FREQUENCY TRANSPOSITION- THE ONE OCTAVE COUNTER EXAMPLE:

Many people that have a hearing loss have frequency regions that are significantly damaged, whereas other frequency regions are healthier. For example, a person with a hearing loss may perceive a note on the right hand side of the piano keyboard to be flat or distorted, and in some cases, no matter what is done to the setting on the hearing aids, these notes will not sound good. This have been referred to as a "cochlear dead region", and as this overly dramatic sounding name suggests, it is best to avoid this frequency region (Baer et al., 2002; Moore, 2004; Moore, 2010). A short-cut to quickly assessing cochlear dead regions can be found in Chasin (2019).

The short answer is that frequency transposition should NOT be used with music, but…

The one octave counter-example- an island of refuge:

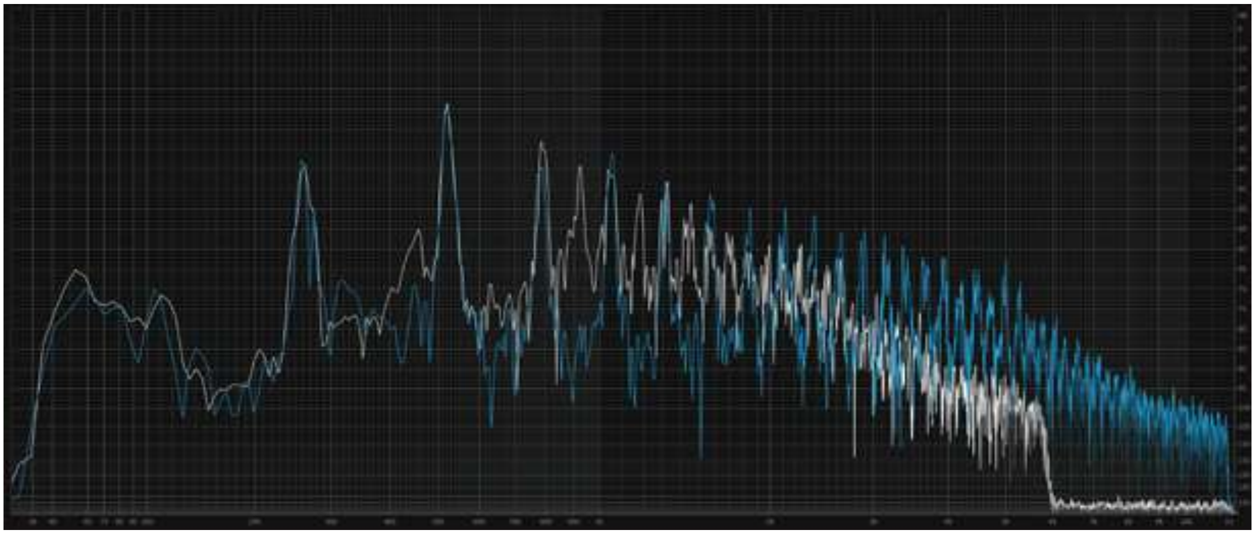
Are there specific frequency transpositions that would be acceptable? As it turns out, more may not necessarily be such a bad thing. Just because one half of a semi-tone or a full semi-tone may sound bad, doesn't necessarily mean that 2 or 8 semi-tones would be worse. There may be "islands" where the frequency transposition doesn't sound too bad.

It is true that a transposed harmonic (or range of harmonics) can co-incidentally line up with a different pre-transposition harmonic, thereby not creating dissonance, and other than a slight increase in overall harmonic intensity, this should sound good. And there can be other transposed harmonics that can create "new" harmonies such as a major third or perfect fifth, which will also not cause dissonance in the music. It the latter case, it would still sound great, but not be as originally orchestrated… something that my music teacher may call "funky". For the non-music readers, the word "funky" in jazz means "different, but OK". In classical music, "funky" can also mean "go home and practice more!" I suspect that the creation of some unexpected harmonics may be more acceptable for classical music than the more complex harmonies and counterpoint associated with jazz music.

In the specific case of a one octave frequency transposition, the first harmonic in the transposed region (e.g. only above 1500 Hz) would line up perfectly with the pre-exposed harmonic just below it in frequency, and this would be the case of all odd number multiples above that. For the even numbered harmonics above the first harmonic to be transposed, the result would be one that is a perfect fifth, which would not sound dissonant. The even numbered harmonics would all be at the geometric mean of the octave below it, like an A being changed to an E. The notes A and E can sound quite nice together, but the orchestrator did not include a perfect fifth in the original music.

The following audio file shows a violin transposed exactly one octave above 1500 Hz, in an A-B-A comparison where the "A" portion is the untransposed note and the "B" portion is the transposed note. The untransposed and transposed spectra are also shown with the blue color for the unaltered violin spectrum playing A (440 Hz) and the white color for the spectrum that has been frequency transposed by exactly one octave. Note the creation of "additional" harmonics at the perfect fifth. That is, an E (1319 Hz)- actually an octave and a perfect fifth higher than A

(440 Hz)- is created where none had existed before, but the musical notes A and E sound quite nice together.

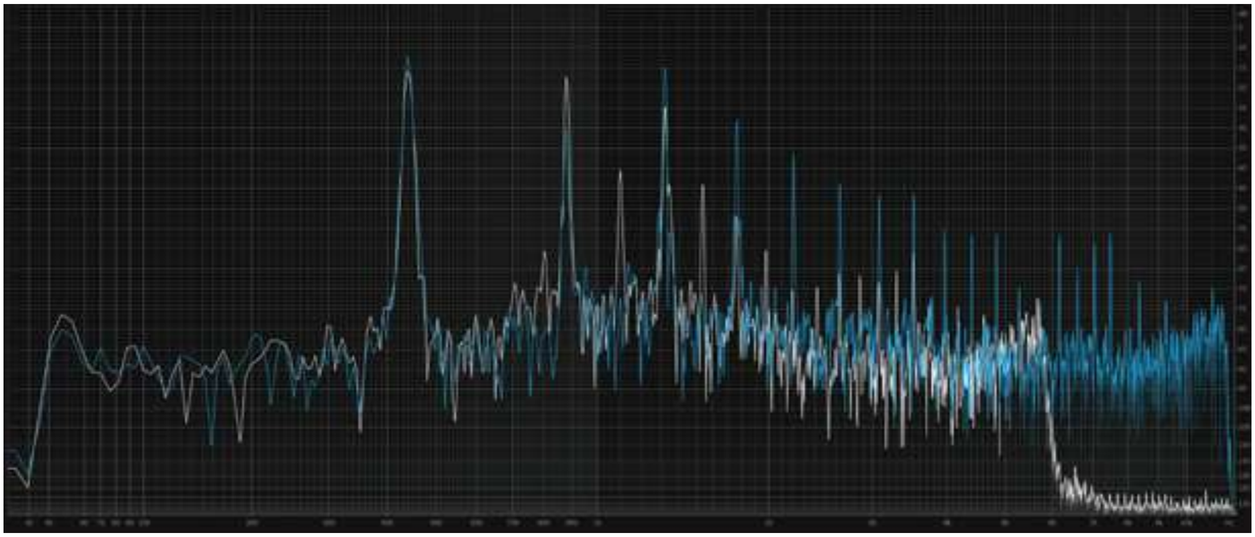


Violin_ABA_OctaveLowering_24khz.mp3

However, this is a case where the violin was used as an example. The violin, like the saxophone, guitar, piano, oboe, and a range of other instruments are one half wavelength resonators with integer multiples of their harmonics. But this one octave transposition should also be able to be useful for one quarter wavelength resonator instruments such as the clarinet, trumpet, and French horn where the fundamental note would have "odd" numbered multiples. This is why there is a special key on the clarinet called a "register" key rather than the "octave" key that is found on the saxophone. A register key increases the frequency by 3 times the similar fingering in the lower register; an odd numbered multiple (or an octave and one half).

With a clarinet, a one octave transposition would also create additional harmonics that were not in the initial orchestration, but in this case they would be major thirds- again it still sounds great but not exactly what the music composer had in mind.

The following audio file shows a clarinet transposed exactly one octave above 1500 Hz, in an A-B-A comparison where the "A" portion is the untransposed note and the "B" portion is the transposed note. The untransposed and transposed spectra are shown. Similar to the previous case of the violin, the blue color is for the unaltered clarinet spectrum playing A (440 Hz) and the white color is for the spectrum that has been frequency transposed by exactly one octave. Note the creation of "additional" harmonics at the major third. That is, a C is created where none had existed before, but the musical notes A and C also sound quite nice together.



Clt_ABA_OctaveLowering_24khz.mp3

My clinical "gut" feeling is that all forms of frequency transposition may be useful for speech but not for music, however manufacturers may want to consider creating a "one octave frequency transposition" button in the software that may be "tried" as part of a music first-fit program.

Acknowledgment:

I would like to acknowledge Shaun Chasin, Composer, who created and altered these audio File. More about Shaun can be found at www.Chasin.ca.

References:

1. Baer T, Moore BCJ, Kluk K. Effects of low pass filtering on the intelligibility of speech in noise for people with and without dead regions at high frequencies. *J Acoust Soc Am*. 2002;112(3):1133.
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