Sound attenuation and permissible noise levels for hearTest occupational health audiometry

De Wet Swanepoel, PhD | *Scientific advisor, hearX group, Pretoria, South Africa*

INTRODUCTION

Conducting pure-tone audiometry in occupational settings require a controlled test environment with ambient noise levels that are sufficiently low to allow for threshold measurements down to 0 dB HL. To avoid the expense and mobility issues related to a sound booth alternative solutions using insert earphones combined with earcups have been evaluated with reasonable success (Swanepoel et al. 2015). The expense of audiometers have remained a barrier however. Recently the use of smartphone apps with calibrated headphones have demonstrated accurate and affordable mobile audiometry (van Tonder et al. 2017; Sandstrom et al. 2016).

This study investigates the sound attenuation of the hearTest smartphone app using insert earphones covered by earmuffs compared to permissible sound levels for screening audiometry in occupational health (SANS 10182:2006).

OBJECTIVES

1. To determine the average sound attenuation levels of the hearTest occupational health setup (insert earphones covered by earmuffs).

2. To compare attenuation and maximum permissible ambient noise levels (MPANLs) between transducer setup for hearTest occupational health, standard audiometric headphones and the Kuduwave audiometer.

METHODS

A sample of 15 normal-hearing subjects was recruited. A within-subject design was used to determine the attenuation of the hearTest occupational health and Kuduwave setup in accordance with procedures described in ISO/SANS 8253-1 and reported for the Kuduwave previously (Swanepoel et al. 2015). Age ranged from 19 - 41 years with an average age of 28.3 years.

Equipment

Data collection was conducted in a double-walled IAC (Industrial Acoustic Company Inc., New York) audiometric booth adhering to ambient noise levels specified by ANSI/ASA S3.1-1991 (R2018) and SANS 10182:2006 for evaluating hearing for air- and unoccluded bone-conduction down to 0 dB HL from 125 to 8000 Hz. A calibrated GSI-61 diagnostic Type 1 clinical audiometer (Grason-Stadler, Eden Prairie, USA) was used to obtain air-conduction thresholds within a sound field for determining transducer attenuation.

The hearTest occupational health setup (figure 1) included insert earphones (Radioear P5011 50 ohm) covered by earmuffs (3M Peltor X5A) similarly to the Kuduwave audiometer which uses its own proprietary earcups.

Figure 1. The hearTest™ occupational health setup

Procedures

The experimental setup involved the free field presentation of narrowband noise through left and right speakers simultaneously at octave and interoctave frequencies from 125 to 8000 Hz. The azimuth of the speakers was 45 degrees on the left and right, 1 m from the subject's ears. A modified Hughson-Westlake threshold seeking method was used to determine hearing thresholds (-20 to 80 dB HL range) starting at 1000 Hz down to 125 Hz, and then from 2000 to 8000 Hz.

There were three test conditions, 1) No transducer condition; 2) hearTest setup with insert earphones and earmuffs; 3) Kuduwave setup with insert earphones and earcups. Condition 1 and 2 were counter-balanced.

RESULTS

The average attenuation levels of the hearTest transducer setup compared to ISO/SANS 8253-1 and Kuduwave transducer setup is provided in table 1. The average MPANLs of the hearTest transducer setup compared to ISO/SANS 8253-1 and Kuduwave transducer setup is provided in table 2. There was no statistically significant difference across frequencies for hearTest and Kuduwave sound attenuation ($p>0.05$, Wilcoxon signed ranks test)

Table 1. Average sound attenuation of typical audiometric headphones (ISO/SANS 8253-1) and hearTest occupational health and Kuduwave transducer setup

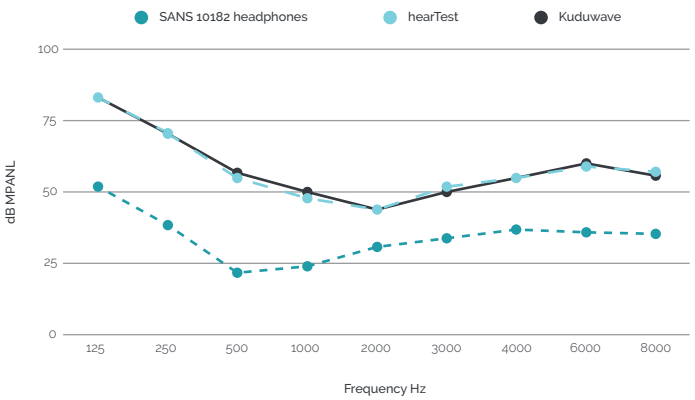
Frequency Hz	Typical headphones (ISO/SANS 8253-1) dB	hearTest transducer setup dB	Kuduwave transducer setup dB
125	3	34	34
250	5	36	37
500	7	42	40
1000	15	41	39
2000	26	39	39
3000	31	47	49
4000	32	50	50
6000	26	50	49
8000	24	44	45

Table 2. Maximum permissible ambient noise sound pressure levels (MPANLs) for screening audiometry using typical audiometric headphones (SANS 10182:2006) and hearTest occupational health and Kuduwave transducer setup

Frequency Hz	Typical headphones (SANS 10182:2006) dB	hearTest transducer setup[1,2] dB	Kuduwave transducer setup[1] dB
125	52.0	83.0	83.0
250	38.5	70.0	70.5
500	22.0	57.0	55.0
1000	24.0	50.0	48.0
2000	31.0	44.0	44.0
3000	34.0[2]	50.0	52.0
4000	37.0	55.0	55.0
6000	36.0[2]	60.0	59.0
8000	35.5	56.0	57.0

1. Attenuation advantage (dB) over SANS 10182 headphones added to MPANLs for SANS screening audiometry
2. Inter-octave frequencies not specified by SANS 10182. Average between adjacent octave frequencies

Figure 2. Maximum permissible ambient noise levels for screening audiometry using different transducers setups. SANS 10182 headphones (TDH 39); hearTest (insert and earmuff); Kuduwave (insert and earcup).



CONCLUSIONS

- The hearTest occupational health transducer setup (inserts covered by earmuffs) exceed the ambient noise attenuation required for screening audiometry by ISO/SANS 8253-1 (Figure 2).
- No statistically significant difference in attenuation was found between the hearTest occupational health (inserts covered by earmuffs) and Kuduwave setup (inserts covered by earcup).
- hearTest occupational health attenuation levels are similar to a mini 5-cm panel sound booth and exceed those of typical transportable sound-treated booth (Frank, 2001).

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