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The Final Element

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The Final Element may sound like the title of a science fiction novel or a movie starring Bruce Willis (or was that the "Fifth Element"?), but this is all about that one last piece of the puzzle to optimize a hearing aid for music. The last several years has seen a remarkable improvement in a hearing aid's ability to handle the higher level inputs associated with music.

Whereas speech has sound levels on the order of 60–80 dB SPL, even quiet music can have levels on the order of 100–110 dB. Until recently, modern digital hearing aids have been playing "catch up" to the analog technology of the late 1980s and early 1990s. These old style hearing aids were analog and as such did not have analog-to-digital (A/D) converters. Modern A/D converters are typically restricted to transduce inputs of only 90 – 95 dB SPL and as such result in poor fidelity when it comes to the playing of, and the listening to, of music. More on this can be found at www.Chasin.ca/distorted_music.

In the last several years technologies have become available that have shifted up the maximum input that can be digitized through an A/D converter to over 110 dB SPL. These include, among others, the Live Music Plus technology from Bernafon, the Dream circuitry from Widex, and most recently the North Platform from Unitron and the Venture Platform from Phonak. In these last two cases, the manufacturer has changed from a 16 bit architecture to a 24 bit one, thereby allowing a greater dynamic range, and a lower noise floor. I would suspect that in the not too distant future, all hearing aid manufacturers would have resolved this problem found with the higher sound level inputs of music.

Yet one thing remains- the final element, and surprisingly, it is very "low tech". So low tech in fact, that it was previously available but has been withdrawn from the marketplace – a single channel hearing aid.

Single channel hearing aids have been shown to be less than optimal for speech, especially in noisy environments. The resulting signal to noise ratio (SNR) can be rather poor with single channel broadband amplification. Multi-band compression has been the mainstay of hearing aids since the late 1980s with the advent of the K-AMP. However, speech is not music.

While typical SNRs for speech can be on the order of 0 dB, typical SNRs for music can be greater than +30 dB. The advantages of SNR improvement for multi-band compression with speech are not necessary when it comes to the higher sound levels that are typical of music.

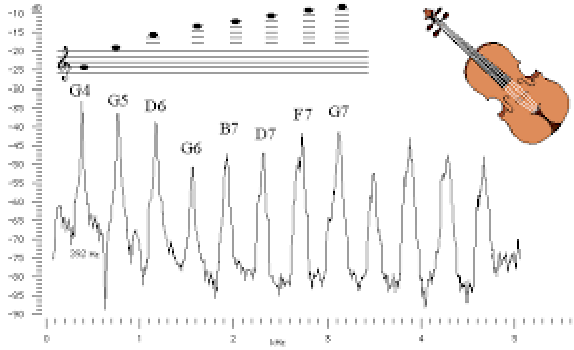

Figure 1. The fundamental G [392 Hz] and its integer numbered harmonics of a violin.

Let’s examine what would happen with a typical multi-band compression hearing aid. A violin would be played generating lower frequency fundamental energy (e.g., at the G, just above the middle of the piano keyboard G[392 Hz]) but also with evenly spaced harmonics at integer multiples of 392 Hz- 784 Hz, 1176 Hz, 1568 Hz, 1960 Hz, and so on (see Figure 1). The relative magnitudes of the harmonics of G are crucial, especially with stringed instruments such as the violin, viola, cello, and bass. Imagine a multi-band compression hearing aid amplifying the fundamental G [392 Hz] by say, 20 dB, and then amplifying the harmonics by any amount. The resulting amplified spectrum would look like almost any other instrument except a violin.

With stringed instruments, the amplification needs to be applied equally across the frequency band in order to still sound like the instrument that it is. Multiband compression can make a violin sound like a flute by differentially applying more or less gain to any number of the harmonics (see Figure 2).

Both the violin and the flute are “half wavelength” resonator instruments, so have equally spaced (integer numbered) harmonics but multi-band compression would significantly alter the harmonic structure of all music.

Perceptively when listening to, or playing of, stringed music, the fundamental/harmonic ratio is crucial and must be maintained. Only a true single band hearing aid will be able to accomplish this. Woodwinds are a slightly different animal – when I play my clarinet, it is the lower frequency inter-harmonic noise that I am listening to, that defines a high fidelity sound. Despite my clarinet and a violin being able to generate a wide band spectrum, the perceptive requirements of a woodwind sound is restricted to the lower frequency region, and in many cases, below 1000 Hz.

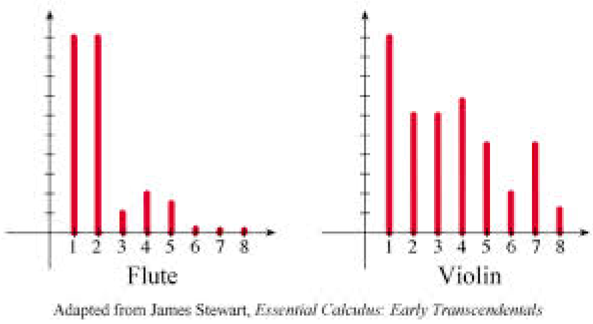

Figure 2. Despite both the flute and the violin being half wavelength resonator musical instruments and having their harmonics at exactly integer multiples of the fundamental, it is the relative heights of the harmonics that define their unique sounds.

For string-heavy music such as classical music, a single channel hearing aid is indeed the missing element. This is probably less so for hearing and playing woodwind music, but given the impressively higher SNRs that are characteristic of music, a true single channel hearing aid is a necessary requirement, which will have no downside for listening and/or playing music.