THE PROBLEM WITH FREQUENCY TRANSPOSITION AND MUSIC

AN ISLAND OF REFUGE: the one octave example- part two

By Marshall Chasin, AuD., Doctor of Audiology

Frequency transposition, frequency shifting, and frequency compression are all terms that refer to algorithms that lower the frequency above a certain start point using either a linear or a non-linear processing. Many manufacturers have their own terminology for their algorithm and in some cases, manufacturer's software will include in as a default setting for their first-fit algorithms. Similar to part one, I will be using the phrase "frequency transposition" generically, to refer to shifting a range of frequencies to a lower frequency range. In part one (THE PROBLEM WITH FREQUENCY TRANSPOSITION AND MUSIC) the limitations of frequency transposition were discussed.

Are there specific frequency transpositions that would be acceptable? As it turns out, more may not necessarily be such a bad thing. Just because ½ of one 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 don't sound too bad.

It is true that a transposed harmonic (or range of harmonics) can co-incidentally line up with a different already existing non-transposition harmonic thereby not creating dissonance, and other than a slight increase in overall harmonic amplitude, this should sound good. And there can be other transposed harmonics that can create "new" harmonies such as a 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!" However, 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, even if Beethoven would be turning over in his grave.

In the specific case of a one octave LINEAR frequency transposition- an exact shift above 1500 Hz (in this example), the first harmonic in the transposed region would line up perfectly with the non-transposed harmonic exactly one octave lower in frequency, and this would be the case of all odd number multiples above that (first, third, fifth, … harmonics). For the even numbered harmonics above the first harmonic to be transposed, the result would be one that is a perfect fifth, and this 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, even though the orchestrator did not include a perfect fifth in the original music.

The following audio file shows a violin linearly transposed exactly one octave above 1500 Hz, in an A-B-A comparison where the "A" portion is the non-transposed note and the "B" portion is the transposed note. The non-transposed and transposed spectra are also shown with the white color for the unaltered violin spectrum playing A (440 Hz) and the blue color for the spectrum that has been linearly frequency transposed by exactly one octave (Figure 1a and 1b). Note the creation of “additional” harmonics at the geometric mean between harmonics, also known in music as a 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.

PLACE FIRST AUDIO FILE ABA COMPARISON HERE

Fig. 1a: PLACE SPECTRUM OF UNTRANSPOSED NOTE AND THE TRANSPOSED SPECTRUM SHOWING THE CREATION OF AN ADDITIONAL PERFECT FIFTH

Fig. 1b: The creation of the new note with harmonics at exactly a perfect fifth (yellow) (E) above the intended A (blue).

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, is also known as a twelfth).

Fig. 2: The creation of the new note with harmonics at exactly

a minor third (yellow) (C) above the intended A (blue).

With a clarinet, a one octave linear transposition would also create additional harmonics that were not in the initial orchestration, but in this case they would be 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 linearly above 1500 Hz, in an A-B-A comparison where the “A” portion is the non-transposed note and the “B” portion is the transposed note. A C (524 Hz) note is created where none had existed before, but the musical notes A and C also sound quite nice together.

PLACE SECOND AUDIO FILE ABA COMPARISON HERE

All of this would be useful for purely instrumental passages. When speech/vocals become involved with the music, this approach would not be useful. Following is an audio file with a one octave linear transposition above 1500 Hz for a speech passage in an A-B-A comparison.

PLACE AUDIO FILE OF SPEECH THAT IS TRANSPOSED ONE OCTAVE

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 linear frequency transposition" button in the software that may be "tried" as part of an instrumental-only first-fit program.

Acknowledgment:

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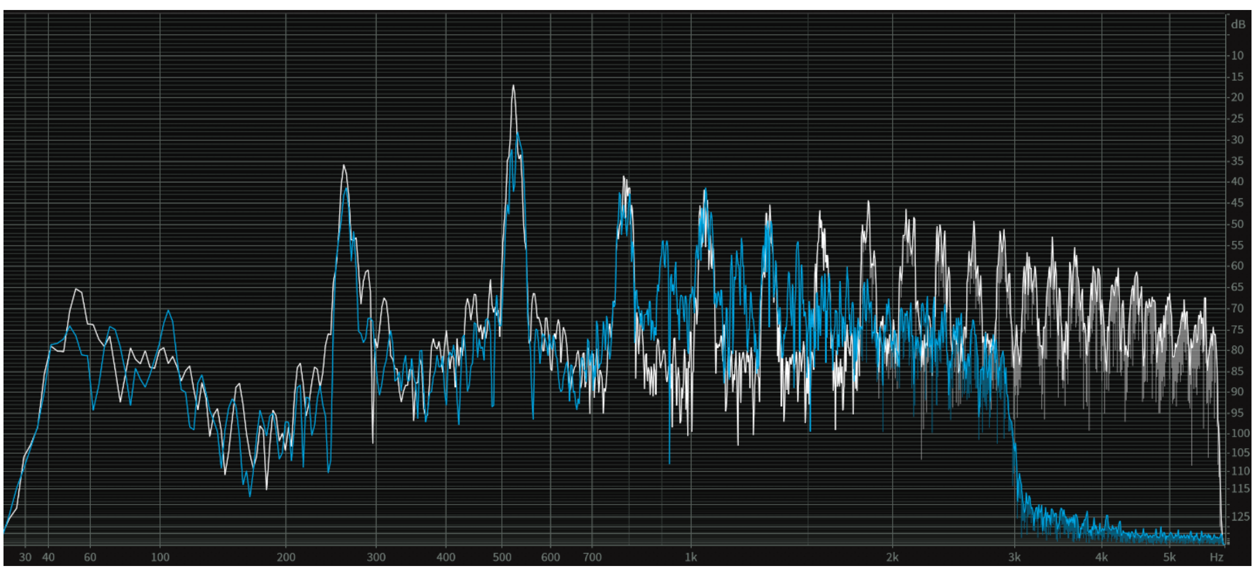

Figure 1a: The untransposed and transposed spectra are also shown with the white color for the unaltered violin spectrum playing A (440 Hz) and the blue color for the spectrum that has been frequency transposed by exactly one octave, showing the creation of a perfect fifth (E).

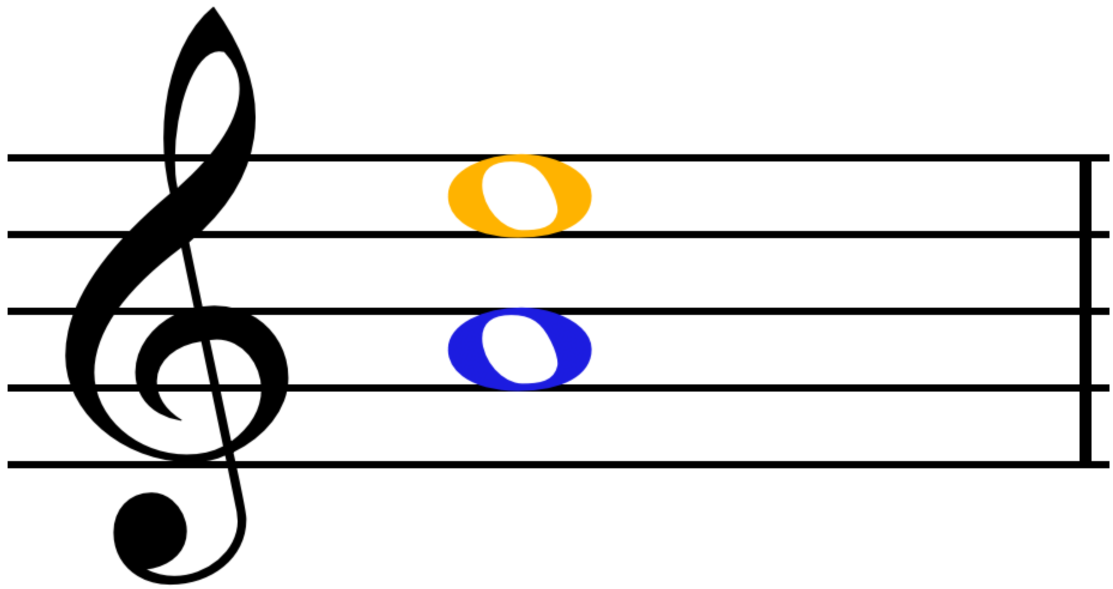

Fig. 1b: The creation of the new note with harmonics at exactly a perfect fifth (yellow) (E) above the intended A (blue).

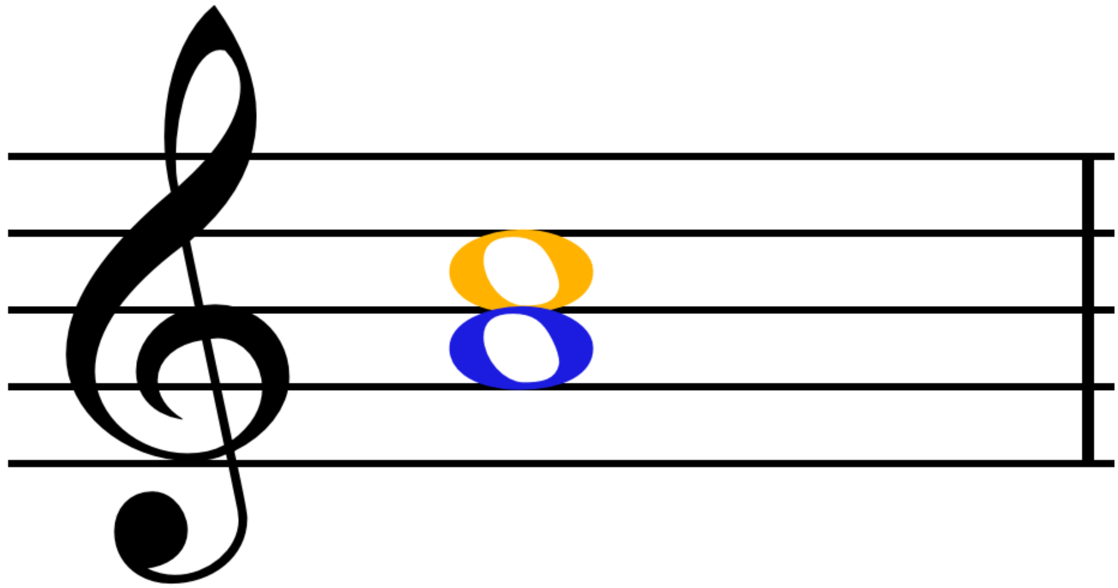

Fig. 2: The creation of the new note with harmonics at exactly a third (yellow) (C) above the intended A (blue).