Know How To Hear - Part II

A public health matter

For readers who missed the First Part, Know How To Hear is all about the 'Ear' a very delicate organ towards which we should always be considerate. Last but not the least, this organ with the help of our brain is gifted with unique properties that make us feel intense emotions when listening to a song or music.

by Jean-José Wanègue

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Walkman and earphone concerns

All walkmans that are sold now in France, i.e. the player and its specific earphone (or headset), mustn't deliver a sound intensity that exceeds 100 dB SPL. The output sound pressure of a walkman can go from 70 dB to 110 dB. Is it a good and efficient measure? For Dr. Loth who was member of the committee which prepared a report for the Department of Health, he would have preferred a convincing communication campaign to make the teenagers aware of the risks that exist when listening for long period of time to walkmans at high level rather than curbing them at 100 dB. We have to be conscious of the fact that 100 dB is quite high level. In case of classical music ear damage risks are limited as this music exhibits a large dynamic range which leaves room for the ears to get rested and have a quick recovering. On the other hand when what we call "amplified music" is heard with a walkman the problem is totally different. Right away this music can begin at quite a high level and will stay within a tight dynamic range (within few decibels) due to heavy compression which is now part of this music genre. It is obvious that this will generate some hearing fatigue that won't be necessarily perceived, but that will be easily detectable if you carry out an audiogram. Then you will see that a significant period of time is needed to get back to normal hearing. Due to the close coupling of the transducers (tiny loudspeaker) to the ears, hearing damage from headphone or earphone can be higher than with loudspeakers, even for the same sound pressure level. When you use loudspeaker for music reproduction, the sound has to travel through the space before it reaches your ears. Thus (remember the inverse square law) a noticeable amount of high frequencies will be absorbed by the air. Also there is a decreasing sensitivity to sound level over the time. So inevitably teenagers tend to pump up the volume to keep the same sensation. Now if you take into consideration the environment where our young listeners are, may be in the bus, in the train or in the tube, it sounds logical to turn the volume up to drown out traffic noise as the acoustic isolation of the headphone is far from good (up to 80/85 dB in the subway train). You have already experienced the corollary of this poor isolation. A last detail that must not be ignored about the curb of the walkman. The 100 dB is set up for the player and the headphone which is sold with it. But if you change the headphone for a more sensitive one, then you are out of control. What this health regulation means now? Are you still below 100 dB or above? When we know how difficult it is to assess the sound intensity, then we have good reasons for concerns regarding this. Kids and young adolescents can listen to a walkman for a few hours per day at a sound level close to 100 dB. Tests have showed that after only 15 minutes of white sound exposure at a level of 110 dB, at least one resting day is needed to get back to initial audiogram conditions (Picture 8).

It is easy to imagine what the consequence of continuous use of headphones can be. Some survey has reported that more than 10% of teenager population from 15 to 18 has already impaired hearing. So now we have enough evidence to consider the use of the walkman very cautiously and it should have become obvious for everybody. Beside the fact that environmental

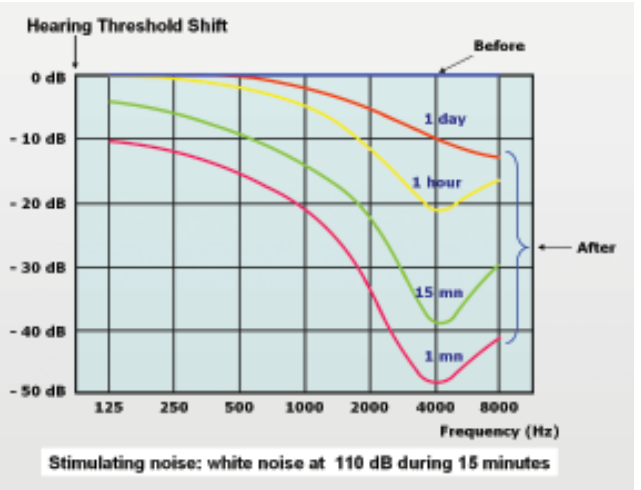

Figure 8: After exposure to loud noise the hearing sensitivity will be affected by a temporary threshold (TTS)

noise level could be one reason to crank up the volume (a recent study showed that people set up their walkman volume at least 20 dB above the ambient noise level), there is another reason that has much more to do with culture. Due to the small size of the earphone membrane, it is impossible to reproduce the low frequencies. But as Yann Coppier pointed out, these frequencies became a very important component of the current music. So to compensate this loss in the low part of the spectrum, people tend to increase the volume just by reflex. Young people want to experience the same vibrating sensations they have during a concert. Actually with music techno and rave concerts, the trend is a form of tribal music where heavy low frequency and beat are playing an important role. Very high power equipment is used in order to transmit directly to some parts of the body like the thorax or the abdomen mechanical vibrations generated at low frequencies.

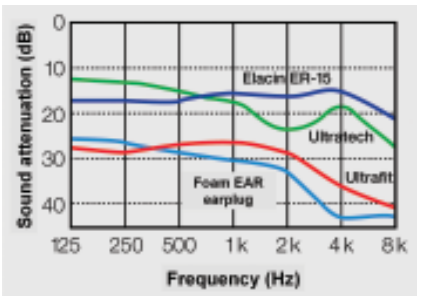

Figure 9: Attenuation curves of different earplugs

« High Fidelity » ER-20 earplug protection from Etymotic Research

Plug your ears

Needless to say that these typical vibrations will never take place with the tiny loudspeakers that are used for earphones. Regarding these very peculiar body vibrations, Dr. Loth is referring to tactile sensations. People feel the music with their skin and with some part of their body. He recognizes that these sensations are very much in demand. It seems that according to Bart P. Billing[7] the real thing behind that is the adrenaline and endorphin release that make the people high. We do not want here to take a stand for or against this type of music as long as it doesn't create prejudice for the neighborhood and health damage to the audience, whether or not it is warned of the risk. On the other hand it is possible to protect your hearing when you attend such a concert or any concert you know that may go out of control with sound level. Just take with you a pair of earplugs. At least you will reduce the amount of sound reaching your eardrum by 15 to 20 dB. Just go to your pharmacy and get a box with few pairs that will suffice for you and your friends. Usually we can find disposable earplugs made from a soft and expandable foam. Some offer a noise reduction rating (NRR) of 29 dB like the Elvex Blue model. For those who do frequently remove their noise protection, there are ear canal caps on headband with a NRR of about 18 to 23 dB. It is also possible to find reusable earplugs that are made of an ultra-soft polymer with a noise reduction of 25 dB. But if these foam earplugs are efficient and pretty cheap, one reproaches them for being too isolating and having a frequency response that make almost impossible their use to enjoy the richness of a sound during a concert as they preferably cut the frequencies in the higher part of the spectrum. So you may want to consider custom made earplugs like the Elacin ER-15 or ER-25 that the Dutch company ELCEA is offering. So go to specialists instead of going to the pharmacy down the corner. An impression of each of your ear canal is made and from that the specialist will make a pair of earplugs that perfectly fit your ear canal.

These earplugs work as passive attenuator and can be chosen within a range of sound reduction going from 15 dB to 32 dB. They offer a relative flat frequency response from 125 to 8 000 Hz (±3dB). It is also possible to have earplugs that also take into account your audiogram. More and more musicians have recourse to them. This year for the first time one could see at the MIDEM in Cannes a company manufacturing such hearing protection devices. Some of these earplugs include an amplifier system and are used as in-ear monitor.[8]

Permissible noise exposure

Two main factors govern the risk for a premature impairment of hearing: noise level and long exposure time. But added to that could be genetic factors we will not discuss here, and specific weaknesses due to drugs or repeated otitis. The consequences of the sound level/exposure time pair are difficult to identify in the case of amplified music as from one type of music to another, or from one concert or entertainment location to another, many factors will drastically change. To make this problem a little more complex, it has to be noted that if starting at 85 dB SPL we are generally at risk, we will start to really feel a pain at 120 dB. It means that before a sound alarm comes from our body, there is a large room where we are exposed to possible hearing damage. Similar to our skin for which there is a sun exposure quota that shouldn't be exceeded, our auditory system has its own limits above which hearing fatigue takes place[9] with more or less important consequences on our physiological health and psychological health, and of course on our hearing threshold. This is why in terms of occupational regulation some standards have been set and employers must comply to them. The problem is that these regulations vary quite a lot from country to country. In general we consider that

below 70 dB (A) there is no hearing fatigue. Between 80 and 95 $dB^{(A)}$ hearing fatigue phenomenon is taking place. It will be detectable with an audiogram that will exhibit a threshold shift (hopefully temporary). A prolonged exposure to noise at a sound level of 95 $dB^{(A)}$ will definitively cause a loss of hearing that necessitates a period of rest that can go from few hours to few days depending of the people. Starting with the idea that a standard occupational day lasts 8 hours it is agreed in France that we can be exposed to a permanent sound level of 85 $dB^{(A)}$. Using this reference, each time this sound level is increased by 3 dB (exchange rate), the exposure time has to be reduced by a factor of 50% during one day of labor. If during a full 8 hour working day the daily sound exposure exceeds 85 $dB^{(A)}$ or the exposure to impulsive or impact noise exceeds 135 dB peak SPL, then the hearing protections have to be available for the workers. At 90 $dB^{(A)}$ and above or for impulsive noise exceeding 140 dB, the use of hearing protections is mandatory. It should be time now to have thoughts for all the operators and technicians who have replicated so many LP and CD for our delicate ears and who have to spend thousands of hours within molding machines. In US there is standard for permissible noise exposure that has been defined by the OSHA[10]. This standard significantly differs from the one used in France. The reference is set at 90 $dB^{(A)}$ for 8 hours. Each increase of 5 dB requires a halving of the exposure time. So according to OSHA you can stand 95 $dB^{(A)}$ for 4 hours.

Considerable progress have been made to reduce the noise of CD and DVD replication line with the help of electric injection machine. With this modern DVD line noise level should be around 78 dB. (Picture JJ Wanègue)

Noise dosimeter: an idea to go deeper in to it

But work is not everything in your day life. So if you really want to verify whether or not you are at risk, you should take into account the sum of all the different sound and noise you have exposed to during the day, whatever it is: work, listening to your walkman in the transportation, or a quite exciting evening at the discothèque. Hence the unit of noise ($0.04\ Pa^2.H$) that is used by a Swished insurance company (SUVA) to convert all the successive sound exposures using this unit and summing them up on a one week period. If the sum is below 100, it is OK for you. If your score stands between 100 and 200,

Noise dosimeter to monitor noise exposure during a day or a workshift (Picture Larson Davis)

you should be careful as you put your ear at risk. Above 200 it is imperative that you reduce your exposure to sound by one mean or another. Why don't we use a noise dosimeter in that case? This is the simple question a journalist colleague who is also a sound engineer asked me sometime ago. That would be so simple. In fact such systems already exist for long time (Brüel & Kjaer, Larson Davis or Quest Technologies noise dosimeters).

It is the most accurate method for measuring an employee's noise exposures. The employee wears the noise dosimeter during his workshift and it measures noise level at the locations he visits. The noise dosimeter integrates any employee's exposures and calculates a number of values like noise dose. This value is then used to determine whether or not the employee should enroll in a hearing conservation program. Usually these systems can be set up with a set of parameters (threshold, time, average speed, etc.) to take into account the specific regulation locally applied. Of course these professional devices are sophisticated, expensive and quite cumbersome to be distributed in large quantities for entertainment activities (discothèque or rock concert). And what my friend had in mind was a kind of credit-card format device with tiny colored LED that would tell you at the end of the day if you got your dose of noise or if you had really exceeded the permissible exposure. A kind of the dosimeter that could be similar to the one that radiologist are wearing all day long to make sure that their X-ray exposure was within permissible limits. So before such a device becomes available, it is highly recommended to recourse to earplugs.

Noise exposure in the studio

Among working people who are significantly exposed to sound are the sound engineers. For the time being this occupation is not listed as high-risk occupation with regard to sound exposure. It doesn't mean that we shouldn't have any specific care for this aspect and that nothing has been done. But thankfully it seems that sound engineers are cautious, or may be their long experience added to their musical knowledge and physics knowledge lead them in a very natural way to limit their exposure to sound. Of course if you go to the Maison de la Radio[11] studios in Paris (French broadcasting corporation) you will see that this matter is subject to special care and Didier Gervais who is the director of the recording studios is full of consideration when it comes to recording sessions and mixing sessions. But there, there is no specific rules or regulation that have been put in place. Even, there is no closed headset ban. The output of mixing consoles is not curbed. For Didier Gervais is not necessary to set drastic constrains as in these studios there is literally a sound culture where people do not listen at high level. But according to him, what is true for these studios mainly dedicated to radio broadcasting and audio recording for some prestigious classical labels, is not true with the people from television studios. For an unknown reason, the TV people are listening at a significant higher level. An interesting thing for him is the fact that as soon as the artist gets into the studio for a listening, then the sound engineer has to pump up the volume and add at least 6 dB. Otherwise the artist will find the sound too bad. Of course the artist will spend a small fraction of his time listening in the control room compared to the time the sound engineer will spend there. But sometime it can reach impressive levels and Franck Ernould reported cases where he preferred to let the artist in the control room adjusting whatever SPL he wants and going out to secure his hearing. What is for sure is that you do not listen at the same level in the morning and in the evening. Usually from morning to evening you increase the sound level by 3 to 6 dB as Didier Gervais could noticed it. This can be the result of tolerance to loudness and fatigue. But unfortunately not all sound engineers work at the Maison de la Radio. So the question of what are acceptable levels of noise exposure for sound engineers is still pending. Some literature has been published on this matter in different professional magazines. Sometime it is simply based on the day to day experience and practice. Sometime it is the result a real scientific approach. But what all this means when from country to country standards are not the same, or even within a same country 2 standards set by different organizations may have dramatic differences with their recommendations. It is the case when you compare the OSHA standard of US Federal Government and the DOD (the US Department of Defense). DOD is much more cautious than OSHA as it allows an average continuous exposure of only 84 $dB^{(A)}$ for an eight-hour workday, with an exchange rate of 4 dB. In France we have respectively 85 $dB^{(A)}$ and 3 dB. A comparison between these different noise exposure allowances is given in table 1. If we consider that a 90 dB SPL is common practice in a control room (in fact between 80 dB to 90 dB), then according to OSHA our sound engineer can work 8 hours, while the DOD recommendation would tell him to finish his job after about 3 hours. If we would apply the French labor regulation to sound engineers, then after 2 ½ hours we should stop. What does it mean?

The third and concluding part of this article shall apear in the forthcoming May/June 2005 issue.