COMFORT FROM HEARING PROTECTORS

Alberto Behar*[1], Roopa Segu[1] and Frank A. Russo[1]
[1]Ryerson University, Toronto, Canada

1 Introduction

The two properties of utmost importance when dealing with hearing protectors are sound attenuation and comfort. Sound attenuation, defined as the difference between the sound levels of the open and the protected ear is well defined and there are standardized methods for its measurement.

There is no clear definition, however, on hearing protector comfort, nor are there standards for its measurement. Also, research done regarding comfort appears to be limited. A search conducted on the popular Web of Science database, shows that between the years 1970 and 2014, 208 papers were published dealing with attenuation, while there were only 22 papers related to comfort.

Comfort is an evaluation that may be defined quite simply as "all is well." It is inherently subjective in nature. It is also dependent on issues other than the protector itself, but related to the environment, such as temperature and humidity of the workplace. Other factors to be considered include the need for speech intelligibility and anatomical differences among wearers.

In contrast, discomfort may be defined (and measured) along many dimensions. Some examples of those dimensions are shown in Table 1.:

Pressure on the eardrum
Irritation of the canal lining
Feeling of fullness
Occlusion effect
Heaviness
Heat and humidity
Pressure against the head
Interference with headgear, eyeglasses and hair

Table 1: Some factors for discomfort

*alberto.behar@psych.ryerson.ca

Over the years researchers have taken different approaches to study comfort. Some did literature searches; other did lab and/or field studies. In general, the lab studies involved short exposure times. Nonetheless, some researchers claim that short exposures lead to similar outcomes than would be expected from longer exposures typical of the work environment.

When studying comfort of earmuffs, some focused on the force exerted against the head, while others were interested in pressure measurement. Also there are studies regarding the influence of heat and humidity on comfort. Finally, some researchers have tried to put together sound attenuation and comfort. Almost all of them made use of some sort of questionnaire to quantify the weight of the different factors of discomfort. Table 2 shows an example of a questionnaire.

How does the protector feel?

Painless	____	____	____	____	____	Painful
Tight	____	____	____	____	____	Loose
Heavy	____	____	____	____	____	Light

Table 2: Example of Bipolar Scales

This presentation critically evaluates studies on comfort in hearing protectors completed over the past 25 years, with the intention of developing a novel procedure for ranking hearing protectors on the basis of comfort under specified conditions. This approach will involve statistical regression, allowing us to evaluate the relative contribution of different factors on comfort.

2 Discomfort factors

As defined in Wikipedia, "*comfort (or comfortability, or being comfortable) is a sense of physical or psychological ease, often characterized as a lack of hardship". Further, "because of the personal nature of positive associations, psychological comfort is highly subjective*".

The definition of comfort involves several contributing factors that are not simple to define. For example, if we qualify a pair of shoes as "comfortable", there is no need to explain why: it is implicit that those shoes fulfill every requirement for feeling comfortable. However, if the shoes are not comfortable, then one must define the quality or the qualities that make them feel as such and those can be numerous. The same concept can be applied to hearing protectors. As shown further below, there are many factors that can make them uncomfortable.

As a start, we shall propose that no Personal Protective Equipment (PPE) is comfortable. All PPEs imply a certain degree of discomfort, probably related to the fact that they are "extra garments", not needed for performing the task at hand.

There are several qualities that can cause discomfort. For instance, safety shoes are heavy and cumbersome. Hard hats are also heavy and particularly cumbersome to wear in a hot and humid work environment. Gloves can be uncomfortable in a similar environment. On top of perspiration, they may cause skin reactions such as eczema. Safety glasses can be considered the best accepted PPE. They are typically light and, because most people are used to wearing glasses, there is a little perceived discomfort or rejection

With respect to comfort, respirators and hearing protectors are often considered the worst offenders. Depending on the type, respirators tend to restrict breathing. Also they are often heavy and hot. However, respirators are perceived as life-savers. Very little effort is needed to convince workers that they must wear them for their own good.

The situation is different with hearing protectors: in general, as mentioned above, there is much resistance to their wear. A greater amount of effort and time is also required to build awareness regarding noise as a hazard. (« Ears don't bleed »). In addition, HPDs often interfere with speech perception, warning sounds and alarms.

It should be noted that some comfort factors are a function of the length of time HPDs are worn. There are instances when devices appear comfortable when they are first donned. After a while, however, the user may start feeling the weight/pressure and finds them burdensome. This is often the case with muffs, particularly when cap-mounted. Other types of hearing protectors, on the contrary, feel uncomfortable when they are first donned, but after a while, the wearer forgets that he has them on. This is often the case with earplugs.

Based on the above considerations, one would expect that comfort studies should be performed over extended periods of time.

3 Conclusions

The issue of comfort (or discomfort) is complex and appears to be governed by subjective and objective factors:

a) Subjective.
   Different subjects perceive and react differently to the same protector.
b) Objective.
   a. Anatomical differences
   b. Duration of use
   c. Environmental factors (mainly heat and humidity)
   d. Types of protectors (plugs, muffs and semi-inserts)

Bibliography

[1] Akbar-Khanzadeh, F., Bisesi, M. S., & Rivas, R. D. (1995). Comfort of personal protective equipment. *Applied Ergonomics*, 26(3), 195–198.

[2] Behar, A. & Jackson, R.A. (1987). Selection of hearing protectors. *Applied Acoustics*, 22 (25 - 34).

[3] Berger EH & Mitchell (1989) Measurement of the pressure exerted by earmuffs and its relationship to perceived comfort. *Applied Acoustics*, 27(1989) 79 – 88.

[4] Casali, J. G., & Lam, S. T. (1986). Over-the-Ear Industrial Hearing Protectors: An Assessment of Comfort Issues. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 30(14), 1428–1432. doi:10.1177/154193128603001420

[5] Casali, J Lam, S. and E. B. (1987). HPD Comfort Rating S&V 87.pdf.

[6] Centnerová, L. & Boerstra, A. (2010). Comfort is more than just thermal comfort. *Proceedings of Conference: Adapting to Change*: New Thinking on Comfort. Windsor.

[7] Davis, R. (2008). What do we know about hearing protector comfort. *Noise and Health*, Vol 10 No 40 (83 - 89)

[8] Davis, R. R., & Shaw, P. B. (2011). Heat and humidity buildup under earmuff-type hearing protectors. *Noise & Health*, 13(51), 93–8. doi:10.4103/1463-1741.77200

[9] Fernandes, C. (2003). Effects of hearing protector devices on speech intelligibility. *Applied Acoustics*, Vol. 64, Issue 6 (581-590).

[10] Gerges, S. (2010). Hearing protectors: noise attenuation and comfort. *Internoise*, 2010. Lisbon, Portugal.

[11] Hsu, Y.-L., Huang, C.-C., Yo, C.-Y., Chen, C.-J., & Lien, C.-M. (2004). Comfort evaluation of hearing protection. *International Journal of Industrial Ergonomics*, 33(6), 543–551. doi:10.1016/j.ergon.2004.01.001

[12] Ivergård, T. & Nicholl, A. (1976). User tests of ear defenders. *American Industrial Hygiene Association Journal*, Vol. 37, Issue 3 (139-142).

[13] Lindeman, H. (1976). Speech Intelligibility and the Use of Hearing Protectors. *International Journal of Audiology*,Vol. 15, No. 4 (348-356).

[14] Nilsson, R. & Lindgren, F. (1980) The effect of long term use of hearing protectors in industrial noise. *Scand Audio Suppl.*, 12:204 -11.

[15] Park, M.-Y., & Casali, J. G. (1991). An empirical study of comfort afforded by various hearing protection devices: Laboratory versus field results. *Applied Acoustics*, doi:10.1016/0003-682X(91)90082-P

[16] Stenfelt, S. &Reinfeldt, S. (2007). A model of the occlusion effect with bone-conducted stimulation. *International Journal of Audiology*, Vol. 46, Issue 10 (595-608).

[17] Wilkins, P.A. & Martin, A.M. (1985). The Role of acoustical characteristics in the perception of warning sounds and the effects of wearing hearing protection. *Journal of Sound and Vibration*, Vol. 100, Issue 2 (181-190).

[18] Williams, W. (2007). Clamping Pressure and circum-aural earmuffs. *Noise and Health*, Vol 9, No35 (45-50).