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Preliminary Study on the Influence of Headphones for Listening Music on Hearing Loss of Young People

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The paper presents results of hearing loss measurements provided for 81 young people (from 16 to 25 years old). The main aim of the work was to find the influence of headphones of the types used (closed, semi-open, open and in-ear) on the hearing losses. The first part of the research was to answer questions about the influence of: time of listening, loudness of music, other noise exposures as well as the type of the headphones used. It turned out that all factors mentioned above influence thresholds of hearing but the found dependencies are not explicit. The greatest hearing losses were observed for people who work as sound reinforcement engineers and, moreover, no influence of the headphone types was found for them. It turned out that the use of in-ear headphones causes the greatest hearing losses for some subjects (thresholds shifted up to about 20 dB HL at 4 kHz). The daily time of a listening also affected the hearing thresholds. It was found that for users of in-ear and close headphones, an average time of musical exposure of three hours causes the hearing loss of 10–15 dB HL at higher frequencies. The use of open as well as semi-open headphones has no influence on the hearing damage. Thus it would be stated that these kinds are safety in use. Almost 15% of the investigated young people have their thresholds shifted up at higher frequencies, particularly at 4 kHz, which means that they have the first symptoms of a permanent hearing damage.

Keywords: hearing threshold, headphones.

1. Introduction

In the past few years, the tendencies of sound production caused an increase of loudness of sound for communication, particularly for musical recordings. Many radio stations as well as record companies have applied increasing amounts of dynamic range compression and other means of the recording process in order to be perceived in the today noisy world (Katz, 2007). Radio stations may adjust the dynamic ranges in attempt to trade off a louder sound, which may attract listeners searching for a station. The trend called as "loudness wars" has been reflected in the higher subjective impressions in the psychological domain, and the slogans "louder means better" and "louder sounds are sold better" have come true (Vickers, 2011). Many young people want to separate their minds of different backgrounds by the use of special kinds of headphones and they listen to the sound material louder, beside of the fact that the listened material is louder in comparison to the recordings made in the previous century. The contemporary designed and produced equipment allows the listeners to consume music in accordance with their way of life. On the other hand, young people say: we listen to the music that sounds nicely for us and it is not alike as noise, so why may it be dangerous for our hearing? Sometimes, one could find many pieces of classical music from the XXth century, which are very loud while performed. The main differences between classical and pop-music are in the time of continuous exposition to the sound, the character of musical structure and spectral consistence of stimuli. In popular music, the way used very often during musical production process is based on the sound compression, and this compression itself may increase the potential for hearing damage. Moreover, the way of stimuli presentation (via headphones or loudspeaker, or naturally listening to the event) seems to be an important thing causing the hearing loss. Young people do not take into account that popular or rock music

causes effects like that of higher and longtime exposure to noise when the earphones are used for listening due to the average sound level and duration of exposure, which simply leads to a listening fatigue (Moore, 1997). Of course, the higher hearing thresholds induce difficulties in receiving many information from human environment that influences the sense of safety and causes changes in the way of thinking and living together in a society (Strelau, 2000). It also may be interesting while the European Standard EN ISO 7029 still remains actual in the light of youngsters' way of life and this aspect was the aim of the research presented.

2. Experimental research

The results of audiometric measurements of 81 young people aged between 16 and 25 years are presented. The subjects declared frequent listening to loud music on headphones. None of them complained of hearing problems. The participants were asked to fill out the questionnaire sheet and to answer the following questions: the type of the used headphones, the daily listening time, the preferred levels of listening and the kind of music. Additionally, they have to point on other conditions concerning the noise exposure at the work, the background noise connected with the place of living, the work activity etc. The research was made for the inhabitants of Wroclaw.

Some of the people under investigation are working for an entertainment industry in a professional way so they were divided into three groups reflecting their activities:

- young classical musicians or music academy students,
- sound reinforcement engineers of FOH/PA systems (Front of House / Public Address sound system),
- sound engineers working in recording studios.

The ordinary young users of portable audio equipment were representative as the reference group for this range of age.

Characteristics of the study population obtained on the base of the questionnaires are as follows:

- 81 people (including 26 women),
- the average age: 22.5 years (between 16 and 25),
- average daily time of using of the headphones: 32 h (from 2 to 7 hours, 1 person declared 14 hours),
- other noise exposures: 4.9 hours per week (for example loud rock concerts).

The noise exposure occurred in the group of professionals.

According to the questionnaires, taking into account the subjects' activities, the whole group of the 81 persons was divided into the following four subgroups:

- young classical musicians or music academy students (26 people including 10 women),
- sound engineers of FOH/PA systems (10 men only),
- sound engineers working in recording studios (11 people including 3 women),
- users of audio equipment involved not professionally with the entertainment industry (34 people, including 13 women).

The first three subgroups were considered later separately.

The young musicians usually practice individually being exposed to noise for a long time (up to 8 hours per day). An equivalent level weighted during practicing with A curve that does not exceed 70 dB and is not harmful to hearing. On the other hand, this an important fact in their work is a symphony orchestra in that the rehearsal unweight peak levels can be as high as 110 dB SPL and the equivalent level A may be even of 85 dB. These are facts often overlooked and very reluctantly discussed by directors of operas and symphony orchestras due to the damages for musicians.

The second type of division of the whole population is defined by different types of earphones used by the subjects as declared in questionnaire what resulted in four subgroups:

- in-ear headphones – 23 users,
- open headphones – 18 users,
- closed – 22 users,
- semi-open – 18 users.

In this case each group consists of almost the same number of women and men. The most of the subjects (80%) declared that they listened to very loud music and the daily time of the headphone use was 3.2 h, which results in a weekly exposure of more than 22 h. The results of the questionnaires did not allow indicating any other factors that could influence the hearing threshold values because of their different representatives within each subgroup.

After the interviews and spoken instructions the people were measured by means of audiometers. The audiometric tests were conducted in an anechoic chamber and in the recording studio of the Wrocław University of Technology. These places meet the requirements of a maximum allowable amount of the background sound pressure level (ISO 8253-1:2010). Therefore, during the tests any masking phenomenon from outer signals does not occur (PN-EN 26189, ISO 8253-1:2010, ISO 7029:2000). Before the measurements, all the audiometers had been basically calibrated and checked aurally, they had also been calibrated subjectively in accordance with the ISO recommendations (PN-EN 26189). The threshold of hearing levels were determined by the air conduction audiometry with the

Maico M 53 audiometers. The measurements were carried out according to the applicable standards (PN-EN 26189) by ascending methods and with the use of continuous sinusoidal signals with steps of 2 dB. All measurement points were repeated twice in order to eliminate random errors for inexperienced subjects.

3. Analysis of the results

3.1. Average hearing threshold

Figure 1 shows the values of the hearing threshold for the left and right ears of the population tested. These values have been averaged over results obtained for 81 listeners. It can be easily seen that the threshold of hearing is uniformly shifted by about 6–7 dB. The statistical treatment by means of the Bartlett test (Greń, 1978) showed that the variances of the results obtained were homogenous ($\chi^2 = 24.893 < \chi^2_\alpha = 39.977$, at $\alpha = 0.05$) for all frequencies.

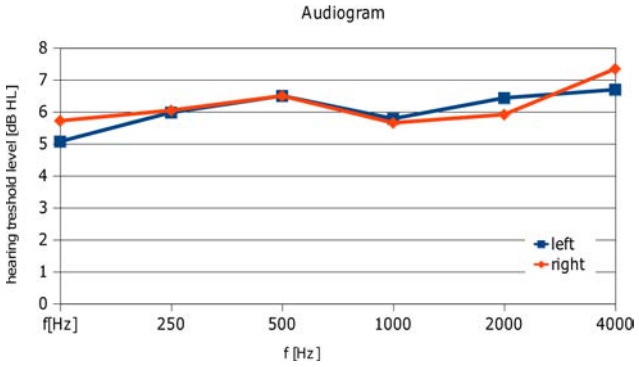

Fig. 1. Average values of the threshold of hearing (dB HL) for the tested population.

According to classification of BIAP (BIAP Recommendation 02/1), the young people tested belong to the group of normal hearing, but the shift in the threshold of hearing points to a slow tendency of the beginning of a permanent damage of hearing. These values, however, are the average ones and the greatest hearing losses can be balanced by the results for the people with otological normal values shown in Table 1 as values of standard deviations, especially for higher frequencies. Thus, it was decided to divide the whole group into categories which could influence the obtained results and reflect the real hearing loss for some specific nature of work as well as kinds of equipment used by the people.

Table 1. The average values and standard deviations for hearing thresholds (dB HL) for the left and right ears, respectively, measured for all of 81 subjects.

Frequency [Hz]	250	500	1000	2000	4000	8000
$\overline{x}_L$	5.1	6.0	6.5	5.8	6.4	6.7
σ_L	7.2	6.9	6.1	6.6	10.2	11.1
$\overline{x}_R$	5.7	6.0	6.5	5.6	5.9	7.3
σ_R	5.5	6.4	5.7	7.4	11.5	10.8

3.2. The influence of different kinds of headphones on the threshold of hearing

In this section, the results of pure tone audiometry for users of different types of headphones are presented. These results present "the worse" ear (left or right) for each subject and these values have been averaged over the people which use particular types of headphones. They are shown in the Fig. 2.

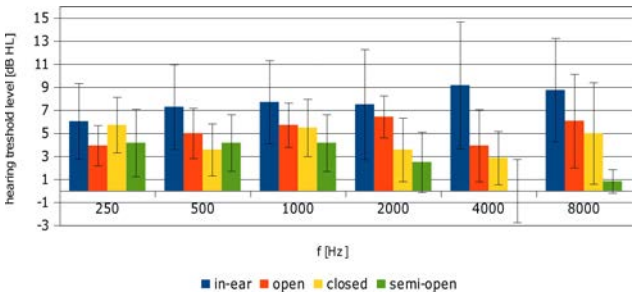

Fig. 2. Influence of different kinds of headphones on the threshold of hearing (dB HL). Standard deviation values are presented as vertical lines on the tops of the bars.

It turned out that except for the frequency of 4 kHz there is no relationship between the types of the preferred headphones and the shift of the hearing thresholds ($F < F_\alpha = 2.75$, where F, F_α – calculated and critical values of the F-Snedecor test, respectively, at $\alpha = 0.05$). For the frequency of 4 kHz, a statistically important influence of the headphone type on the threshold values was observed ($F = 3.35 > F_\alpha$). This means that most unfavorable for the hearing are inner earphones, especially at high frequencies for which our hearing system is most sensitive. The air in the ear canal is a natural protection from high sound pressure. Using inside earphones the length of the channel is reduced whereby the natural protection becomes less effective and the sound level in ear channel increases by 6 dB. Good alternatives are semi-open headphones that in a small way can isolate us from the outside noise. They additionally ensure good hygiene of the ear and by their design they are a protection from very high sound pressures acting directly on the ear membrane. The results of the hearing threshold values obtained for the frequency of 4 kHz are presented in Table 2.

Table 2. The average values of hearing thresholds at 4 kHz for various types of headphones, in dB HL.

Type of headphones	in-ear	open	closed	semi-open
Hearing threshold [dB HL]	9.2	3.9	2.9	0.1

In order to determine how the particular kinds of headphones are injurious for listening conditions, the structure index test (Greń, 1978) was applied as a statistical treatment for the series which reflects the degree of the hearing damage caused by the type of the used headphones, with $u_\alpha = 1.96$ at $\alpha = 0.05$. It turned out that for the frequency of 4 kHz the most dangerous for the hearing threshold is the inner-ear headphone type ($|u| = 4.73$), while the influence of the semi-open type is statistically inessential ($|u| = 1.05 < u_\alpha$). The degrees of injuries of the hearing damage obtained for the open and the closed headphones are lower than those for the in-ear headphones ($|u| = 2.52$ and $|u| = 2.12$, respectively).

3.3. Threshold of hearing in terms of professional work

In this section, only the professional group is analyzed (the three first subgroups listed in Sec. 2). The number of people in this group is equal to 47. Among them 35 persons have been working in the profession up to 7 years. By analyzing these data it can be concluded that even 3–4 years of working at an entertainment industry, especially as the front-of-house engineers may cause a slight loss of hearing ability. Comparing the other professional groups, it can be assumed that the results coincide to a large extent and the type of work (noise level) have no longer such effect on the threshold of hearing. In Fig. 3 hearing thresholds depending on the profession are presented. These results present "the worse" ear (left or right) for each subject, and these values have been averaged over the people within the particular group of profession.

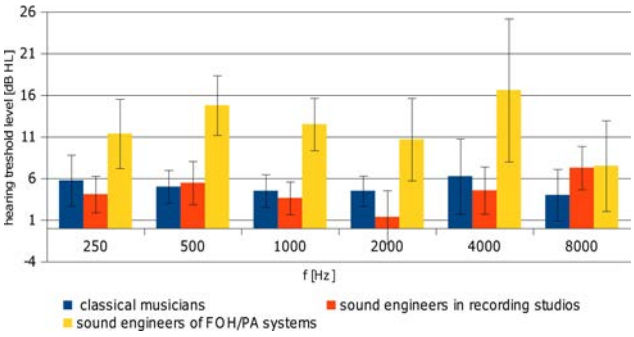

Fig. 3. Thresholds of hearing (dB HL) depending on the profession. Standard deviation values are presented as vertical lines on the tops of the bars.

As in the previous case it was decided to use the single-factor statistical treatment and on the base of the analysis of variance, it turned out that for frequency values of 500 Hz, 1 kHz as well as 4 kHz an influence of the working activity on the threshold of hearing has been observed ($F > F_\alpha = 3.29$, where F, F_α – calculated and critical values of the F-Snedecor test, respectively, at $\alpha = 0.05$). For other frequencies there is no relationship between the profession of work and the shift of the hearing threshold values. As mentioned in the previous chapter, the hearing loss at 4 kHz can be interpreted as the beginning of a permanent hearing damage that results from the exposure to sounds at high levels while the upward threshold shifts appearing for lower frequencies (500 Hz and 1000 Hz) result from the exposure to hyper-compressed musical sounds in these frequency bands, especially occurring on the stage situation in order to increase the total loudness impression.

4. Conclusions

On the base of the results presented it would be fairer to say that the most dangerous kind of headphones is the in-ear headphone set which causes the upward threshold shift of 9 dB HL at the frequency of 4 kHz. When the music would be played very loud and as long as declared at a level of approximately 100 dB SPL, a permanent hearing damage will occur after no more than 4 years of using such devices. Another factor influencing the hearing condition system is the professional activity connected to the exposure to loud signals. The presented results have also shown that working as reinforcement engineers with FOH/PA systems can permanently destroy the hearing system because an activity as long as 3–4 years causes the upward threshold shifts even of 16 dB HL at 500 Hz and 4 kHz. These values may mean the beginning of a permanent hearing damage and have to be taken into consideration by the industrial health protection. The results of the other researches (Chiou-Jong *et al.*, 2007; Gulati, 2011) conclude that it is enough to listen to loud music on MP3 players one hour a day for five years to ruin the hearing system permanently.

Hearing care professionals skeptical to listening to music with headphones admit that only a moderate volume for up to 8 hours a day is no longer a risk of hearing loss.

It was clearly shown what kind of problems we are dealing with. Listening to music is becoming a disease primarily among young people, but this fact is ignored in the media. The biggest problem is the type of headphones used for the every day listening. Most of young people listen to music through inside earphones what causes that the length of the ear canal is reduced, and as a consequence, the natural protection becomes less effective. The body does not give us a sign that the process of destroying the hearing has just began, and once damaged the hearing cells would never regenerate.

From the sociological point of view, young people like this kind of earphones because they take up little space and can be always carried in a pocket, however on the other hand, they are the worst ones for our hear-

ing. Research has shown that 2–3 years of using this type of headphones leads to a slight hearing damage resulting in an incomprehensibility of whisper or quiet voice.

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