Frequency Raising- perhaps the time has come?

By Marshall Chasin, AuD

Starting with the Davis et al. (1950) study and later with the excellent work of Brian Moore in the 1990s, we now know that there can be "cochlear dead regions" where less may be more. For people with significant hearing loss, cochlear damage may be so great that amplification needs to be either reduced or transposed away to a healthier region of the cochlea—most of this research has been with high-frequency hearing loss, and hence, the transposition has been downward. Our field has many names for this "frequency lowering" technology such as: frequency compression, frequency transposition, sound recovery, extended audibility, and many other marketing terms used by major manufacturers. Frequency lowering can be very useful in order to improve speech intelligibility, and in some rare cases, for music appreciation as well. For music, a common clinical practice is merely to lower the amplitudes of the higher frequency harmonics (such as with a high-cut of the frequency response) which will assist in avoiding the distortion in a cochlear dead region.

An algorithm that is yet to be commercially available for some of our patients with a low frequency (or reverse slope) sensori-neural hearing loss would be "frequency raising". Like its high frequency cousin, frequency raising would take lower frequency sounds and relocate them in a region that has better cochlear function. And like frequency lowering, there would need to be strict requirements where distortion would not occur; namely a one octave linear frequency increase. With a one octave linear frequency increase, all altered or raised harmonics would be shifted up to overlay an already existing harmonic of the original sound with no other "new" harmonics being created.

One strategy is to simply reduce the amplitude of the low frequency fundamental to a point where it does not cause cochlear distortion (Figure 1 and Audio file 1). This technology is available and represents the current state of affairs when dealing with reverse slope sensori-neural hearing loss-essentially a low-cut tone setting. The limitation of this approach is that the person may be receiving very little information about low frequency cues in speech and in music, such that it is akin to not wearing any amplification at all.

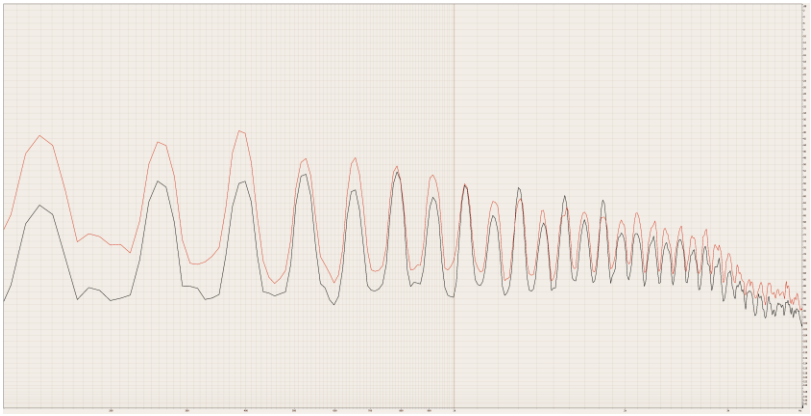

Figure 1

Audio File 1

However, another algorithm shows the spectrum where the low frequency fundamental is removed and linearly frequency raised exactly one octave (Figure 2 and Audio file 2). An associated audio file demonstrates this in an ABA format where the A portion is the unaltered music, and the B format is the processed sound with a linear one octave frequency raising. There are some audible artefacts with this type of processing, but it is unclear whether this is merely an artefact of the simulation and not this proposed hearing aid technology- no additional harmonic or inharmonic components are created so, at least in theory, it should function as predicted.

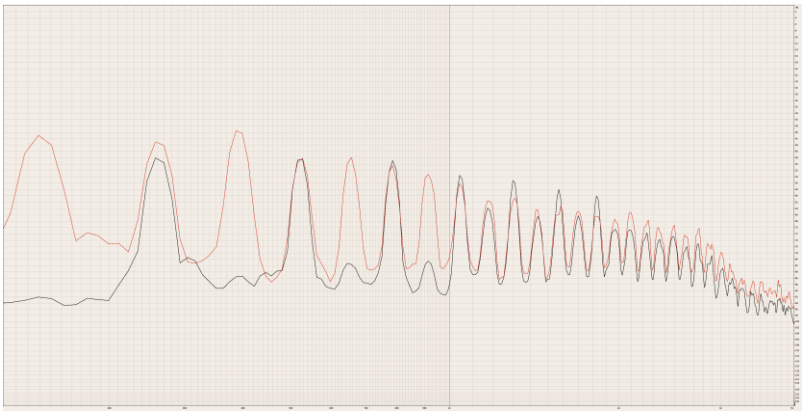

Figure 2

Audio File 2

Such a frequency raising algorithm may also have benefits for those fit with cochlear implants where there can be significant issues in transducing low frequency elements of speech and music such as rhythm and an adequate bass response.

Currently there are two manufacturers that utilize a one octave linear frequency lowering (Chasin, Fabry, and Kuk, 2024), and extending this to a frequency raising digital signal approach should be a rather straight-forward innovation that may be quite useful for both those people with low frequency sensori-neural hearing loss and for those with cochlear implants.

Reference:

Chasin M.; Fabry D.; and Kuk F., The Benefits of Linear Frequency Lowering for Music. *Hearing Review*. 2024;31(1):08-13.