Music and hearing aids - the current state of affairs

BY MARSHALL CHASIN

'Speech sounds great, but music isn't right' is a common complaint from hearing aid users across the globe. In this article, **Marshall Chasin**, one of the most published audiologists on the subject of music and hearing, outlines why patients with hearing aids so often struggle with music perception and offers some in-depth technical, as well as clinical, suggestions to help.

Even soft music can be at a higher level than the peaks of speech. This higher level input is something that, until very recently, modern digital hearing aids could not handle. Recent innovations, including altering the input signal and changing the operating range of the analogue to digital converters in hearing aids, have resulted in hearing aids being able to handle music inputs with minimal distortion.

With the advent of digital hearing aids in the early 1990s, the field of hearing aids and music took a giant leap backwards. Even up to five years ago, the 1988 K-AMP circuit was infinitely better than the best that could be offered in modern hearing aid circuitry. And I still have hard of hearing musicians from around the world asking me where they can obtain this 1988 circuit. Thankfully, the ability of modern digital hearing aids to handle music has recently improved to a point where, after a quarter of a century, the hearing aid industry has finally caught up with the older analogue technologies.

The problem

The capabilities of modern digital hearing aids are vast. With a push of a button on a computer screen, feedback can be successfully managed at the clinical level; noise reduction algorithms can now suppress the inherent, and sometimes audible, microphone noise; directional microphone patterns can be dynamic and can, in some instances, search and destroy unwanted background noise; and wireless communication for remote controls and assistive listening devices, televisions, radios, and smartphones, are all now standard clinical fare.

The issue has come to be known colloquially as a 'poorly constructed front end'. All digital hearing aids have a component known as the analogue to digital (A/D) converter. As the name suggests, this is the device that digitises a signal and presents a series of binary numbers as an input to a digital algorithm. In hearing aids, there may be several A/D converters for various modes of input such as microphone, telecoil, or wireless reception. Depending on the construction, there may even be 'stacked' A/D converters where one may deal with lower level signals, and the other with higher level ones such as music.

Simply stated, until recently, and still in the majority of hearing aids dispensed around the world, the A/D converter and associated 'front end' technology could only handle inputs up to the mid-90dB sound pressure level (SPL) range. Higher level inputs such as music, FX effects at movies, and even the level of the hearing aid wearer's own voice, were limited by the 'front end' with subsequent distortion. More specifically, and quite importantly, the 'dynamic range' of the hearing aid was limited to about 90dB. A website with some audio files demonstrating this distortion can be found at www.chasin.ca/distorted_music. Once there is distortion so early in the hearing aid processing, no amount of software adjustment that occurs later in the system, will improve things. This is why the topic of hearing aids and music is considered a 'hardware' issue and not a 'software' programming one.

Some technical design solutions

1. **Changing the 'dynamic range' absolute values:** One of the first solutions, other than trying to buy up all of the K-AMP circuits laying around in a manufacturer's backroom, was to have the A/D converter 'auto-range'. This was quite clever and this technology is still in widespread use today, typically if the IC circuitry has been purchased from third party manufacturers such as ON Semiconductors. This idea derives from the definition of the phrase 'dynamic range'. The dynamic range is the difference between the quietest sound that can be transduced by the A/D converter and the highest level sound. This difference, for 16 bits systems, is roughly 90-95dB. This is not 90-95dB SPL, but merely a range without any suffix units after the decibel value. This technology is able to have the A/D converter transduce 0-90dB SPL for some sounds; and then 15-105dB SPL for other higher level sounds. In both cases the dynamic range is 90dB, but the second range (15-105dB SPL) is much more appropriate for music (and the hard of hearing person's own voice). A version of this technology can be programmed statically into a special music program which, when implemented, is used for music. This technology has been around for more than a decade.
2. **Conditioning the louder music before the A/D converter:** Another approach, realising the inherent limitations of

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16 bit A/D converters, is to reduce the level of the input after the microphone but before the A/D converter - much like ducking under a low hanging doorway and then standing up after. There are a number of implementations of this idea in the hearing aid industry. One is the use of a compression system to reduce the level and then digitally reestablishing the level after the A/D converter stage. Digitally, the signal is identical to the original signal, but without the 'front end' distortion. Another version includes using a transformer technique which effectively increases the dynamic range, despite being limited by the 16 bit architecture.

3. **Post 16 bit architectures:** Up until recently, hearing aids used a 16 bit architecture and this 16 bit system defined the 90-96dB dynamic range. Currently there are a number of manufacturers which are switching to 18 and 19 bit systems. Although this may not sound like a big change, each additional bit can provide another 6dB increase in dynamic range. For example, a 2 bit increase from 16 to 18 effectively means that the dynamic range has increased from 96dB to 108dB - a range that is better suited to handling the higher levels that are characteristic of music. This approach certainly seems to be the way of the future and I would predict that within several years, all hearing aid manufacturers will be using post 16 bit technologies.

Some clinical solutions

What can be done for a patient who already has hearing aids and is rather happy with them for speech, but has difficulty with the higher levels of music? Clinically there are a number of strategies.

1. **Use tape over the hearing aid microphone(s):** Although this seems to be a bizarre clinical solution, the use of four to five layers of tape placed over the hearing aid microphones can reduce the sensitivity by 8-10dB. The A/D converter is then 'deluded' into thinking that the input is 8-10dB less and this new reduced input may be within the optimal operating characteristic of the A/D converter and hearing aid. The hearing aid user may need to turn up the volume control slightly to compensate and since the volume control is after the A/D converter, this is a reasonable and problem-free approach.

2. **Turn down the radio volume:** This simple approach can be useful for those who listen to their music from an MP3 player, radio, or TV. The correct approach is to turn down the input (such as the MP3 player or radio) and then, if necessary, turn up the volume of the hearing aid. This allows the higher level input to duck under the low hanging doorway, and get into the hearing aid, processing without distortion.

3. **Music is louder than speech so take off the hearing aid:** This is especially true for live music and other higher level inputs. While it may be true that a hard of hearing person may require 30dB of gain for soft or medium level inputs, it is also true that they may not require any gain at all for the higher levels associated with music - let the person's own equal loudness contours do their work.

The current state of affairs

'Hearing aids' and 'music' are two phrases that traditionally should not be used in the same sentence. Or at least, that was the case until recently. Current technologies can handle the higher levels of music, as well as the higher levels of a hard of hearing person's own speech, without distortion. Once digitised, the software program for listening to music is not all that different than the programming for listening to speech in quiet. There are no major changes in bandwidth, compression, or gain. The only suggestions are to remove the feedback management, noise reduction, and definitely remove any frequency transposition. More suggestions and updates can be found on my weekly blog at www.HearingHealthMatters.org/HearTheMusic.

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Declaration of Competing Interests:
None declared.

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