Loud vs. intense: Three ways to delude the musician

By Marshall Chasin, AuD

Five minutes into your first audiology class, you learn the difference between loudness and intensity, and this distinction runs throughout your training. Once you are out of school, the first thing you learn is not to confuse your clients by saying "loudness" when you mean "intensity."

When talking about speech, the two concepts are not that different, but that is not at all the case for music.

CRITICAL BANDWITHS

Loudness summation accounts for the psychoacoustic similarities and differences between intensity and loudness. Simply stated, a person will consider one sound louder than another if the energy exceeds one's critical bandwidth than if its spectrum is constrained within one critical bandwidth.[1]

A critical bandwidth is approximately a third of an octave, which is why one-third octave bandwidth analysis is so common in our field. One can attribute loudness for a single puretone at 1000 Hz. Adding another at 1050 Hz will slightly increase its intensity but not its loudness. The same is true of adding a third puretone at 1100 Hz, and this holds true as long as the sound energy is within a critical bandwidth. When adding another puretone at 1200 Hz (exceeding the critical bandwidth at 1000 Hz, which is about 160 Hz), however, a person will subjectively report that the sound is now louder because the sound spectrum has exceeded the critical bandwidth. (Table 1.)

In speech

Fundamental frequency is the lowest frequency element of speech, and is typically written as F0 or f_0. For men, this ranges from 120 Hz to 150 Hz, and is roughly one octave below the middle of the piano keyboard. All other harmonic energies of the long-term speech spectrum are at integer multiples of F0.

The F0 of my voice, for example, is 125 Hz. The first harmonic of 125 Hz is at 250 Hz, then 375 Hz, then 500 Hz, and so on. Each harmonic is spaced 125 Hz apart, and this spacing is the primary factor in defining pitch. Each harmonic speech occurs in a different critical bandwidth—250 Hz is in a different critical bandwidth from 125 Hz and also from 375 Hz—and critical bandwidths in the lower frequencies are narrower than in the higher ones.

This means that each element of the speech spectrum adds to the subjective impression of loudness. This is well known in the hearing aid industry, and has been used to set the proper intensity (to accomplish an acceptable loudness) for those who are hearing impaired.

Table 1. *Three examples of critical bandwidths and their center frequencies.[1] *The validity of the critical bandwidths for very low frequencies has not been well established because of experimental issues.*

Center Frequency (Hz)	Critical Bandwidth (Hz)
40	100*
1000	160
4000	700

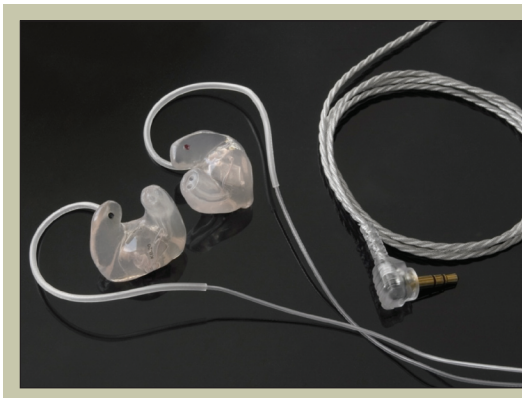

Figure 1. *An in-ear monitor can improve music monitoring while on stage. The monitor has a preamp and a series of one or more receivers, and can be hard-wired to the sound production rack or coupled via wireless FM routing of the signal. Photograph courtesy of Sensaphonics, Inc.*

In music

The situation is a little more complicated for music. Instrumental music usually has significant energy in the lower notes of a piano, and the lower notes of a cello, for example, are typically around 40 Hz. The first harmonic is at 80 Hz, but unlike speech, this is still in the same critical bandwidth as the fundamental at 40 Hz. Loudness does not increase for a bass instrument until the addition of the second or third harmonic. Hearing impaired people

who like to listen to orchestral or bass-heavy music should have less gain and output specified in their music program than for their speech in their quiet program.[2] This is why rock and roll musicians tend to play quite loudly; they need a significant increase in intensity to get a significant increase in loudness. Rock music doesn't need to be intense; it just needs to be loud.

An easy though not practical solution to make a person think the music is loud at a lower intensity level is based on the work of Cullari and Semanchick, who found that listeners prefer music that is played louder.[3] Three strategies, however, can delude the musician into thinking that music is sufficiently loud, even at a lower intensity level.

IMPROVED MONITORING

Improved monitoring of music allows the musician and the listener to turn down the volume (the intensity level) while maintaining a sensation of loudness. Electrical monitoring using in-ear monitors (Figure 1) have been shown to be quite useful, and with proper counselling, musicians will reduce the listening level by 6 dB.[4] The preferred listening level with in-ear monitoring may be the same as with normal on-stage wedge monitors, but musicians will accept a less intense signal that they still consider to be sufficiently loud.

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Acoustic monitoring can also be quite beneficial, especially for bass instruments, because it optimizes the signal intensity while, reducing the masking environmental noise, just like in-ear monitoring. Acoustic monitoring may take several forms, one of which is the use of four feet of #13 hearing aid tubing connected to an earplug (either custom or a foam ear-like earplug with a 2 mm hole drilled down the center to receive the #13 tubing).[4,5] Figure 2 shows an illustration of this inexpensive innovation with a bass player.

INCREASING BASS RESPONSE

Increasing the bass response will create the perception of greater loudness at a lower intensity level, a frequent strategy in dance and aerobics classes. Merely increasing the bass response of the media player means that one can reduce the volume (intensity) by about 4-6 dB depending on the room.

Elevating and angling the loud speakers can also improve the bass response of sound so that the musician will choose to play at a sufficiently loud but lower intensity level. If a loudspeaker is sitting flat on the floor, the lower frequency components of the sound that emanate from it are absorbed into the floor and lost to the audience. Most sound engineers will turn up the overall volume to compensate for this loss of low frequency energy, re-establishing the desired loudness but at a higher intensity level. Elevating the loudspeaker allows a broader range of loud sounds to reach the listener at a lower intensity.

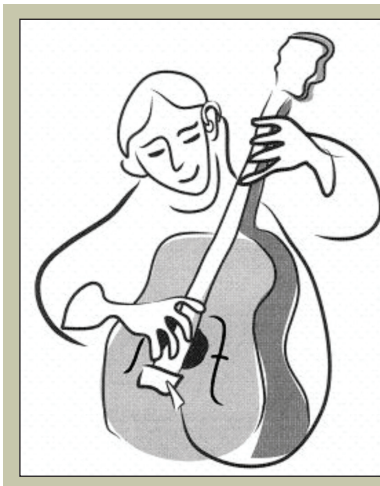

Figure 2. *Hearing aid tubing can be used like a stethoscope to improve the monitoring of one's own bass instrument; it enhances sound pressure of the lower frequencies by up to 20 dB.*

Loudspeakers are highly directional but only for the higher frequencies. This is why bass woofers can be placed anywhere in a room, even behind a couch. Low-frequency sounds are not directional, which is why trumpet players should be on risers. Tilting loudspeakers toward the listener will allow all sounds, including the higher frequency ones, to reach him directly. When this is done, the intensity setting on the volume control is frequently set lower while still maintaining an acceptable loudness.

INCREASING VIBRO-TACTILE RESPONSE

We actually feel much of what we hear. This is especially true of the bass response. A number of products can delude the musician and occasionally the listener into thinking that something is loud at a lower intensity.

Shakers are a general name for hockey puck-sized loudspeakers that function in the subwoofer, low-frequency region.

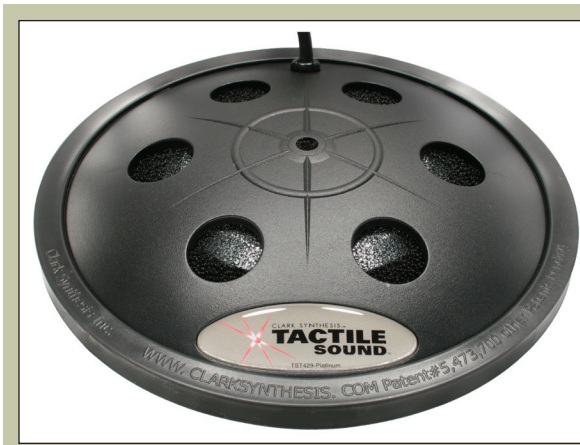

Figure 3. *Shakers are very low frequency subwoofers that transduce sound energy in the 50 Hz to 150 Hz range. They are typically bolted to the seat of the drummer or placed on the floor near the bass player. Photograph courtesy of Sensaphonics, Inc.*

An ultra-low frequency loud speaker can be bolted to a drummer's chair or onto a 1-square-foot piece of plywood placed on the floor near the drummer and bass players. (Figure 3.) When a drummer or bass player hits a bass note, he will really feel the vibration and play at a lower intensity level, despite feeling that he is playing loudly.

Balloons can be useful for listeners with significant hearing loss. I first discovered this idea at a national consumer conference for the hearing impaired. During the nightly entertainment, I saw people inflating balloons. Hearing-impaired people have used this trick for years because it allows them to obtain a vibro-tactile bass response, increasing their enjoyment of the music. Some even said it improves their understanding of the vocals.

The best strategy is to educate the artist about these approaches

While I've been using sort of a tongue-in-cheek approach by saying that we should delude the musician, the best strategy is to educate the artist about these approaches. Some may be more useful than others, but they all work by either increasing the bass response, the vibro-tactile response, or the overall monitoring. In all cases, the intensity at the musician's ear is reduced despite the sense that the loudness has been maintained.

Marshall Chasin, AuD, is Director of Auditory Research at the Musicians' Clinics of Canada in Toronto. *Thoughts about something you've read here? Write to us at HJ@wolterskluwer.com.*

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