THE ANALYSIS OF SPEECH PERCEPTION WITH THE USE OF HEARING PROTECTION EARPLUGS USING THE CANADIAN DIGIT TRIPLET TEST

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1 Introduction

To prevent noise-induced hearing loss, it is recommended that workers wear hearing protection when the daily exposure exceeds 85 dBA. Choosing the right type of protector depends on the amount of attenuation achieved in relation to the noise level. Labelled attenuation values reported by manufacturers, such as the NRR, have limited accuracy in predicting what an individual worker will achieve in practice [1]. To counter this deficiency, fit-testing measurement systems have been developed that have shown to be a reliable method to determine attenuation for an individual wearing hearing protection [2]. Additionally, workers need to communicate and hear important sounds in their environment. Standards like the CZA Z1007:22 [3] recommend conducting practical tests, but there is currently no recognized efficient methodology or objective tool available to determine if the communication needs of workers are adequately met. The Canadian Digits Triplet Test (CDTT) is an automated screening speech test based on simple digit material that can be administered in about 2-3 minutes and could proved to be a useful tool to determine individual worker's speech perception when wearing hearing protectors.

The objectives of this research are to (1) compare earplug attenuation in individuals with normal hearing and hearing loss based on fitting instructions, and to (2) analyze speech perception with earplugs using the CDTT in individuals with normal hearing and hearing loss, considering the attenuation achieved.

2 Methods

2.1 Participants

A total of 18 adult participants, ranging in age from 19 to 74 years, were recruited for this research project. Among them, 11 participants had normal hearing, while 7 participants had a hearing loss in at least one ear.

2.2 Materials

Hearing thresholds in each ear were measured using the Interacoustics AC40 audiometer in conjunction with the supra-auricular RadioEar DD45 headset. Speech perception was assessed using the Canadian Digit Triplet Test (CDTT) on a portable Windows computer, with sound presented through the circum-auricular RadioEar DD450 headset. Each participant was placed in an acoustically insulated room and tested with and without wearing a pair of 3M E-A-R Classic Earplugs.

2.3 Procedures

Before conducting the experimental tests, preliminary measures were administered to determine the participants' hearing status (normal or impaired) and to ensure the absence of contraindications or safety concerns, such as excessive earwax. These preliminary measures consisted of otoscopy, tympanometry, and bilateral tonal audiometry.

Participants then underwent a series of experimental tests under three different conditions: (1) without wearing earplugs, (2) wearing earplugs without receiving specific instructions on their proper usage, and (3) wearing earplugs with instructions on the correct method of insertion. For each condition, participants completed a speech perception test in quiet using the CDTT, which included different lists, male and female voices, in the participants' preferred language (English or French). Additionally, binaural tonal thresholds were measured in each of the three conditions above at frequencies of 250, 500, 1000, 2000, 4000, and 6000 Hz using the Bekesy method and the Interacoustics AC40 audiometer and circum-auricular RadioEar DD450 headset.

2.4 Data Analysis

Data analysis was performed using Microsoft Excel. The collected data for each participant were entered into the spreadsheet, and calculations were conducted to determine the average, standard deviation, minimum, and maximum values for binaural tonal thresholds and speech perception thresholds. These measures were analyzed for all three testing conditions. Furthermore, the attenuation was calculated by subtracting the tonal thresholds obtained without earplugs from those obtained with earplugs at each frequency. The global attenuation of the CDTT speech signals was also calculated by considering the speech spectrum of the male and female speakers.

3 Results

Speech perception thresholds in silence measured with the CDTT are shown in Figure 1 for male and female voices. When testing with the male voice, most participants had higher speech thresholds with earplugs than without and thresholds generally increased after providing instructions on the proper fitting method. Only participants 9, 14 and 15 had higher thresholds without proper fitting instructions. With the female voice, participants 2, 7, 9, 12, and 14 had higher thresholds without proper fitting instructions. Although some participants had lower thresholds with instructions that without instructions, Figure 2 shows that attenuation with instructions is always higher except for participant 14.

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Figure 3 demonstrates that when comparing participants with normal hearing to those with a hearing loss, there was no significant difference between attenuation when tested in the same condition.

Data analysis also demonstrated that on average, participants with a hearing loss had speech perception thresholds close to 50dBA and sometimes surpassing 65dBA (which corresponds to a normal vocal effort at close range) when wearing earplugs (see Figure 1).

4 Discussion

This pilot study indicates that CDTT thresholds in silence generally increase with the attenuation of an earplug or with a better fit, sometimes to a level where communication could be compromised in some individuals with hearing loss, especially when considering that more complex speech materials like sentences require higher speech levels than digit tests. According to [4], workers situated at a distance of 1.2 meters reported speaking at a normal voice amidst noise reaching up to 81 dBA and at a raised voice level in 87 dBA of noise when not wearing hearing protectors. When wearing hearing protectors in noise, many studies indicate a decrease in voice levels by the speaker [5].

The CDTT is a straightforward and quick speech assessment that simply requires participants typing in digits heard on a computer or tablet and can assist in determining the minimum voice level for speech recognition by workers wearing hearing protectors.

5 Conclusion

Although preliminary findings suggest that the CDTT can proved to be a useful field test to efficiently assess speech perception for individual workers when wearing their hearing protectors, this research has an important limit. Results were collected in silence, and thus relates to situations of low noise levels or noise interruptions. Further speech testing in noise is necessary to obtain valuable information on the efficacy of the CDTT in assessing speech perception for workers wearing hearing protectors in noise.

6 References

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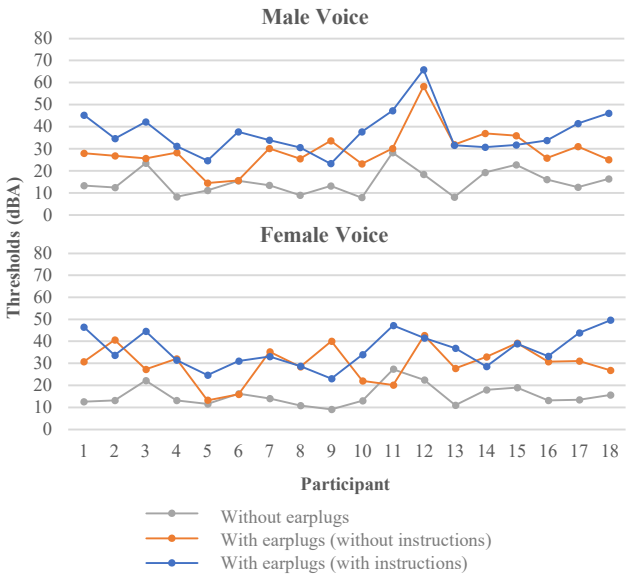

Figure 1: Speech perception thresholds with the use of the Canadian Digits Triplet Test for each Participant.

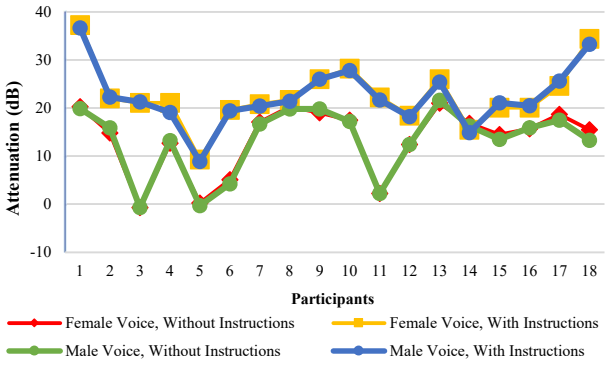

Figure 2: Comparison of global earplug attenuation of the male and female voices for each participant.

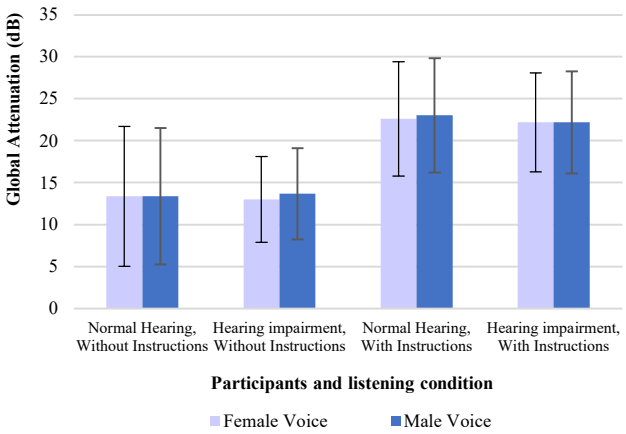

Figure 3: Comparison of global earplug attenuation between normal hearing and hearing-impaired participants.