HEARING DEGRADATION – A PERSONAL ACCOUNT

Philip Newell

1 INTRODUCTION

This paper is a report of the progressive hearing degradation as it affected the author's perception whilst working as a designer of recording studios and loudspeaker systems. The many symptoms include presbycusis, tinnitus, and loudness recruitment, together with some strange perceptions of non-linear distortion. The implications are far-ranging because all forms of reproduced sound are ultimately assessed by people's ears, even though it can be difficult to fully imagine the changes to perception until they occur. However, once experienced, it also becomes clear that the changes are idiosyncratic, with the combinations affecting no two people in exactly the same way. Furthermore, only once experienced does it become obvious that referring many reproduction standards to 'normal' hearing parameters may be short-changing a large proportion of the population, because what is 'average' may not be representative of any majority.

Hearing loss begins to affect most people as they age, but for those whose hearing acuity is a fundamental part of their professional lives, the insidiously progressive losses can not only be worrying, but can also be embarrassing, and professionally compromising. The changes can even threaten the credibility of professional decisions, and for this reason, many people who rely on their ears in their daily work may be loth to make public admissions of any changes to their hearing. Nevertheless, understanding the limitations can also lead to valuable insight and useful practical knowledge.

2 FIRST SIGNS OF CHANGE

Between the ages of 20 and 40 years old, I spent much of my time in and around recording studies, most of which used analogue tape recorders. These machines were frequently aligned each day with the use of reference tapes having tones typically at 100 Hz, 1 kHz, 10 kHz and 15 kHz, all recorded at some standard operating level – such as 185 nWb/m. Hearing the tones gave me a rough daily check of the audibility of the high frequencies relative to the lower ones, but by the time that I passed my 40th birthday, digital recording had become the norm, so the opportunities to hear the analogue test-tones became much scarcer.

When making final checks on studio monitor loudspeaker systems, once the basic responses had been verified by means of measurements, I had a wide selection of CDs, of various types of music, with which to make overall assessments of the tonal balances. My experience as a recording engineer and record producer would probably have indicated to me that something was still wrong with a system if those levels did not seem to be musically appropriate, but even up to the age of 55, I don't recall noticing any particular changes in the tonal or instrumental balances. For example, triangles did not sound musically low to me in the orchestral mixes, and cymbals did not sound to be lacking in level from drum kits. Like everybody else, I had sometimes experienced hearing deficiencies after having had a cold, or suffered brief periods of tinnitus after leaving the occasional rock concert, but despite everything usually soon returned to normal, looking back, it now seems clear that some aspects of my 'normal' perception *did* begin to more permanently change when I was in my late 50s.

After spending several years of being involved more in cinema sound (with its standard HF roll off) than in music studios, I was asked to check the monitoring responses in a studio where the mixing console had just been changed for a physically much larger one. I had previously known the studio very well, and I had taken my usual selection of CDs with me, but on listening to them, the 'air' in the sound seemed to be lacking. The music didn't actually sound to me like the high frequencies were attenuated, and the measurements confirmed this, but there seemed to be less 'clarity', or 'transparency' in the sound. This effect was not untypical in loudspeaker

systems whose HF diaphragms were becoming fatigued, even though it was something that was not easily measured, but in virtually all cases like this, if the diaphragms were at fault, most people in the studios would notice the extra 'life' when new diaphragms were installed. In these cases, the retired diaphragms would usually then be kept as emergency spares, but in the case in question, the HF loudspeakers were of a beryllium type which did not usually suffer from such ageing, and the younger people in the studio (who were often the first to point such things out) said that they had not noticed that anything was significantly missing in the treble end of the spectrum.

Despite this, I asked for new (expensive) diaphragms to be ordered, which were delivered the following day, but after they were installed, neither I nor the studio staff heard any change. That is to say, *I* did not hear the expected improvement, and the studio staff thought that the HF sound was the same (hence still OK). In addition, the measurements also showed no change, but fortunately, sparing my embarrassment, the studio owner decided to keep the new diaphragms in the loudspeakers, and retain the original ones as spares. I would probably have thought little more about this had I not then visited two more studios, shortly afterwards, and noticed a similar character to the sound. As all of the loudspeakers involved were from the same range, I initially expected that it could be some sort of common problem developing with these systems, but it was somewhat disconcerting that nobody else in the studios was complaining about the high-frequency sound. Oddly though, other than from loudspeakers, nothing else seemed to sound different to me in the outside world. Everything else still seemed to sound completely normal to me, but it must also have been around this time that I began to notice sporadic bouts of tinnitus which did not seem to correlate to any recent spells of being subjected to loud sounds. So, although these 'unexplained' bouts of tinnitus did not inconvenience me in any way, and were easily ignored, they were something completely new.

Just prior to me taking part in some extended listening tests in Southampton University, when I was 40 years old, the results of my hearing test, carried out in the Audiology department, showed an essentially normal response up to around 7 kHz, with a gentle roll-off only beginning in the 8 kHz band, and a slightly lower LF sensitivity in the left ear. Since that time, I had noticed no great changes in my hearing, but around the time that I was 60 years old, the general subject of hearing sensitivity arose in a conversation when, along with several younger engineers and assistants, I was installing a new type of loudspeaker system in a studio. As a result of the discussions, I suggested that we should all go for hearing tests to a local clinic, which we did, but the range of our results surprised most of us. In the event, no two of us had similar hearing, but notwithstanding the fact that the audiometrist insisted that they were all 'within the normal ranges for our ages', my own results looked disastrous, which the plots shown in Figure 1 would seem to confirm.

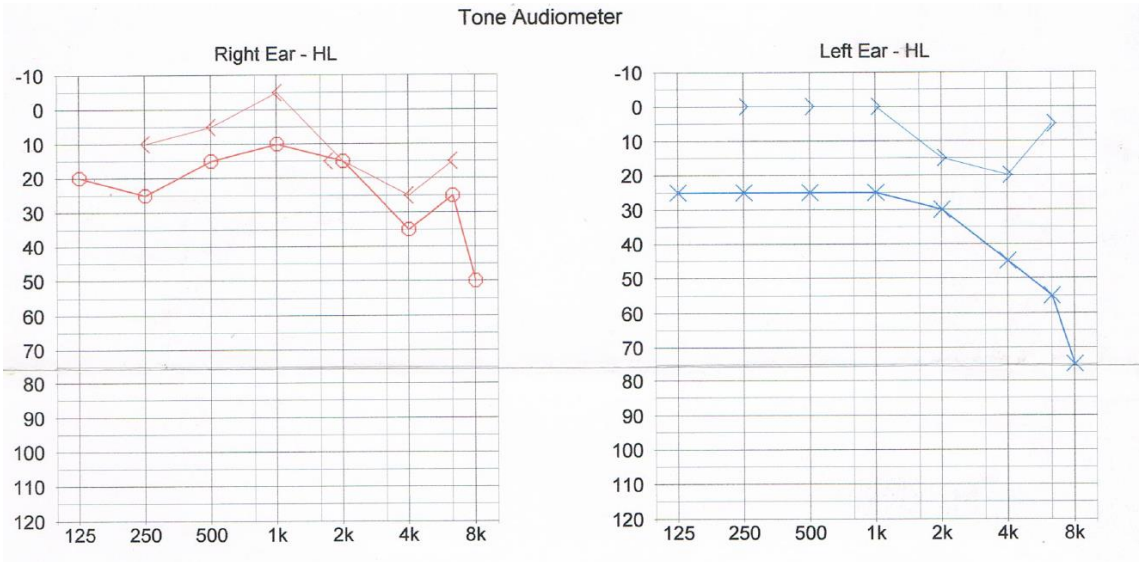

Figure 1. The state of the author's hearing loss (HL) at the age of 60, said to be within the normal range for his age. The chevroned upper traces are the bone-conduction responses

The sight of the responses in Figure 1 immediately led me to question my ability to make *any* judgements at all about sound in general, and from that day forth I never passed any opinions about the high-frequency responses of any loudspeakers, but shortly afterwards, and to confirm the findings, I went to see a clinical audiologist. After further tests, she, also, stated that my hearing was 'within the normal limits for my age', so I asked her whether, if *my* tests were relatively normal, she had ever measured any man of my age with what was considered to be *truly* normal hearing (the zero level on the plots, and flat). That is to say, did any of them have hearing which would be considered to be normal for a person of 25 or thereabouts, but her reply was that, if she *did* encounter such a man, it would be a sure sign that he was extra-terrestrial.

Later the same year, I was writing an article for a very reputable recording-industry magazine, in which I referred to the state of my own hearing, but I also questioned some of the frequent claims made by various 'audiophiles' of my own age and beyond. I just couldn't understand how, with the age-related losses being almost universal, some of the claims of high-frequency sensitivity could be justified, but the editor initially refused to publish the article. After considerable re-writing, I did at least manage to state in the article that my own hearing was far less than perfect, but I was not allowed to even *question* the hearing of any other groups of people. Even so, I still found it difficult to accept that many older people could reliably make a half-dB 'correction' of a master recording at 15 kHz, or judge phantom centre-images to within one or two degrees, irrespective of the frequency content of a signal. Clearly, the *importance* of many such decisions is ultimately 'artistic', and justifying the claims may not actually matter if the end-results are desirable to the clients. Indeed, as this is the case, we cannot discount such assessments completely, but nor can we give them any definitive credence. Also, given years of experience, we may get into the realms of some 'tricks and adaptations' which can allow some people to make some valid assessments beyond their measured hearing responses, but even so, some of these abilities may also be restricted to limited circumstances – such as working with familiar equipment in familiar surroundings. However, work done at Harman indicates that this ability may not be completely reliable, as it has been extensively discussed by Toole [1].

3 TINNITUS

Tinnitus is something that gets variously described as a humming, a whistling, a buzzing or a hissing sensation in the ears, when no such external sound is present. In my own case, it is definitely a multi-toned (probably harmonic) high-pitched whistling sensation that has a different tonality in each ear. Occasionally, I also 'hear' pure-ish tones of short-duration (<10 seconds), perhaps around 1 kHz, and sometimes quite loudly, but I think that some of the higher pitches that I hear in the whistling 'sounds' are actually above the frequencies of the tones that I could now hear in the normal way. The tinnitus has crept up on me since my mid 50s, but although it is aways there, I often still don't notice it in my daily life. Nevertheless, it can definitely get in the way if I am trying to concentrate on listening to a quiet sound, such as bird-song at a distance, and it can certainly increase in level on seeing certain politicians on television. (Seriously, if 'my 'blood boils', my tinnitus increases in level.) The fact that I also notice it if I am concentrating on listening means that no music can now fade or decay into silence, which is sad, but as the tinnitus tends to be more noticeable at night, and less when I wake up in the morning, it perhaps also increases with tiredness. But despite all this, I feel that my *understanding* of tinnitus gives rise to me feeling less stressed by it than some 'lay' people may feel about this 'confounded affliction'.

4 LOUDNESS RECRUITMENT, AND REFLECTED SOUNDS

Especially when listening to television programmes with family, in my 60s I began to notice that, at what was a seemingly comfortable listening level for some people, I was not understanding the lower-level dialogue, such as when people in the programme were speaking softly for dramatic effect. I also began to notice that in some series of programmes, the general dialogue was becoming harder for me to understand than in other series, even when other people in the room said that they clearly understood what was being said. The dialogue intelligibility was becoming significantly different to me from one series of programmes to another, and with some voices in particular, there was a type of dynamic/resonant expansion occurring, almost like

listening through a loudspeaker which resonated at various speech frequencies, distorting the general dynamics and making some sounds leap out. Also, at times, the voices themselves could sound downwardly expanded, suppressing some of their subtler characteristics.

Initially, this seemed to occur with me around the time of the switch to Digital Terrestrial Television, which could have been coincidental, but it could also have been that there was a wider range of programmes, not all of which were mixed to common standards, although my younger friends and relatives still seemed to have little trouble understanding *all* of them. The switch to the digital TV also coincided with my first experience of flat-screen televisions with loudspeakers on the rear. For me, this was another blow to intelligibility because the TVs with front-facing loudspeakers seemed to be easier to understand. Perhaps significantly, high-fidelity loudspeakers and clear soundtracks tended to remain intelligible, even without elevating the level, so my difficulties were evidently more pronounced with poorer-quality loudspeakers and highly processed sounds, in which the quieter sounds just didn't seem to be loud enough to be useful.

Around the same time, I also noticed that land-line telephones were becoming more intelligible for me than many mobile phones. That is to say, I was noticing more problems with intelligibility when using mobile phones that I was experiencing when using 'fixed' phones. It was also becoming more difficult for me to understand conversations in noisy surroundings, where the direct-to-reverberant/reflected ratio was reduced, and similarly, a television sound-bar, facing towards me, helped me to understand the television dialogue much better than from the reflected pathways of the rear-facing loudspeakers. In fact, reflected sound was definitely becoming a problem for me, but apparently, this can be more of a cognitive function than an audiological one. That is to say, my brain is becoming less able to discriminate between the direct and reflected sounds – 'the *what* from the *where*' – so the 'cocktail party effect' is significantly reduced. Conversely, I still seem to be able to understand even low-level dialogue in acoustically 'dry' rooms, or outside (as long as there is not too much background noise), but reverberant sounds are definitely difficult to deal with.

5 NON-LINEAR DISTORSION

By my mid 60s, I gradually began to also suspect that I was hearing non-linear distortion that other people seemed not to be hearing in loudspeaker reproduction. Initially, I wondered if the non-linear distortion from the loudspeakers (both harmonic and inharmonic) was clashing with the tinnitus frequencies, or whether it could be that the low-pass roll-off of my hearing was resulting in me perceiving 'unnatural' harmonic structures that would have sounded more natural with the higher harmonics present. Either way, something was clearly not right, but I soon also realised that I would not noticeably perceive this type of sound when listening to acoustic instruments at similar sound levels to their reproduction via loudspeakers. In fact, the combined aspects of the gradual deterioration of my hearing were introducing some aspects such as this which I had not only never previously imagined – or even heard about – but they didn't even seem to make sense. Therefore, as time went on, I seemed to be having more questions than answers about my auditory perception in general.

6 COMBINED EFFECTS

By the age of 70, it was patently evident to me that I could still enjoy *listening* to music without too much noticeable detriment, even though I could no longer accurately assess either the timbral responses, the dynamic responses, or the non-linear responses of loudspeakers. Nevertheless, by then, my sensitivity loss had clearly deteriorated further, as shown in Figure 2, but the audiometrists *still* consider my hearing-loss to be 'light', despite me no longer being likely to be able to hear subtle background noises in recordings, or hear some high-frequency noises at all (even with elevated level). Apparently, if I can hold a normal conversation in reasonably quiet surrounding, and I have no insurmountable problems with telephone communications, my losses are considered to be 'light' if they did not adversely affect me going about my daily domestic life. Such is the definition of 'light', but it is apparent that even very-light losses can reduce one's ability to make reliable judgements in listening tests, because the 'light'

losses of different people are not necessarily of a similar nature. That is to say, thy might hear different differences which have no common compensation, so they cannot meaningfully compare them.

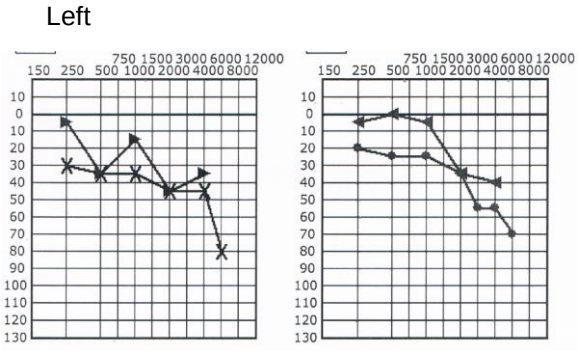

Figure 2 Left and right ear responses (Xs and dots respectively) in 70th year. The age-related neuro-sensorial loss is still considered to be 'light'

By contrast, 'professionally speaking', I nowadays simply hear what I hear in the way that I hear it, so I cannot make reliable judgements about how anything would sound to the average young person. The combinations of the degradations that have occurred also make the perceived losses very programme dependent, such that a problem in assessing one type of programme may not be so consequential on another, or vice versa. I have also noticed significant difficulty in understanding digitally-disguised voices (such as used to hide a person's identity on TV), as in general, the less natural a voice sounds, the greater the difficulty there can be in understanding it; although this may be more of a cognitive loss than a purely audiological one. That is to say, my brain is perhaps having more difficulty in unscrambling unfamiliar sounds, but even so, this 'natural quality' issue may be more general. Leembruggen noticed that in noisy environments, even though at face value it would appear that compressing the dynamic range of speech would allow for a higher L_{eq} and increase the speech-to-noise ratio, tests have indicated that the subjective intelligibility can be higher without compression, because the compression degrades the modulations that may be critical for intelligibility [2].

7 SUMMARY AND CONSEQUENCES

7.1 Implications for older audiences

Despite the fact that many younger people may also suffer from various degrees of hearing loss, a very significant proportion of the older audiences for most programmes (either cinematic or television) will be suffering from a significant degree of hearing loss. Clearly, I knew for many years about the *existence* of some of the consequences of hearing loss, but it was not until I suffered from them myself (even if only 'lightly') that I could begin to understand the true implications. What we consider to be 'normal' hearing is not likely to be possessed at any one time by much more than half of a general population, so if everything is referenced to *normal* hearing, such as in the mixing of television programmes, it will automatically tend to lead to perceptual difficulties for a large proportion of the listeners, and in some rather unpredictable ways.

Another thing that I have noticed with my own hearing degradation is that I need to put more concentration into listening to anything which is marginal in terms of intelligibility. It then becomes difficult to both listen to the programme and simultaneously respond to comments from whosoever I may be watching it with, because too much effort is going into concentrating on the dialogue. I also miss a lot of 'throw-away' comments, be they in the dialogue of the programmes themselves, or from the people accompanying me, and subtitles don't help much with this, either, because I cannot focus on the subtitles whilst also watching the action and listening. I must admit that I was always a relatively slow reader, but it does now seem to me that the subtitles often do not remain on the screens for long enough for me to read them, in

which case, it often seems better to miss a few comments rather than miss most of the action on the screen.

7.2 Effects on ability to work

In recent years, and in recognition of the general intelligibility issue with many entertainment programmes, a group of broadcasting and media companies initiated a research programme to look into ways to make it easier for listeners to adjust the relative levels of the dialogue, music, and effects 'stems' of their programmes, so that, if required, people experiencing difficulties with the intelligibility could render the dialogue more exposed. I participated in some tests at Salford University in 2019, involving both the subjective and objective assessment of the hearing of people over 65 – or younger if showing noticeable hearing loss. (The general outline of the project is described in reference [3].) The overall assessment of the hearing acuity was many-faceted, because measurements alone cannot give a true picture of the subjective difficulties. Once again (see Section 2), I asked the person performing the audiometry if she, personally, had ever measured anyone over 60 without any seemingly age-related losses, and after some deliberation, she said that she had not. This, of course, does not mean that none exist, but I began to realise that as my situation was effectively 'normal', I had no hope of professionally fulfilling all of the functions that I had previously expected (or at least *hoped*) to be timeless.

In spite of me having worked in the music industry for most of my life, there would appear to have been no significant link between my particular work and my hearing-loss if that loss is considered to be within normal limits for my age. Therefore, if some degrees of age-related losses are almost an inevitability – no matter how much we protect our hearing – it seems to be unreasonable that so many people are made to feel reluctant to speak about their own situations. No professional footballers at 40 years of age pretend to still have all the physical speed and stamina that they had when they were 25-year-old, or even their capacity to recover from injuries, although their *experience* can still be very valuable, especially off the pitch. Questions of health are generally considered to be private matters, but if a footballer is employed for his or her physical prowess, any diminution of capacities tends to become obvious on the field. By contrast, a person's perception of their hearing is something *sui generis*, and degradation is not as easily recognised by others 'on the field' as the loss of speed and stamina of an older footballer, but if any people are selling their ability to do a job, their clients perhaps do have a right to know the extent of their ability to carry it out – just as a football club will check the fitness of any player who they are considering buying. For this reason, once I realised the extent of my hearing loss, I made it public, and perhaps surprisingly, opportunities for work did not tail off. As a consequence, once I was over 60, I did get more people involved in any decision making that involved listening, but my experience was still valuable.

The 'watershed' moment when I decided that I had to accept the situation was whilst watching a drama programme on the television with a younger family member. It was set in the 1960s, and two people suddenly ran across a street to an old telephone box. It appeared from their actions that the phone had rung, but I had heard no bell. So, I asked the person sitting alongside me if the bell of the phone *had* rung, and I was told that it had (if only as a distant sound). It was an awful moment that I will never forget, because it was the end of an era, for whilst spectacles and operations could largely correct my degrading eyesight, nothing can comprehensively restore my complex hearing losses, as the correction of any one aspect may degrade another. In any case, it seems that some of the sound discrimination processes, such as the cocktail-party effect, are largely brain-processing dependent, so as a result, partial compensation for specific losses, such as HF responses, may still not restore the ability to understand conversations in noisy surroundings.

Unfortunately, there is also no consistency to hearing loss [1], but people who understand it from direct experience may develop a wider understanding of the hearing abilities of the public at large, and may therefore be well placed to help guide others during the inevitable discussions of the overall awareness of the problem. Consequently, losing the acuteness of hearing will not necessarily be a precursor to redundancy. In fact, I still have the memory of my experiences, and I can still discuss sounds with younger people and give them advice. I can even help them trace noises that I cannot hear if they can explain to me what they are hearing themselves. The general situation is therefore probably akin to that of a 45-year-old footballer who becomes a coach, or a team manager. The specific tasks change, but the experience gained from the previous career can still be very valuable to a group. However, for this ability to be best

exploited in the world of subjective listening, the whole subject may need to become far more openly discussable, because beyond a certain age, these problems seem to be far more normal than they are exceptional.

8 REFERENCES

[1] Floyd E. Toole, 'Sound Reproduction – the acoustics and psychoacoustics of loudspeakers and rooms, Third Edition', Focal Press (Routledge) (2018).

[2] Glenn Leembruggen, 'Another look at the relationships between frequency response and the speech transmission index, with respect to word scores and road tunnels – part 2', Acoustics Bulletin, Institute of Acoustics (October 2022).

[3] Lauren Ward, Ben Shirley, Bill Davies, 'Development and preliminary results of the University of Salford media accessibility and hearing impairment database (U-SAID)', Proceedings of the Institute of Acoustics, Vol 40, part 4 (November 2018) [Footer showed Vol. 39. Pt.1 2017. (sic)].