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TOPICS IN AMPLIFICATION

Live Music Plus: For the Pure Enjoyment of Live Music

Throughout time, playing and listening to music have been universal human behaviors with no known geographical or cultural boundaries. When people gather together, music is most often present, such as at a wedding or a party to name but two (Levitin, 2006). As hearing care professionals our primary goal is to improve the communication abilities of our clients and enhance the quality of their lives. While concentrating our clinical efforts on the perception of speech in many different environments, we sometimes forget about other signals such as music, which may be very meaningful to the client. Music may be a hobby or a profession or perhaps just a pleasant way to spend some time. Unfortunately, music lovers and musicians are often disappointed by the sound of music through their hearing instruments, due to the fact that they are designed to focus on speech. Settings and electroacoustic characteristics of hearing instruments may be ideal for speech signals but not for music (Chasin & Russo, 2004). There are many acoustic differences between speech and music, so naturally the hearing instrument may react inappropriately when music is present.

Bernafon recognizes that music is very important for many clients and so has developed a dedicated listening program for live music called: **Live Music Plus.** This program combines the power of ChannelFree™ processing with a wideband frequency response along with Live Music Dynamics to enhance the listening experience for both musicians and music lovers.

In this paper we will first review some of the differences between music and speech signals, then we will explore the three elements that make up **Live Music Plus.**

The differences between Music and Speech

Chasin (2006) and Chasin & Russo (2004) have pointed out that there are a number of differences between music and speech. Here are just three of them:

1. Speech vs. Music Spectra
Speech has a relatively uniform spectrum (the range of frequencies produced) due to the fact that the human vocal tract is the source. While there are individual differences between males, females and children, the sound source is similar. There is also a long term average speech spectrum referred to in a variety of acoustical standards (e.g. Byrne et al, 1994 and ANSI S3.5–1997) which demonstrates how the sounds of speech are acoustically represented. The speech spectrum is used as a foundation by fitting rationales in order to restore the audibility of speech via amplification. Music, on the other hand, has many sources which are highly variable and the resulting spectrum can resemble noise in some cases and speech in others (Chasin & Russo, 2004). A truly representative long term music spectrum therefore does not really exist.

2. Different intensities
As hearing care professionals we typically consider soft speech as being 50 dB SPL, conversational speech as 65 dB SPL and loud speech as 80 dB SPL. Shouted speech is around 83 dB SPL (Chasin, 2006). Music on the other hand is quite different and can easily reach 105 dB(A)[1] and can have peaks of 120 dB(A). Killion (2009) measured peaks of a symphony orchestra in a concert hall at 114-116 dB (C). It must be noted however that these high intensity peaks are very short and so should not be considered to be damaging to our hearing (Killion, 2009).

Speech has a well defined relationship between loudness (the psychological impression of the intensity of a sound) and intensity (the physical quantity relating to the magnitude or amount of sound). For music this relationship is variable and greatly depends upon the musical instrument being played (Chasin, 2006).

3. Crest Factor
The crest factor can be described as the difference between the peak level and the average (RMS) level, in other words the instantaneous difference between the peak of a signal and the overall level. Speech has a fairly consistent crest factor of 12 dB while music has a crest factor of up to 18–20 dB for many instruments (Chasin, 2006). This acoustic characteristic is very important for the dynamic impact of music.

From this discussion of the differences between speech and music, it is quite easy to see why these signals must be processed differently within the hearing instrument. Now we will explore the three systems in Live Music Plus that Bernafon has implemented to improve musical sound quality.

Live Music Plus

The three systems that make up **Live Music Plus** are
1. Live Music Dynamics
2. ChannelFree™ processing
3. Wideband frequency response

We will now look at each of these systems individually and how they work together.

1. Live Music Dynamics
As we have discussed earlier, music has different intensities and crest factors than speech. These dynamic characteristics create a challenge to digital hearing instruments. Typically a digital hearing instrument compresses the peaks of the signal once they reach 95 dB before the conversion from the analog domain to the digital domain. This is more than adequate for even loud speech, however, for the peaks of live music this is too low and the music will sound compressed, unnatural, and even slightly distorted. This is especially a drawback for musicians who may be trying to hear their fellow musicians in order to play correctly. Live Music Dynamics increases the level to 110 dB in order to preserve the peaks in music before they reach ChannelFree™ processing.

1 The dB A scale is used to approximate what we hear as opposed to the physical sound pressure level (SPL). The dB C scale is used to measure the peaks of a signal. Both dB A and dB C filters are found on most sound level meters.

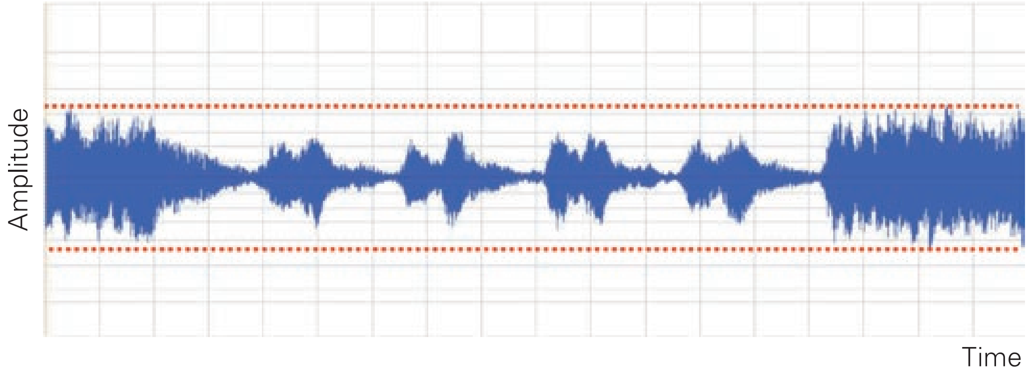

Figure 1: Amplified music without Live Music Dynamics

In Figures 1 and 2 we see amplified music displayed as waveforms with amplitude on the y axis and time on the x axis. In Figure 1 we can see a live music signal without Live Music Dynamics. The peaks of the waveform are cut off, indicated by the red dotted line. This line signifies the maximum level that the hearing instrument will permit to be converted to the digital domain. The same signal can be seen in Figure 2 with Live Music Dynamics, the peaks of the musical signal are preserved and the dynamic range is higher, demonstrating that the natural dynamic characteristics will be converted into the digital domain.

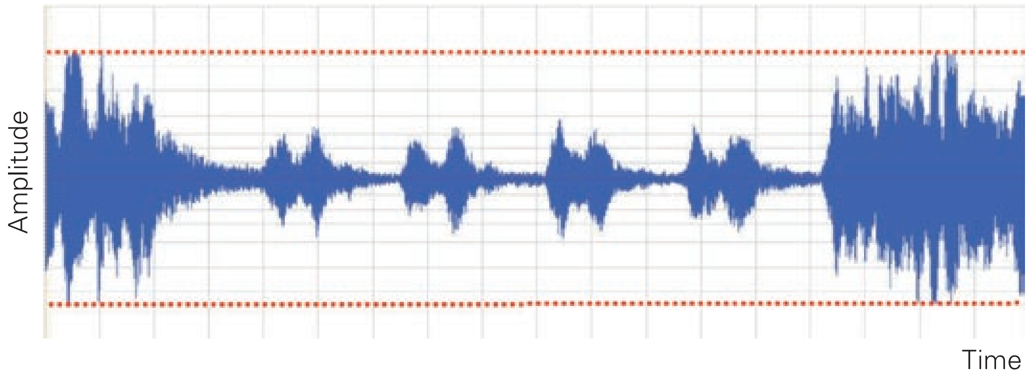

Figure 2: Amplified music with Live Music Dynamics

2. ChannelFree™ processing

ChannelFree™ processing is a great step forward in the processing of musical signals. It has a fast processing time and treats signals as a whole to maintain the balance between low and high frequency harmonic energy[2]. The high frequency harmonics, for example, are especially important for the judgment of the timbre (the difference between musical instruments playing the same note at the same intensity) e.g. a trumpet and a violin playing the same musical note. This balance is crucial for musical sound quality. With ChannelFree™ processing the level differences between the sounds of music are maintained resulting in a natural perception of the musical signal. The peaks of musical signals may be sharper than speech as described earlier in our discussion of the crest factor and may send a standard hearing instrument into compression early. ChannelFree™ processing however can quickly follow the level of the signal in order to preserve the relationships between different levels of the

2 For a more complete discussion of ChannelFree™ processing please consult the July 2009 Topics in Amplification entitled "ChannelFree™, proprietary Bernafon technology" www.bernafon.com, Schaub (2008) and Schaub (2009).

musical signal. The result is that the signal is amplified to a comfortable level for the client as defined by the Oasis fitting software and any fine tuning actions made by the hearing care professional.

Bernafon's ChannelFree™ processing has been judged to have high sound quality. In a study by Dillon et al in 2003 with hearing impaired listeners, it was found that Symbio, a first generation ChannelFree™ processing hearing instrument, received the highest ratings for the sound quality of piano music compared with other digital hearing instruments.

3. Wideband frequency response

It is well known that a wide frequency response contributes to the perceived naturalness of music (e.g. Moore & Tan, 2003; Killion, 2009). Hearing instruments with Live Music Plus have a frequency response up to 10,000 Hz. This frequency response is more than enough to convey most musical sounds accurately. For example, the highest C note on a piano is 4186 Hz, while the highest C note on a violin is 2093 Hz (Levitin, 2006).

Putting it all together

Music differs quite dramatically from speech and is a potential challenge for hearing instruments. With **Live Music Plus** Bernafon has created a music program dedicated to presenting musical signals accurately to the client with three important elements. The first is Live Music Dynamics which ensures that the dynamic characteristics of music are preserved. The second is ChannelFree™ processing which ensures that the music is accurately amplified within the dynamic range of the client. The third is a wideband frequency response which contributes to the perceived naturalness of the music. The combination of these three elements is beneficial for both musicians and music lovers. **Live Music Plus** allows the client to enjoy the rich world of music as a listener and even as a performer.

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