

# Clinical Observations on Insert Earphones vs. Headphones

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# Introduction

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In 2005, the random but recurrent finding of what initially appeared to be unexplained air-bone gaps, which seemed to prevail across examiners, equipment, and test suites was recognized. Through trial and error, it was discovered that air conduction (AC) test results could vary significantly depending upon the transducer used (insert earphones vs. headphones). This phenomenon would not occur with every patient, but instead seemed to occur only randomly.

**The question then became to determine which set of thresholds were the most accurate, those obtained with inserts or those obtained with headphones.**

# Background Information

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- **Example of perplexing findings:** (a) Normal tympanograms, and ipsilateral reflexes present. No suspicion of middle ear pathology per immittance data or otoscopy (b) SRTs and PT AC testing completed using insert (EAR 3A) phones w/ good inter-test consistency (c) Initial unmasked, unoccluded BC thresholds suggested HLs significantly better (10-20+ dB) than AC thresholds that were recorded especially from 500 Hz – 1KHz. (d) Masking applied, and sometimes BC thresholds would shift to within 5-10 dB of AC thresholds, but not always. (e) If AC retested w/circum-aural headphones (Telephonics TDH 50-P), thresholds would IMPROVE to line up very closely with previously-obtained unmasked BC thresholds.

# Background Information

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- **Adverse pt. outcomes**: Periodically a patient would return with hearing aids complaining that they were just "too loud." Reductions would be made in gain, to the point where audiologists would question the validity of the audiogram used for REM targets, and would re-test the patient. Once the clinicians became aware of the insert/headphone issue, retesting would be done with headphones. Often, the patient's thresholds would improve significantly enough that the hearing aids would have to be completely re-fitted. Occasionally the aids originally ordered were inappropriate (power circuits) and had to be returned and different aids ordered.

# Background Information

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- Looking for an answer: Calibration issues were ruled out (same findings even immediately following calibration). Based upon considerable experience, clinicians did not believe the patients in the majority of cases were initially elevating thresholds. There were no cerumen issues w/occluded insert tips, and insert tips were carefully placed to ensure the opening was not against the canal walls. Clinicians also ensured that tips were inserted to consistent depths. None of these measures were successful at avoiding the repeated and regular occurrence of the discrepancy between transducers.

# Background Information

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A basic review of the literature yielded the following results:

- Hawkins *et al.* (1990), measured real-ear SPL with insert earphones and headphones and compared it with the SPL measured in 6cc and 2cc couplers. Measurements showed that for the same real ear SPL, there was more SPL in the 6cc coupler than in the 2cc coupler. This suggests that more SPL would be needed in a 2cc coupler to generate the same real-ear SPL as seen with a 6 cc coupler.<sup>1</sup>

# Background Information

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- *Voss et al.* (2000), compared insert earphones with supra-aural earphones in ears with pathologies (mastoid bowl, tympanostomy tube, TM perforation, and “high-impedance” ear.) The study found that neither transducer acted as an ideal pressure source. Measurements of pressures in ear canals of pathologic middle ears using both transducers showed variances in pressure of as much as 35dB, which equated to errors in audiograms of equivalent size. It was found that the effect of the ear’s impedance was more substantial with insert earphones when compared with headphones.<sup>2</sup>

# Background Information

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- Voss & Herrmann (2005) calculated the ratios of sound pressure in adult and infant ears for three types of earphones. Results showed that the sound pressure generated by all three types of earphones (circum-aural, supra-aural, and insert earphones) was dependent on the dimensions of the ear canal and the ear's impedance at the TM. The authors recommended the use of standard supra-aural earphones due to the fact that they provide a more stable calibration over a wide range of ear-canal volumes and impedances.<sup>3</sup>

# Background Information

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Some theories proposed for the discrepancies between inserts and headphones are as follows:

- During threshold measurement with either inserts or headphones, SPL at the TM may be affected by the ear canal volume. This holds true for not only pathologic ears, but also in ear canals that are LARGER than average and SMALLER than average.<sup>2,3</sup>
- Input impedance variations may affect the SPL needed to approximate thresholds.<sup>2</sup>

***It is interesting to note that none of the studies found referred to bone conduction thresholds as a source of comparison with the AC threshold data being obtained. No studies were found that directly addressed the comparison between headphone thresholds and insert phone thresholds in apparently “normal” ears.***

# Purpose

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The purposes of this presentation are to

1. Make clinicians aware that threshold discrepancies may occur depending upon transducer used.
2. Spark interest in formal research to determine the most likely causes of this phenomenon, and how to decide which set of thresholds are most accurate.
3. Research could then provide evidence-based recommendations for how to best remedy the problem in clinical practice.

**The authors attempt to identify some possible sources of the discrepancy and to provide recommendations for avoidance, but recognize the limitations of observational data versus controlled research trials.**

# Methods

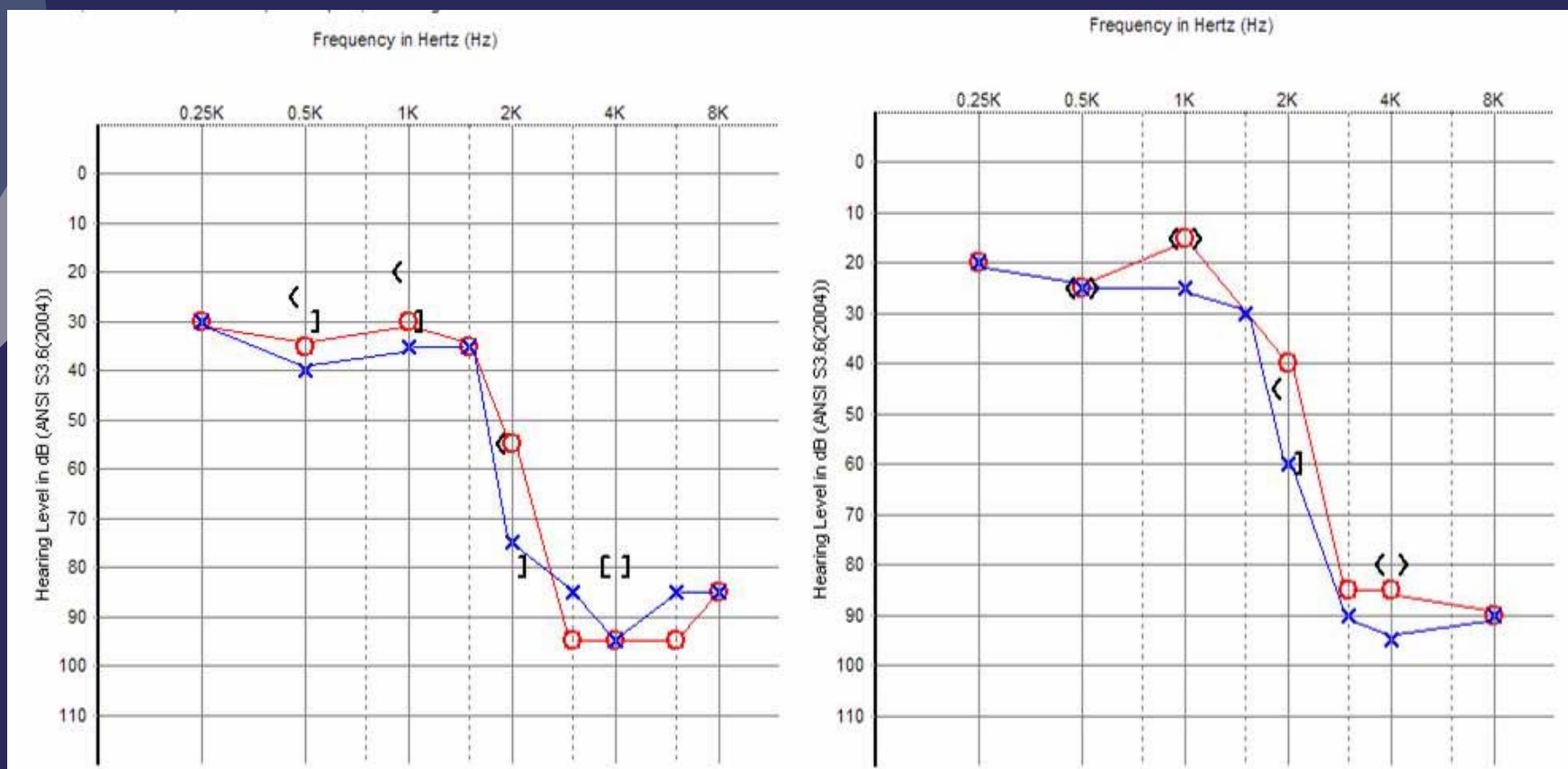
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- Patients were evaluated with comprehensive audiometry in a double-walled sound-attenuated booth using one of three GSI 1761 Audiometers, EAR3A insert earphones and TDH50 headphones.
- All audiometric equipment was appropriately calibrated bi-annually to the most recent ANSI standard. Records were reviewed with <2% change for insert earphones and headphones for all calibration dates from May 2004 through November 2007, which is compliant with ANSI standards.
- Patients may or may not have been tested with both transducers on the same day or by the same examiner.
- Significant numbers of case studies have been identified over the course of several years, and the authors have selected only three examples for the purposes of this presentation.

# Patient #1 Data

## Insert earphones

## Headphones

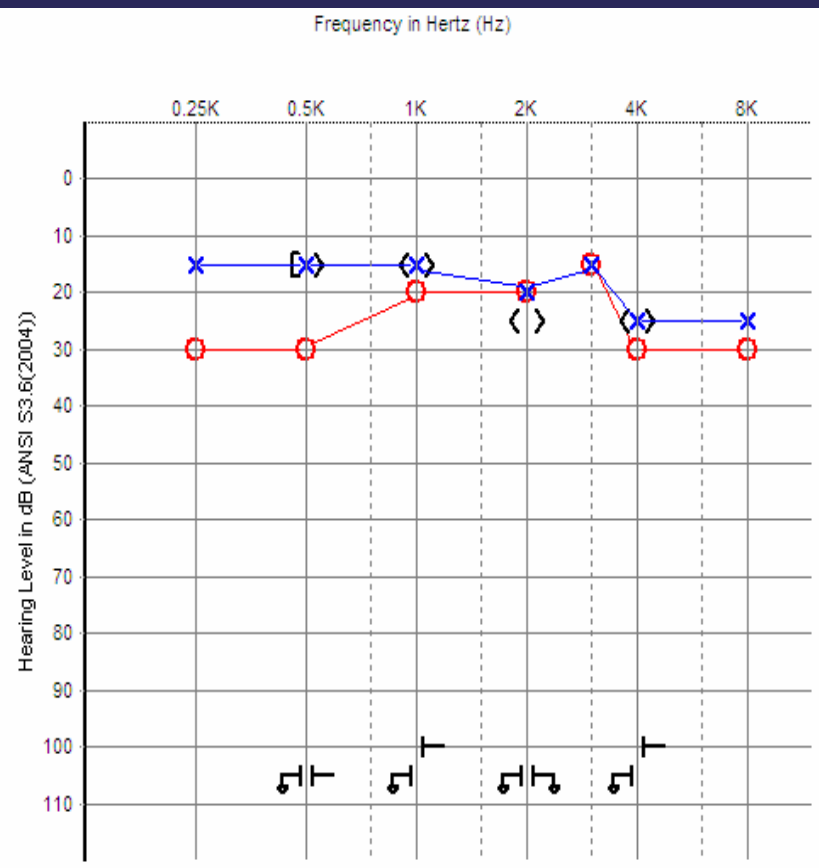
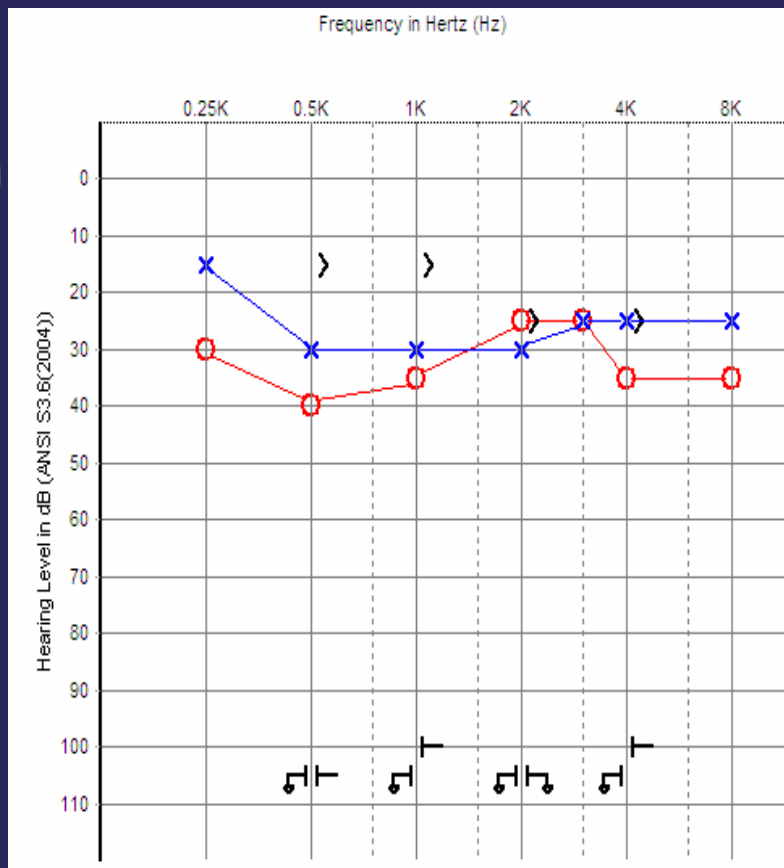


74 y/o male veteran; seen 9/2007 for audio done w/inserts; fit with aids. Seen again 12/2007 for C&P – thresholds not re-checked. Seen later same day for HA adjust due to c/o aids being too loud – thresholds rechecked with headphones. C&P results had to be revised due to invalid results that may have affected rating; ITE aids returned for credit and open-fit aids ordered.

# Patient #2 Data

## Insert earphones

## Headphones

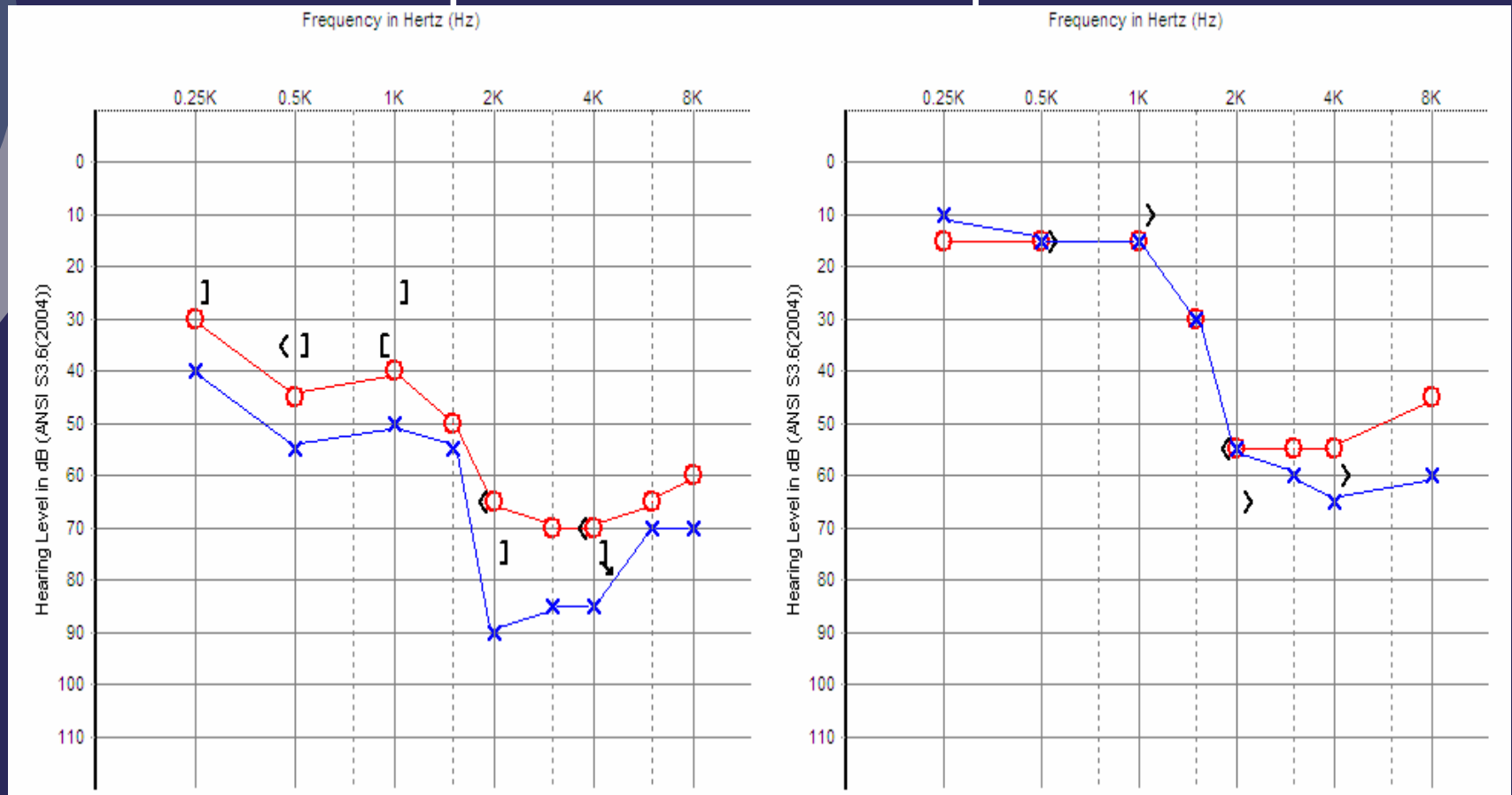


25 y/o male seen 2/2008 for C&P evaluation; reported history of middle ear infections in right ear while on active duty; right-sided tinnitus; normal tympanograms AU; elevated/absent ipsi reflexes AU. Tested with both sets of transducers same session, same examiner. Left ear w/inserts appears to have mild hearing loss, but actually WNL w/phones. Final Air-Bone gaps at right ear are fewer and smaller than would have been identified had insert phone thresholds been used.

# Patient #3 Data

## Insert earphones

## Headphones



63 yo male veteran; seen 8/2007 for audio done w/inserts; ITE aids ordered. Seen again 1/2008 for C&P – headphones used. If examiner had elected to use original audio for C&P (b/c within 6 months) the rating would have been higher than with the second audio. Clinician then recommended reprogramming of current aids or replace with open-fit BTE style aids.

# Results

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As shown by the demonstrated patient data, results differed based upon the type of transducer used. The common finding was that insert earphones yielded poorer thresholds than did headphones. Moreover, headphones were found to be more comparable with the bone conduction thresholds than were earphones. In many instances, conductive components were measured to be *larger* when comparing BC results with AC insert phone thresholds than with AC headphone thresholds.

The same findings have been identified on many more patients clinically whose cases have not been presented here.

# Conclusions

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- Headphones appear to yield threshold results that are routinely more consistent with bone conduction thresholds than do insert phones.
- It is *proposed* that headphone thresholds are therefore the more accurate of the two sets of thresholds if a difference is identified.

# Recommendations

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- Have calibrated headphones on hand in your clinic for these instances. Teach students how to use them.
- Consider testing an unmasked, unoccluded bone line PRIOR TO air conduction testing – so that if an A/B gap occurs with inserts, transducer type can be switched early in testing which may avoid timeliness issues.
- Re-testing with headphones in these instances will help to avoid potentially inaccurate reporting, improper recommendations and fitting of amplification, and improper medical/ surgical referrals.
- If a hearing aid user originally tested with inserts returns complaining of aids being too loud, consider re-testing with headphones, especially if significant reductions in gain are necessary to achieve subjectively comfortable gain.
- **Formal research to examine all theories should be conducted to further investigate this phenomenon and to devise a solution.**

# Key References

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1. Hawkins, D.B., Cooper, W.A., and Thompson, D.J. (1990). Comparisons among SPLs in real ears, 2 cm<sup>3</sup> and 6 cm<sup>3</sup> couplers. *Journal of the American Academy of Audiology*; 1:154-161.
2. Voss, S.E., Rosowski, J.J., Shera, C.A., and Peake, W.T. (2000, March). Acoustic mechanisms that determine the ear-canal sound pressures generated by earphones. *Journal of the Acoustical Society of America*; 107(3):1548-1565.
3. Voss, S.E., and Herrmann, B.S. (2005, December). How does the sound pressure generated by circumaural, supra-aural, and insert earphones differ for adult and infant ears? *Ear and Hearing*; 26(6):636-650.