Performances of Alternative Listening Devices: Candidates for Individuals with Mild to Moderate Hearing Loss?

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1 Introduction

The past few years have seen a meteoric rise in technological advancements in the hearing health industry. Advances in connectivity, miniaturization and artificial intelligence enable many increasingly sophisticated and diverse features within multifunctional in-ear devices. Such alternative listening devices, often referred to as “hearables”, aim to become real “bionic ears” offering hearing protection, amplification, monitoring and biodetection functionalities. With the recent approval of the ”Over-the-Counter Hearing Aid Act” in the United States and the introduction of “Over-the-Counter” (”OTC”) hearing aids, these devices now have the potential to revolutionize the world of traditional auditory amplification. Recently, a systematic review of scientific literature has concluded that given their availability and affordability, these alternative listening devices could be considered for patients with mild to moderate hearing loss [1].

The aim of this paper is to present a research initiative on hearables and OTC hearing aids, launched within the ÉTS-EERS Industrial Research Chair in In-Ear Technologies (CRITIAS) at the École de technologie supérieure facility. To this end, electroacoustic and acoustic performances of alternative listening devices are explored.

2 Method

2.1 Electroacoustic performances

Alternative listening devices’ electroacoustic performances were evaluated according to ANSI S3.22 [2] and ANSI/CTA-2051 [3]. The following characteristics were assessed: 1) OSPL90 Max, 2) Frequency response, 3) Equivalent internal noise (EIN), and 5) Total harmonic distortion (THD). These analyses were either conducted with SoundCheck (Listen Inc., Boston, MA, USA) or with a Verifit 2 real-ear hearing aid analyzer (Audioscan, Dorchester, ON, CA).

2.2 Acoustic performances

Head-related transfer function (HRTF) measurements were performed in an anechoic room, equipped with an automated arm which can move from -45° to 60° on elevation and from 0° to 360° on azimuth. A loudspeaker was installed at one end of the automated arm. For each set of measurements, a total of 72 points were evaluated: from 0° to 360° on the horizontal plane (with 15° steps) and at -40°, 0°, and +45° on the vertical plane. The movement of the automated arm and data collection were fully managed by LabVIEW™ (National Instruments, Austin, TX, USA). At each position, a white noise was generated by the loudspeaker and the acoustic pressure was measured at the two coupler microphones of a 45CB Artifial Text Fixture (G.R.A.S, Holte, Danemark) (Figure 1) with and without the devices in place (on the ATF’s ears). For each ear and each position, the device’s effect on the corresponding HRTF was then assessed as the pressure ratio between the open-ear and ear-with-device conditions. To evaluate the acoustic performance of the listening devices, these were set into their more transparent mode (i.e., the setting in which -based on the manufacturer’s saying- their influence on HRTFs should be minimal).

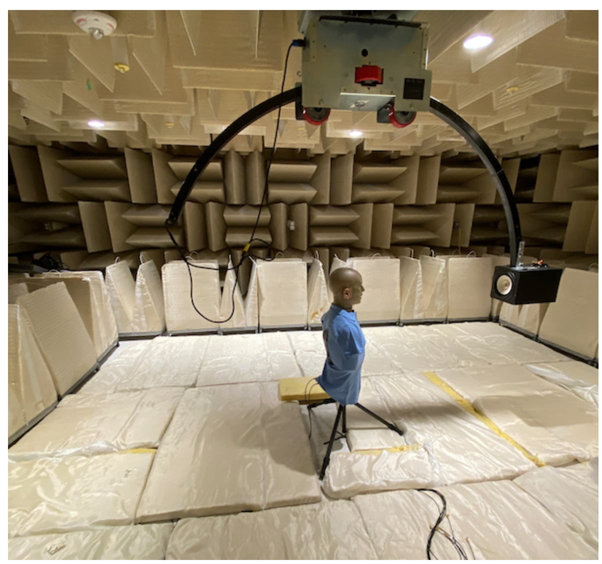

Figure 1: Picture of the anechoic room setup with the ATF and the automated arm holding the loudspeaker.

3 Results

3.1 Electroacoustic performances

Preliminary electroacoustic performance results obtained on two alternative listening devices (Britzgo Optio Hearing Aid Amplifier and AidPods Pro-2nd generation) are presented in Table 1. The two devices were within the tolerance limits regarding OSPL90 Max (< 120 dB SPL) and frequency range

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(250–6,000 Hz). Both devices showed higher EIN than the prescribed tolerance (> 28 dB SPL). Finally, for THD, performances for the AirPods Pro were withing the tolerance limits, while the Britzgo Optio showed less satisfactory results, generating a value of 3% at 500 and 800 Hz.

Table 1: Preliminary electroacoustic analysis of two alternative listening devices.

	Britzgo Optio	Air Pods Pro
OSPL90 Max (dB SPL)	113.0	102.0
Frequency response (Hz)	200-5,000	200-6,300
EIN (dB SPL)	30.0	37.0
THD @500 Hz (%)	3.0	0.0
THD @800 Hz (%)	3.0	0.0
THD @1600 Hz (%)	1.0	0.0

3.2 Acoustic performances

Two listening edevices that include a transparency mode were assessed (i.e., Apple AirPods Pro-2nd generation and Nuheara IQbuds 2 MAX). Figure 2 presents the effects of these two listening devices on the 72 assessed HRTFs. While the IQ Buds give satisfactory results, especially for low frequencies, surprisingly, the AirPods' performances do not differ from that achieved when the earbuds are turned off.

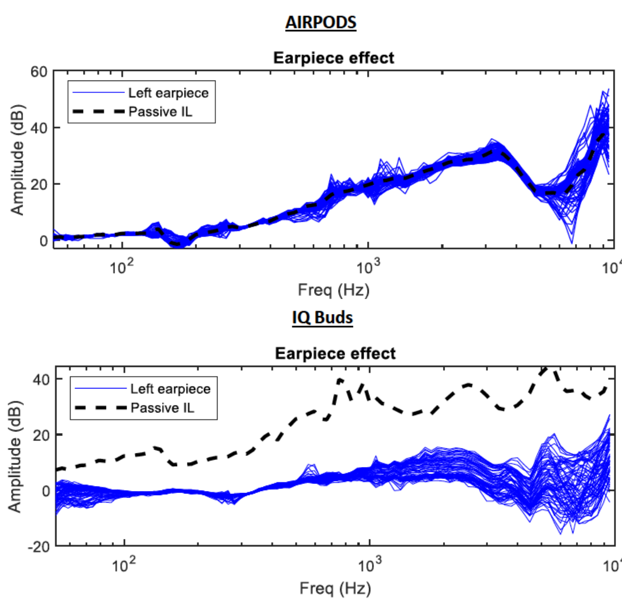

Figure 2: Effects on HRTFs of two alternative listening devices. The black dashed line corresponds to the effect measured when the device was turned off.

4 Discussion

Our preliminary results show that some alternative devices can present with electroacoustic performances that respect current standards ANSI S3.22 [2] and ANSI/CTA-2051 [3]. However, in some cases, these performances are insufficient. For example, while the AirPods Pro present an OSPL90 Max and THD comparable to traditional hearing aids, they also show high EIN and a narrower range of frequency response. Such irregularities could be problematic for users with mild to moderate hearing loss. Current research has shown a wide variety of electroacoustic performances across alternative listening devices [4], similar to those observed in this preliminary study. Future research should aim to investigate the clinical effectiveness of these various devices for individuals with mild to moderate hearing loss. To this regard, some researchers have already obtained promising results [5].

To our knowledge, this research initiative is one of the first to investigate the HRTFs of alternative listening devices to better understand how they can affect localization cues. As for electroacoustic performances, we observed various effects on HRTFs amongst devices. While some devices show promisingly transparent features (e.g., Nuheara IQbuds 2 MAX), others significantly alter the HRTF (e.g., AirPods Pro). Future experiments by our research team will aim to confirm these results and identify what may cause some results to be rather disappointing (e.g.,device malfunction).

5 Conclusions

Our results provide preliminary insight into the electroacoustic and acoustic performances of alternative listening devices. They show that performances can vary from one device to another. Future research should aim to better understand how these devices could be used by individuals with mild to moderate hearing loss.

Acknowledgments

The authors would like to acknowledge the financial support received from NSERC Alliance (ALLRP 566678-2021), MITACS IT26677 (SUBV-2021-168) and PROMPT (#164_Voix-EERS 2021.06) for the ÉTS-EERS Industrial research chair in in ear technologies, and from FRQS Young Researchers Grant 324155 for Université Laval.

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