INCITING OUR CHILDREN TO TURN THEIR MUSIC DOWN: THE AYE CONCEPT PROPOSAL

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1 Introduction

According to the World Health Organization (WHO), more than 1.1 billion people are currently at risk of losing their hearing due to excessive exposure to noise. Of this, a significant proportion consists of children, youth and young adults who are exposing themselves to excessive levels of sound through various leisure activities (music players, concerts, movies at the theatre, dance clubs, etc.).

To address this issue, many approaches have been developed, ranging from general awareness messages to volume limiters on personal music players. For instance, the recent "Make listening safe" [1] initiative from WHO aims at gathering all stakeholders, public health authorities, and manufacturers to define and develop a consolidated approach to limit these non-occupational sound exposures, based on dosimetry. Indeed, significant efforts have been put into the idea of assessing directly on a PMP (personal music player) the individual noise dose, i.e. the product of the level (L_{eq}) and the duration, induced during music listening.

While many technical issues are still actively discussed in some related standards like the recently released [2] or the under development within ITU Q28/16 on Safe Listening (F.SLD), a major concern arose with regards to the message communicated to the end-users. End-users need to be educated on the risk of noise induced hearing loss (NIHL) and its irreversibilily, but at the same time they also need to be made aware that NIHL is 100% preventable pending safe listening practices are followed.

More importantly, end users have to be left with an appealing noise dose measurement. In that regard, expressing equivalent sound pressure level in decibels (dB) or the noise dose in percentage (%) is of little value given the complexity of one and the abstraction of the other. But communicating about the dangers of music playback is definitely something very new for most of the hearing conservation specialists and communicating with this particular group of youth is only adding to the difficulty.

In the quest for a meaningful message to pass to these young end users, this article introduces a new metric, the "Age of Your Ears" (AYE), that is an indication of the predicted extra aging caused by the excessive noise dose each user is exposed to. To perform such prediction, a multiregression statistical model was developed based on normative data found in ISO 1999 [3] standard. This way, an AYE value can be computed for each subject, using only his age, sex and sound exposure, to represent the possible acceleration of aging caused by excessive music listening.

2 Method: Computation of AYE

The AYE is equivalent to an age penalty, A, added to the real age Y, and computed so that the median value of hearing threshold, denoted $H_{0,50}$, of otologically normal person of the same sex is equal to the noise-induced permanent threshold shift $N_{0,50}$, depending on the $L_{EX,8h}$ measured for that person.

The median value of hearing threshold of otologically normal person of the same sex, $H_{0,50}$, is given in Annex A.1 of ISO 1999 as follows:

$$H_{0,50} = a(Y-18)^2 + H_{0,50;18} \tag{1}$$

Where $H_{0,50;18}$ is the median value of hearing threshold, $H_{0,50}$, at age 18 and a is a coefficient depending on the frequency and the user's sex. It is assumed to be zero for practical purposes, as specified in ISO 7029 [4].

The noise-induced permanent threshold shift $N_{0,50}$ is defined in section 5.3.1 of ISO 1999 and given by:

$$N_{0,50} = \left[u + v * \log_{10}\left(\frac{Y-Y_0}{\theta_0}\right)\right](L_{EX,8h} - L_0)^2 \tag{2}$$

Where Y is the current age and Y_0 is the subject's age when the exposure began, both expressed in years. L_0 is the cut-off sound pressure level in decibels defined in Table 2 of ISO 1999 and u and v are frequency dependent parameters provided in Table 1 of ISO 1999. Finally, θ_0 is set to be 1 year in ISO 1999. This expression applies if $(L_{EX,8h} - L_0) > 0$ and $(Y - Y_0) > 10$. Otherwise, if $(L_{EX,8h} - L_0) > 0$ and $(Y - Y_0) < 10$:

$$N_{0,50} = \frac{\log_{10}((Y-Y_0)+1)}{\log_{10}(11)}\, N_{0,50}|_{Y-Y_0=10} \tag{3}$$

Finally, if both $(L_{EX,8h} - L_0) < 0$ and $(Y - Y_0) < 10$ then

$$N_{0,50} = 0 \tag{4}$$

After adding the age penalty A to the age Y in Eq.1, making $H_{0,50}$ and $N_{0,50}$ equals leads to the following three possible equations:

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$$(Y + A - 18)^2 =$$

$$\begin{cases} \dfrac{[u + v \log_{10}(Y - Y_0)]}{a}(L_{EX,8h} - L_0)^2 \\ \qquad \text{if } (L_{EX,8h} - L_0) > 0 \text{ and } (Y - Y_0) > 10 \quad (5) \\ \dfrac{\log_{10}((Y - Y_0) + 1)}{a \cdot \log_{10}(11)} N_{0,50|Y-Y_0=10} \\ \qquad \text{if } (L_{EX,8h} - L_0) > 0 \text{ and } (Y - Y_0) < 10 \quad (6) \\ 0 \\ \qquad \text{if } (L_{EX,8h} - L_0) < 0 \text{ and } (Y - Y_0) < 10 \quad (7) \end{cases}$$

Eq. 5, 6, and 7, can be solved to compute the age penalty A. Two root values can be expected because of the square in the left member. In the end, only the positive values are kept and added to the real age Y because, unfortunately, listening to music cannot make your ears younger.

3 Results: Accelerated Aging Curves

From Eq. 5, 6, and 7, a set of curves can be obtained, for any given age that predicts the AYE as a function of the sex, the exposure duration, the L_{eq} and the frequency of the sound. For example, Fig. 1 shows the AYE of a person exposed since the age of $Y_0 = 25$. The curves are a function of the current age Y and the graph shows the AYE for different levels.

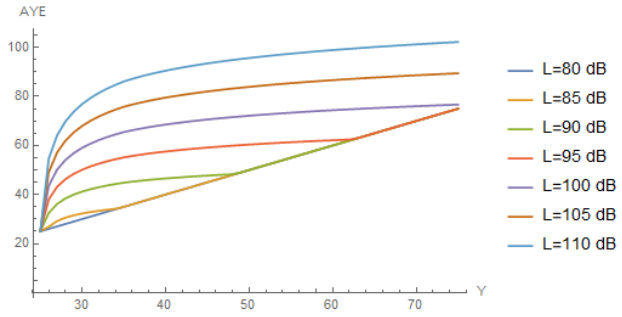

Figure 1: Calculation of AYE as a function of the age, for a male subject exposed since age $Y_0 = 25$. These curves show clearly the accelerated apparent aging of the ear for a critical frequency band of 3 kHz.

The graph shows, for example, that if a man listens to a sound at 90 dB for 8 h daily since he's 25, the age of his ears will be 40 the moment he turns 30, for the most critical frequencies, the 3 kHz octave band. The visible break in every curve shows the moment when noise induced hearing loss becomes negligible compared to aging.

Form another perspective, the graph in Fig. 2 shows the evolution of the AYE as a function of the level of exposure, with the same parameters. This time, the final age is what changes from one curve to another.

4 Conclusions

In a world where personal musical players are ubiquitous, and have also been putting hearing at risk, it is interesting to see

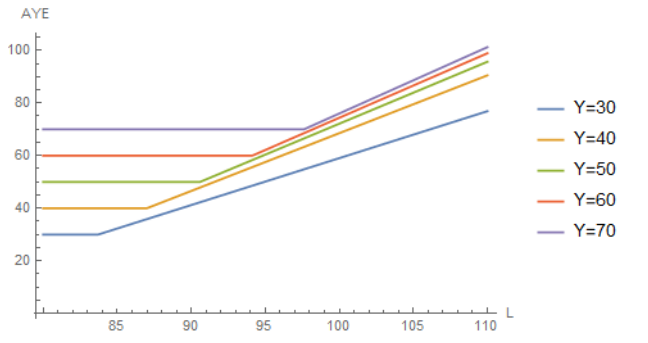

Figure 2: Calculation of AYE as a function of the level of exposure, for a male subject exposed since age $Y_0 = 25$. Those curves show clearly the influence of the level of exposure on the apparent aging of the ear, again for a critical frequency band of 3 kHz.

them as potential tool, not only to address the issues they created, but also for raising awareness on the dangers of Noise-Induced Hearing Loss at large.

The proposed AYE metric will be first implemented in a measurement manikin setup that is currently under development at the Centre for Interdisciplinary Research in Music Media and Technology, housed at the Schulich School of Music at McGill University (CIRMMT). This setup, further described in [5], is inspired by the "Jolene" manikin developed though the "Dangerous Decibels" program [6]. The resulting *measurement kiosk* will be complemented by a smartphone-based measurement app that will enable musicians to assess their entire noise exposure. It is hoped that the proposed AYE metric will be relevant and simple enough to have a beneficial impact on everyone's safe hearing practices.

References

[1] WHO | Make Listening Safe - http://www.who.int/deafness/activities/mls/en/.

[2] CENELEC. BS EN 50332-3:2017 - Sound system equipment: headphones and earphones associated with personal music players. Maximum sound pressure level measurement methodology. Measurement method for sound dose management, 2017.

[3] ISO 1999:2013 - Acoustics – Estimation of noise-induced hearing loss, 2013. 00000.

[4] ISO 7029:2017 – Acoustics – Statistical distribution of hearing thresholds related to age and gender, January 2017.

[5] Jérémie Voix, Romain Dumoulin, Julia Levesque, and Guilhem Viallet. Inciting our children to turn their music down : the AYE proposal and implementation. In *Proceedings of Meetings on Acoustics*, volume Paper 3007868, Victoria, BC, Canada, 2018. Acoustical Society of America.

[6] Dangerous Decibels - JOLENE - http://dangerousdecibels.org/jolene/.