The Problem with Frequency Transposition and Music, Part 2: The One Octave Example

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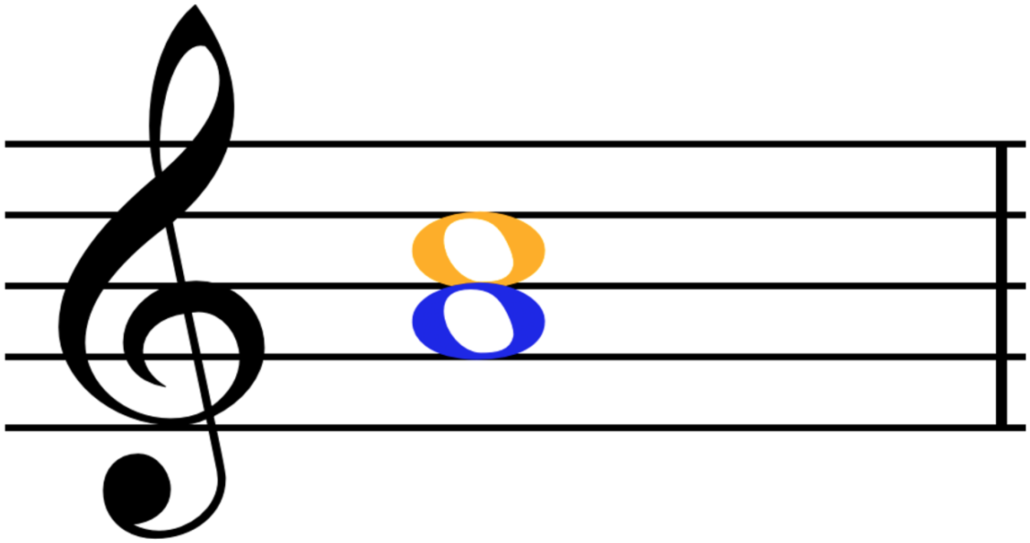

By Marshall Chasin, AuD

Linear 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. In this article I will be using the phrase "linear frequency transposition" generically, to refer to shifting a range of frequencies to a lower frequency range. In Part One, the limitations of linear frequency transposition were discussed.

Are there specific linear 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 linear frequency transposition doesn't sound too bad.

It is true that a transposed harmonic (or range of harmonics) can coincidentally line up with a different non-linear 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 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 counterpoints associated with jazz music.

In the specific case of a one octave linear frequency transposition, the first harmonic in the transposed region (eg, only above 1500 Hz) would line up perfectly with the non-linear transposed 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, 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 transposed exactly one octave above 1500 Hz, in an A-B-A comparison where the “A” portion is the non-linear transposed note and the “B” portion is the linear transposed note. The non-linear transposed and linear 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 linear frequency transposed by exactly one octave (**Figure 1**). 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.

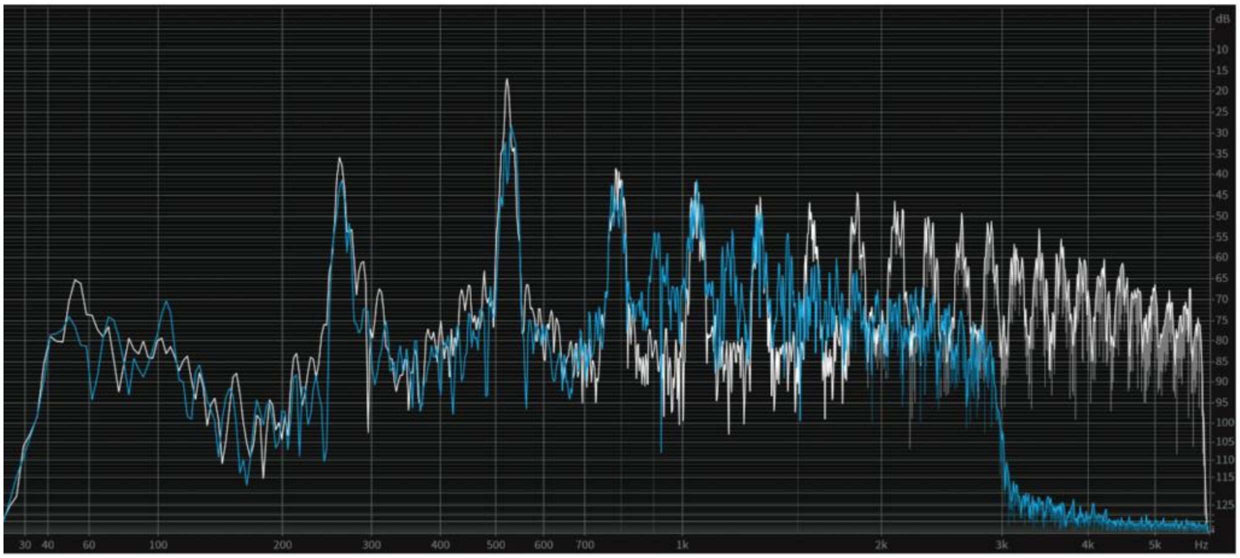

Figure 1a: The untransposed and linear transposed spectra are also shown with the white color for the unaltered violin spectrum playing A (440 Hz) and the blue color for the spectrum that has been linear frequency transposed by exactly one octave, showing the creation of a perfect fifth (E).

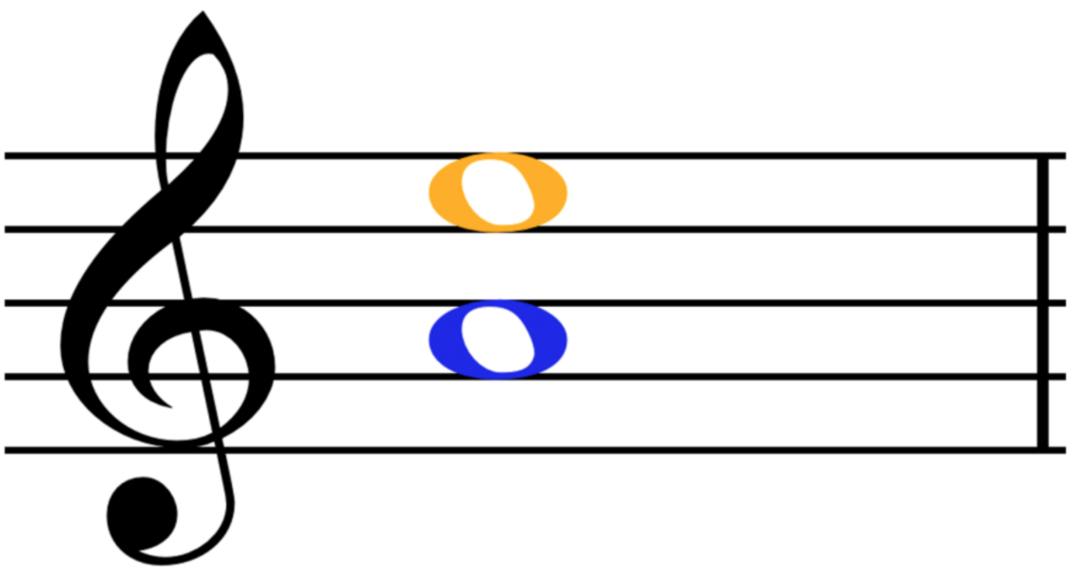

Figure 1b: The creation of the new note with harmonics at exactly a perfect fifth (yellow) (E) above the intended A (blue).

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 linear 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 three times the similar fingering in the lower register; an odd-numbered multiple (or an octave and one half… also known as a twelfth).

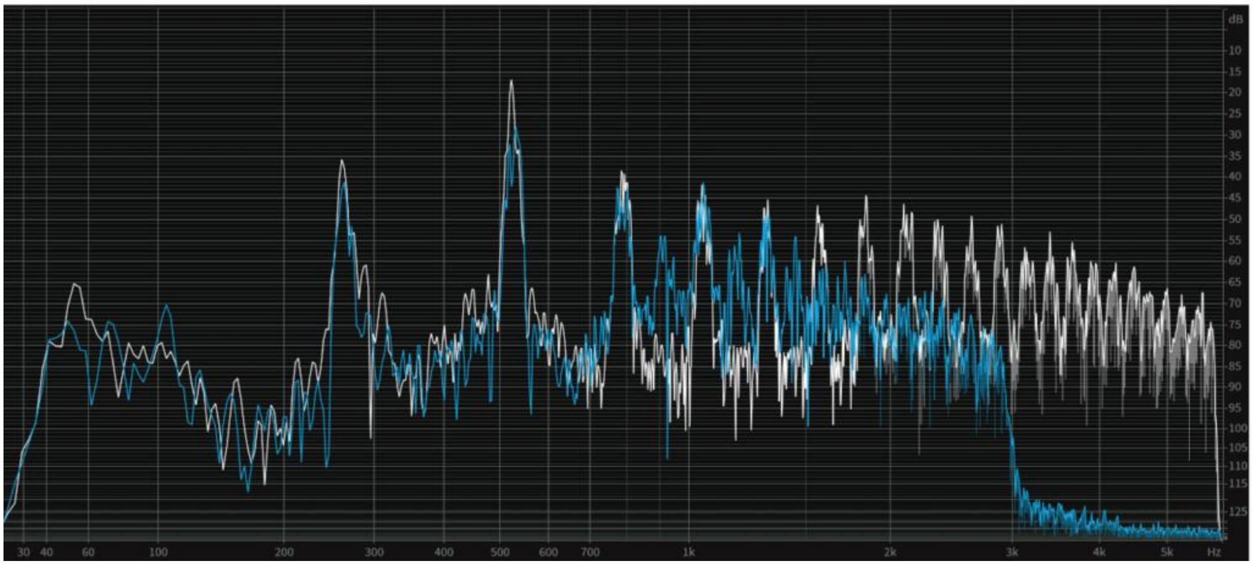

Figure 2a: The untransposed and linear transposed spectra are also shown with the white color for the unaltered violin spectrum playing A (440 Hz) and the blue color for the spectrum that has been linear frequency transposed by exactly one octave, showing the creation of a minor third.

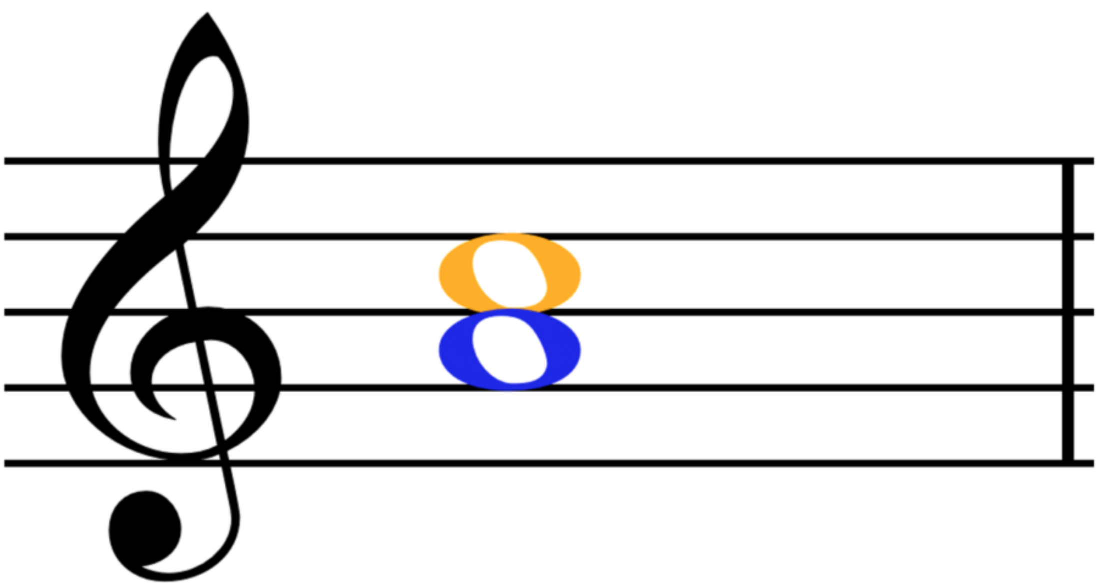

Figure 2b: The creation of the new note with harmonics at exactly a minor third (yellow) (C) above the intended A (blue).

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 linear transposed exactly one octave above 1500 Hz, in an A-B-A comparison where the “A” portion is the non-linear transposed note and the “B” portion is the linear transposed note. The non-linear transposed and linear 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 linear frequency transposed by exactly one octave. Note the creation of “additional” harmonics at the third. That is, a C is created where none had existed before, but the musical notes A and C also sound quite nice together.

Chasin-Clt-ABA-OctaveLowering-24khz.mp3

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 transposition above 1500 Hz for a speech passage in an A-B-A comparison.

ABA-Octave-shift-above-1500hz.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 linear 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 this audio file. More about Shaun can be found at www.Chasin.ca.