount of gain varies across studies, it is generally agreed that ITE microphone placement within the pinna results in some high frequency emphasis. The variability of results across studies may be due to procedural variables such as the use of KEMAR instead of real ears or putty to simulate ITE hearing aids. In addition, measurement variables such as microphone placement and angles of incidence may have influenced reported results.

The purpose of this study was to determine the effect of microphone location on the gain of ITE versus BTE hearing aids in clients wearing custom fitted ITE hearing aids.

METHOD

Subjects

Twenty adult clients of the Central Michigan University Hearing Clinic with their personal ITE hearing aids served as subjects in this study. Ten subjects wore ITE hearing aids on their right ears and ten wore ITE hearing aids on their left ears. The hearing status of the clients and the gain of the hearing aids were irrelevant, since measurements were taken at the pinna.

Procedure

The difference between sound pressure levels received at the BTE and ITE microphone location was measured for each subject.

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For ITE measures, the subjects' own ITE hearing aids were worn. For the BTE measures, a Phonic Ear 805 CD BTE hearing aid with a half moon elbow and front facing microphone was placed on the subject. The ITE hearing aid remained in place to simulate the presence of an earmold. All of the hearing aids were in an "off" position while the measurements were made.

A Madsen IGO/HAT 1000 Insertion Gain Optimizer (version 6.2) was used to measure the sound pressure level at both microphone locations. The subjects were positioned at 0° azimuth, 1 meter from a loudspeaker in a sound-treated booth. The probe tube was taped to the microphone of the hearing aids with the tip of the probe tube facing the loudspeaker. Therefore, the microphone was at a 0° incidence for both the BTE and ITE conditions. A 60 dB SPL warble tone sweeping a frequency range of 250 to 8000 Hz served as the test stimulus. An ipsilateral comparative method of measurement was used (Madsen, 1986), where the probe tube situated at the level of the BTE and ITE hearing aid microphones served as the reference and test microphone locations, respectively. Sound pressure level was sampled 48 times per octave with a stimulus level accuracy of 1 dB. The complete measurement procedure was completed twice for each subject. The time between each complete setup and sequence of measurements was at least 2 minutes.

RESULTS

Differences between the sound pressure level reaching the ITE and BTE microphone locations for each subject were determined two separate times at 500, 800, 1000, 1250, 1500, 1600, 2000, 2500, 3000, 3200, 4000, 5000, 6000, and 8000 Hz. When the results were compared between the two runs, no statistically significant difference was found at any test frequency that confirmed the repeatability of the measurements. Data analysis was completed only for those measurements made during the first test run. In addition, no statistically significant difference was found between ears at any frequency that allowed the combination of measurements from all twenty subjects.

Effect of Microphone Location

For all of the measured frequencies from 500 to 6000 Hz, the signal at the ITE microphone location was greater than the signal at the BTE microphone location (Table 1). However, the mean difference was less than 2 dB for the frequencies below 2000 Hz. A mean advantage for ITE microphone location of 3.7 to 6.3 dB was found for the 2500 to 5000 Hz frequency range and all of these differences were significant at the 0.05 level.

Maximal Advantage of ITE Microphone Location

The maximal advantage of the ITE versus BTE hearing aid microphone location was determined, independent of frequency, for each subject. A mean maximal advantage of 9.2 dB with a standard deviation of 3.8 dB was found to be statistically significant at the 0.05 level. This maximal advantage occurred for all of the subjects between 2500 and 5000 Hz with the mode occurring between 2750 and 3250 Hz (Fig. 1).

DISCUSSION

The ITE microphone location resulted in an advantage of less than 2 dB below 2000 Hz and a 4 to 6 dB advantage between 2500 and 6000 Hz. This is in agreement with Cox and Risberg (1986) and Lybarger and Teder (1986) who found a high frequency advantage for ITE as compared to BTE microphone placement. Thus, less 2cc coupler gain in the high frequencies is needed to realize the same functional gain for an ITE as compared to a BTE hearing aid.

TABLE 1 Means and Standard Deviations (Parentheses) of Measured dB SPL Differences in ITE versus BTE Microphone Location

Frequency (Hz)	*Mean Advantage of ITE Microphone (dB)*
500	1.5 (1.5)
800	2.0 (1.8)
1000	1.8 (2.0)
1250	0.1 (3.4)
1500	1.2 (3.0)
1600	0.4 (3.7)
2000	2.6 (3.0)
2500	5.5 (4.4)
3000	6.3 (4.2)
3200	5.2 (4.5)
4000	5.4 (4.9)
5000	3.7 (5.0)
6000	0.7 (4.8)
8000	−2.4 (5.1)

Positive values indicate an ITE microphone advantage.

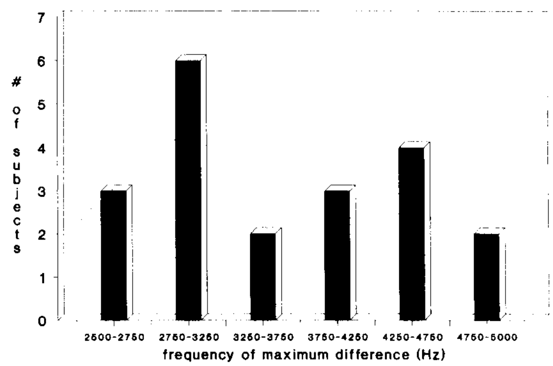

Figure 1 Number of subjects as a function of the frequency at which the maximal dB advantage occurred for ITE versus BTE hearing aids.

The mean maximal microphone advantage for ITE hearing aids was determined by averaging the maximal advantage for each subject independent of frequency. A mean maximal advantage of 9.2 dB was found that occurred between 2500 and 5000 Hz. This mean advantage was larger than the mean difference that occurred at any single test frequency. Cox and Risberg (1986) reported a 6 dB high frequency advantage for a filled concha. Their value was smaller than the present investigation because they analyzed their data at discrete frequencies and did not look at maximal differences independent of frequency. In this investigation the maximal ITE microphone advantage occurred at significantly different frequencies for each subject. Thus by only analyzing discrete frequencies, the mean advantage is distorted when it happens to occur between or across the frequencies analyzed. This finding is significant when it is applied to hearing aid prescriptive formulas. Correction factors based on averaged group data may underestimate ITE microphone advantage for an individual subject.

SUMMARY

Microphone location in an ITE versus a BTE hearing aid will result in a mean, ITE high frequency advantage of 9.2 dB in the 2500 to 5000 Hz frequency range. The frequency and magnitude of this ITE microphone advantage will vary between individuals, which precludes the use of a correction factor to be applied to 2cc coupler gain used in hearing aid prescriptive formulas. In addition, such correction factors may underestimate the high frequency advantage achieved due to ITE hearing aid microphone location since they are based on averaged data.

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