Technical Note on the Effects of Dynamic Range Compression and Other Forms of Digital Sound Processing on the Hearing of Conference Interpreters

This technical note brings to your attention additional and alarming scientific information, some of which has only come to light since the adoption on 16 January of the AIIC Assembly's Declaration on Auditory Heath, and includes very recent material presented at UNESCO's *Semaine du Son* by France's leading auditory health experts. This note explains in detail the effects of dynamic range compression on conference interpreter hearing, as well as other effects caused by toxic RSI sound that has been digitally processed by other means.

Dynamic range compression*

The nerve reflexes in the middle ear play a vital role in protecting the cochlea (in the inner ear) from the effects of loud and/or piercing noise. The latest scientific evidence[1] demonstrates that aggressive dynamic range compression *alone* of an audio signal can do irreparable damage to the neural circuitry in the brain that commands those defensive reflexes in animals (guinea pigs) that have very similar ear anatomy to humans. That evidence points to irreversible destruction of the neurones and synapses in the brain stem as the cause. Such irreversible neural damage thereby disables and exhausts the middle ear's defences, leaving the inner ear exposed to both spontaneous and cumulative acoustic damage from loud and/or toxic sound.

Dynamic range compression is an integral part of videoconferencing platforms. At the time of writing, only HiFi mode in Zoom and Interactio's HiFi version at 128kbp (and only then when all their "enhancements" - noise cancellation, echo suppression, autogain, etc. - are switched off)[2] and WebEx Music mode do *not* liberally apply dynamic range compression. Substandard peripherals (such as phones, tablets, built-in computer microphones and, above all, USB headsets with boom microphones) also liberally apply dynamic range compression, and in certain cases this is a key aspect of their marketing.

These RSI platforms and substandard peripherals, while eroding the middle ear's defences through aggressive dynamic range compression also deliver heavily processed and filtered sound that can further aggravate auditory health problems as a consequence of the dangerous impairment of those defences. As such noise-filtered and narrow-band sound is less intelligible, RSI platforms and videoconferencing systems apply dynamic range compression in order to give such sound the necessary clout and loudness to enhance speech intelligibility. However, this improved intelligibility comes at a very high cost to auditory health because of the combined effect of: a) the dynamic range compression *per se,* b) compression artifacts† and c) the arbitrary concentration of acoustic energy in specific frequency bands, which imposes additional acoustic pressure on the middle and inner ears.

If the findings of the research on guinea-pigs are subsequently corroborated in humans, it will explain why conference interpreters are now experiencing such high levels of tinnitus and hyperacusis as well as instances of partial hearing loss, as a consequence of their being consistently exposed to the

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[1] *Study by **Professor Paul Avan**, Université de Clermont-Auvergne, for INSERM on the effects of **dynamic range compression** of audio signals on the hearing of guinea pigs. Professor Avan's 15-minute presentation at UNESCO's* Semaine du Son, *January 19, 2022*: *https://youtu.be/LHbOzUaSeFI?t=2055*

[2] *Report of **Professor Angelo Farina**, Professor of Applied Acoustics at the University of Parma, Italy, of the study conducted for AIIC on the measurement of acoustic parameters in teleconferencing systems.*

dynamically-compressed, narrow-band sound routinely generated by RSI platforms and videoconferencing systems as well as by the substandard peripherals used by remote speakers.

Furthermore, this serious impairment of the interpreter's middle ear reflexes will make the interpreter's inner ear much more vulnerable to additional harmful effects from what might otherwise be non-dangerous audio peaks or signals. Phenomena such as acoustic shocks, when the ear receives sudden surges and peaks in noise from defective platforms or peripherals, will thereby cause much more damage to interpreter hearing than would otherwise be the case.

Other adverse effects of toxic sound

1. Non-compressed narrow-band sound and tinnitus

Digitally-processed sound does not need to be dynamically compressed to produce similar auditory health effects. It is sufficient for such intense noise to be limited to, and concentrated in, certain frequencies for serious damage to be done to human hearing. This has been amply demonstrated by the widespread incidence of severe tinnitus in dentists, as their drills concentrate high levels of noise in specific frequency bands.

In similar fashion, the alarming increase in tinnitus among interpreters since the surge in RSI use began can also be attributed to the narrow-band audio routinely generated by the videoconferencing systems and RSI platforms they are working from - whether that narrow-band noise is digitally compressed or not (although, but for the exceptions listed earlier, it invariably is).

Importantly, this narrow-band sound has a low signal-to-noise ratio[††], which means that interpreters - who have to speak whilst listening and who thereby mask some of the auditory input - are often compelled to increase the volume in their headphones in order to receive sufficient intelligible signal to interpret. However, this simultaneously increases the accompanying noise in their headphones.

It should also be noted that the tinnitus experienced by conference interpreters is increasingly being attributed to damage to the auditory nerve, partial hearing loss and related effects in the auditory cortex of the brain[3].

(*N.B. Impairment of the auditory cortex is further explained in* **3.** *below*)

2. Vestibular nerve damage

The nerves between the brain and the human ear do not only regulate auditory signals; they also regulate balance. The cochleovestibular nerve is divided between a cochlear nerve regulating hearing and a vestibular nerve that governs balance.

The neural damage caused by dynamic range compression pinpointed in this latest scientific research may also be affecting the neurones and synapses in the *vestibular* nerve, not just the cochlear nerve. This neural damage will also be irreversible. Such damage to the vestibular nerve may explain the vertigo, dizziness and recurring loss of balance experienced by large numbers of conference interpreters who have been frequently and consistently exposed to RSI's toxic sound.

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[3] ***Christophe Micheyl****, European Research Director at Starkey France, on the causes of* ***tinnitus*** *(at the UNESCO Semaine du Son event on 19 January 2022): https://youtu.be/LHbOzUaSeFI?t=3383 (until 1h hour, 6 minutes)*

3. Damage to the brain's auditory cortex and potential link to later-life dementia

This latest scientific research highlights damage to the auditory nerve and thus potentially to the auditory cortex in the brain as well. Damage to the auditory cortex can lead to partial or complete hearing loss. Hearing loss has always been a risk factor among conference interpreters, especially in later life and particularly among those interpreters who have routinely kept the volume in their headsets at potentially hazardous levels during their careers. However, increasing numbers of relatively young interpreters (in their late 20s and 30s) are now reporting partial hearing loss as a consequence of less than two years of interpreting in RSI[4].

For several years now, it has been amply demonstrated that impairment of the auditory cortex and partial or complete hearing loss bring about a major decline in vascularisation (blood supply) of the auditory cortex. It is also widely known that devascularisation of the brain is a major factor in the onset of dementia. As the latest research demonstrates[5], it is becoming increasingly apparent that damage to auditory health and damage to cerebral health are inextricably linked. Substantial and premature hearing damage in conference interpreters may thus increase the risks of potentially catastrophic brain impairment caused by dementia at a significantly younger age than has been typical until now.

4. Other medical complaints potentially linked to toxic sound

AIIC is also aware of alarming reports of other negative health impacts attributed to distance interpreting, including *inter alia* endolymphatic and cochlear hydrops, severe and recurring migraine, persistent sleep disruption and insomnia, and extreme fatigue, and the list in this technical note is therefore not exhaustive.

Conclusions

Toxic sound is so called because, like a slow-acting toxin, it generates cumulative and mostly irreversible adverse health effects throughout the audio process and throughout the human ear, all the way to the brain. The more toxic and heavily processed that sound is, the more damage it will do and the more quickly that damage will occur. The fact that these effects are being experienced in conference interpreters *already* - in some chronic cases, after just a few months of working with RSI platforms - points to a health emergency, especially as many of the victims are young and technologically adept, and so ageing and lack of familiarity with technology are clearly not a factor in explaining such auditory illness.

The latest scientific evidence now provides a much clearer indication of why such toxic sound in RSI is injurious to the auditory health of conference interpreters when they are exposed to it. All of these factors taken together clearly make it more essential than ever, therefore, to reduce exposure to such highly-processed and noxious sound and to increase the breaks between such exposures.

Only a follow-up study on such interpreters will be able to corroborate all these findings, however. Application of the precautionary principle - first and foremost, shorter and fewer assignments - is therefore *imperative*, pending the conduct of further research, as is the use of appropriate platforms and peripherals by remote speakers, without which shorter working hours will not suffice.

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[4] *Report of* ***Anja Garone*** *of the* Vrije Universiteit *in Brussels following a comprehensive survey of staff interpreters at the EU institutions and United Nations* *Report on Impact of RSI on Auditory Health*

[5] ***Professor Christine Petit****, Founding Director of the* Institut de l'Audition *of France's* Institut Pasteur*, on the potential link between* ***auditory cortex impairment and dementia*** *(also at the same UNESCO event):* *https://youtu.be/LHbOzUaSeFI?t=1768* *(until 33 minutes, 15 seconds)*

[*] Dynamic range compression (DRC) is a digital sound-processing operation designed to reduce the volume of the loud sounds and amplify the quiet sounds in an audio signal by reducing (compressing) that audio signal's dynamic range. "Dynamic range" refers to the full span of sound pressure variations in an audio signal.

[†] A compression artifact in sound engineering parlance is a distortion of sound or an extraneous non-human sound arising from dynamic compression that is perceptible to the listener.

[††] Speech intelligibility can be rated in terms of the Signal-to-Noise ratio. The higher the signal (human speech) and lower the noise (e.g. white noise, hiss or background noise), the more intelligible the speech. The lower the signal and higher the noise, the less intelligible the speech is.