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Noise-canceling earphones and vascular noise: some speculations

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I recall sitting in my very first audiology class in 1979 (when tuning forks had just been invented and all hard-of-hearing people were using either body-worn hearing aids or large tin horns in their ears) and the instructor was trying to explain the difference in calibration between using earphones (minimal audible pressure) and loudspeakers (minimal audible field) to convey a signal to our patients.

The differences are primarily in the lower frequency region, amounting to about 20 dB at 125 Hz and gradually approaching a 0 dB difference as one draws near 1000 Hz. The primary explanation is that, when the ears are plugged (by an earphone), a person can hear their own vascular noise—the sound of the blood rushing through the arteries, and this serves to mask or elevate the sensitivity of the lower frequencies. That is, a person's own vascular noise is the reason for this low-frequency calibration difference.

Well so much for Audiology 101. This also brings up an interesting potential explanation about why some people don't like to use noise-canceling headphones.

Noise cancellation was first described in 1933, and although it could be implemented in an analog domain, it is a much easier task when using digital technology. Like many modern forms of feedback management, noise cancellation involves the creation of a sound that is 180° out of phase with the initial signal, which, when added together, results in a reduced or even a cancelled signal. Feedback management and noise cancellation are the two primary uses of this technology.

Noise cancellation has been successfully used to reduce the noise output of large HVAC units on the roofs of building (and the first such usage was on the mechanical engineering building at Keele University in England) and as part of muffler systems in automobiles (such as the Jaguar). Next time you are near a Jaguar (or on the roof of the mechanical engineering building at Keele University), lean down to listen to the muffler or HVAC machinery and you will be surprised how quiet it is.

However, many people, when using noise-canceling earphones, report a sense of "fullness" or "pressure." This comment is not ubiquitous, but it *is* rather common. Personally, I can't use them without this sensation.
One reason may be that some of the normal low-frequency sound energy in the listening environment that serves to partially mask out the vascular noise in one's auditory system is removed by the noise-canceling headphones. Without this low-frequency masking noise, the person's vascular (internal) noise is at a higher level, and this may account for the pressure sensation.

This is empirical and would make for an interesting Capstone AuD project. For example, one could assess the calibration differences between the minimal audible pressure and the minimal audible field in a sound-treated audiometric booth (an expected 20 dB difference at 125 Hz) and compare that with the calibration difference in a typical office or living room with an inherently higher level of low-frequency noise.

This would also have implications for our sister field of speech-language pathology. For years, we have been suggesting that speech-language pathologist clinicians (and linguists) transcribe their speech samples using loudspeakers (or the minimal audible field calibration) as opposed to using earphones (minimal audible pressure) so that they will have better low-frequency acuity for the phonetic errors and modifications of the sonorants (vowels, nasals, and liquids). If indeed the transcription is performed in a normal office room and not a sound-treated audiometric booth, perhaps they would do better with earphones that use noise cancellation? This is also empirical and would also make for an interesting AuD capstone project.

Original citation for this article: Chasin M. Back to Basics: Noise-canceling earphones and vascular noise: some speculations. *Hearing Review*. 2017;24(9):10.

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