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Hearing Aids – From Here to Eternity and Beyond": An Article Written for the Hard of Hearing Consumer and Their Families

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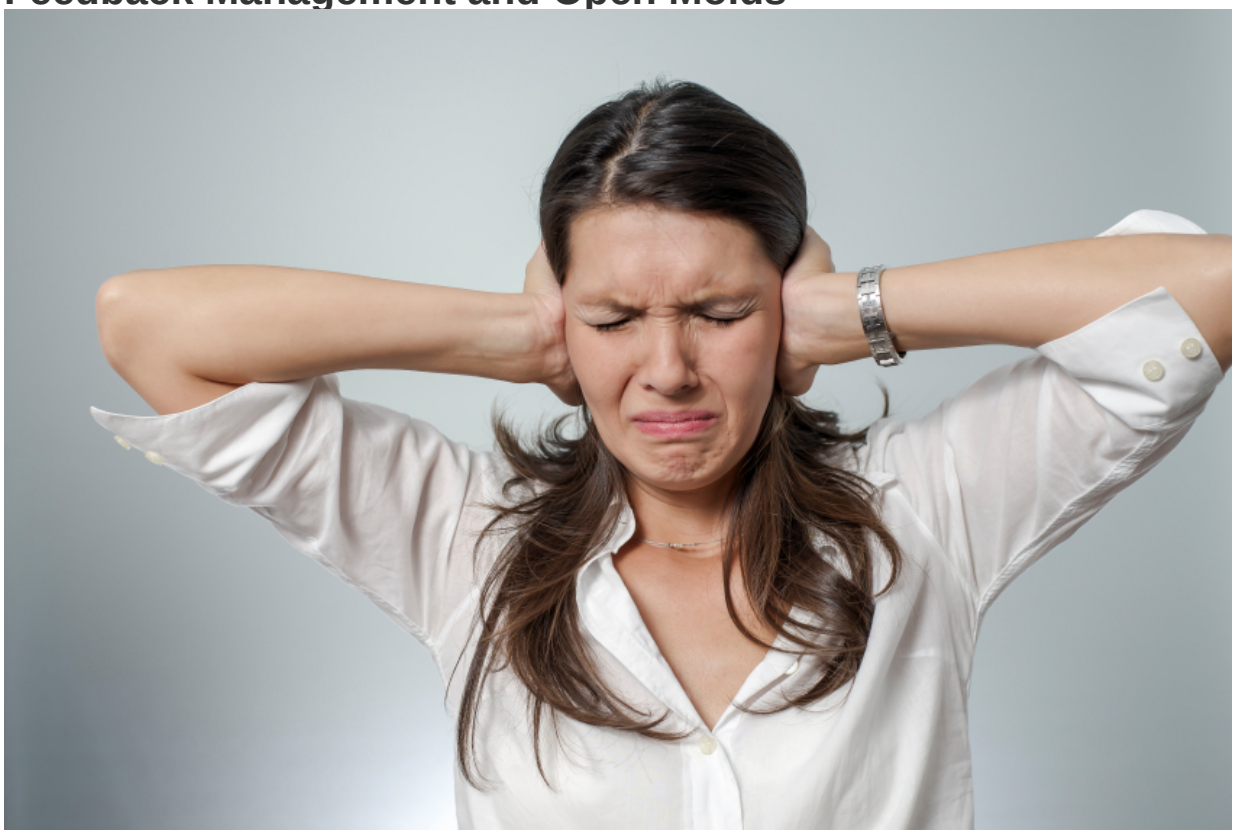
Digital hearing aid technology is now almost 25 years old. Initially the benefits were rather difficult to demonstrate and in the 1990s and perhaps even the first decade of the 2000s, in a blind "taste-test" where a person was blinded regarding whether a hearing aid fitting was the old style analog or the newer digital technology, there was not a significant difference. In the past 5 years or so, digital hearing aid technology has caught up and in most cases, surpassed the old analog hearing aid technology. Following are some of the things that modern digital hearing aids can do that could not be done (easily) with hearing aids of the past.

Feedback Management and Open Molds



Feedback, that annoying whistle heard from hearing aids, is a common side effect of trying to cram

a lot of amplified sound into an ear – on occasion, some of the sound leaks out, and is fed back to the hearing aid microphone, where it is re-amplified, and the cycle continues from there. This is more of an issue with more severe hearing losses but also with those who use open or non-occluding hearing aids fittings.

Modern digital hearing aids now use a rather neat trick – they measure the feedback sound and actually generate that same sound, but 180 degrees out of phase – like a water wave crest combining with a trough in the sea; as they pass each other, there is a moment of smoothness to the ocean surface. These two signals (the feedback and the internally generated tone) cancel themselves out so that a hearing aid user can now turn up the volume to a higher level before any new feedback will occur.

Technically this could have been done in the olden days with the analog technology but with today's technology, it can be precisely controlled to provide the greatest amount of feedback cancellation, also known as feedback management.

With this improved control over hearing aid feedback, we are now able to provide an open mold, or unoccluded, hearing aid fitting where the only thing that is placed in the ear is a soft piece of plastic that serves to anchor the hearing aid in place. This technology (which is now the most commonly seen hearing aid style) is ideal for those people who do not require much low frequency amplification. Stating this in a different way, this open mold hearing aid fitting is for those people who only have a mild to moderate high frequency hearing loss that is commonly seen with noise exposure or associated with aging (also known as presbycusis).

We Now Have Frequency Compression As Well

Since the late 1980s, hearing aids have had the capability to make soft sounds louder and loud sounds softer – they essentially adjust the volume control automatically. This is called amplitude compression and has been a real boon to the field. Amplitude compression has allowed improved communication in a number of difficult listening environments. Well, now we have "frequency compression" as well. As the name indicates, frequency compression moves sounds from the higher frequency region where a person with hearing loss may have only limited hearing, to a lower frequency region where the hearing status may be better. It's like taking the top few octaves at the most right hand side of the piano and squishing them downwards towards the centre. Sounds such as the "s" in "string" may be difficult to hear, but if placed in a hearing region that has better hearing, the "s" is quite audible.

Again, this could have been implemented with older analog technology in the 1980s, and indeed it was, but the control of this "squishing downwards towards a healthy hearing region" has dramatically improved since the advent of digital technology.

Like feedback management, frequency compression is found in many, if not most, of the modern digital hearing aids that are on the market today.

Noise Reduction

Noise reduction is a technology that can be especially useful for those people with relatively good hearing for the lower frequency vowel sounds. It is a common statement in any technology that "you don't get something for nothing." Even Barry Commoner, a famous economist wrote that "there is no such thing as a free lunch." Whether it's a free lunch or a technology tradeoff, the hearing aid industry is no stranger to this phrase.

All hearing aids require microphones, and in most cases, two microphones – the device that translates sound in the environment to electrical energy for the hearing aid. Hearing aid microphones have not changed significantly since the late 1980s. However, they are noisy –

microphones have a “noise floor” that can be heard especially by hard of hearing people with good low frequency hearing.

Modern digital hearing aids have a noise reduction circuit (essentially the opposite of amplitude compression) which serves to decrease the noise floor in hopes that the noise will not be audible to hearing aid users. For those who like technology, this is called amplitude expansion. Unfortunately it is still called amplitude expansion for those who do not like technology!

Hearing in Noisy Locations

The rest of this article pertains to technologies that can assist in helping a hard of hearing person hear better in a noisy location. Some of these technologies were around in the 1980s with the older analog technology and therefore are not unique to digital technology. Like many innovations, digital technology has just allowed for better control and processing of the sound to help these approaches work better. There are a number of accessible sources of information on these technologies but perhaps the best (and I do admit to some bias here since I am one of the editor/bloggers) is the www.HearingHealthMatters.org blog. This is a weekly blog that is the largest in the hearing aid industry. There are 8 regular bloggers that write clearly on every aspect of hearing and balance ranging from hearing aid technology, to hearing loss prevention with musicians, and from the economics of hearing loss to consumer issues.

The technologies that will be discussed are multi-channel processing, directional microphones (both of which were available in the old style analog hearing aids of the 1980s), data logging, trainable hearing aids with learning algorithms, and digital wireless technology between hearing aids and also between hearing aids other devices.

Multi-Channel Processing

Multi-channel processing (also known as multi-channel compression) was first invented for the hearing aid industry in the 1970s and became widely used by the late 1980s. This technology allows certain sounds that are not desirable (e.g., overly intense emergency vehicle sirens) and reduces them slightly to a more comfortable level, while maintaining the audibility of all of the other speech sounds in the environment. Multi-channel processing essentially chops up the piano keyboard into many sections – each of which can be amplified a lot, or not at all. This provides much better control over a hearing aid fitting, and with the advent of modern digital technology, the processing can be much better controlled.

As we will see in a subsequent section, this can be combined with “learning algorithms” which over time can “teach” your hearing aids to adjust themselves depending on the environment that one is in.

A Return to Directional Microphones

Directional hearing aid microphones are a misnomer. They do not improve one’s ability to locate the direction that a sound comes from – that is a binaural (two sided) hearing aid issue. These directional microphones are set up, and programmed, to receive the sound from the front with full sensitivity, but would seek to suppress the sound if it was coming from the rear direction. This of course is predicated on the assumption that what you want to hear is in front of you, and what you don’t want to hear, is to your rear. This is a relatively valid assumption but there are cases where that may not be desirable.

Hearing aids had directional microphones in the 1970s and 1980s but they were rarely used. Having been an active clinician at the beginning of the 1980s, I recall not recommending them, and that was the habit of most of my colleagues at that time. And like all habits, they should be re-addressed from time to time. Perhaps because of better control of the nature of sound rejection with

modern digital technology virtually all modern hearing aids have more than one microphone that allows many unwanted noises to be suppressed.

Some of the digital approaches are quite sophisticated now with directional microphones and in many cases can switch their characteristics on the run, like a dog can move his ears when trying to locate a sound.

Data Logging – To Help the Hearing Health Care Professional

This is something that a hearing aid user may never be aware of because it's really something that is only of assistance to the hearing health care professional. Many modern digital hearing aids are actually keeping track of which hearing aid setting you choose and for how long. When a hearing aid user comes in to my office, I can plug the hearing aids in to my computer and read off the history of usage. It may be that the hearing aids have not been worn in weeks, or maybe only program 1, out of possibly 4 programs is ever being used. This provides invaluable information for any adjustments and reprogramming that needs to be done. Data logging also can be linked to a "learning program" that is based on how an individual actually uses their hearing aids. In this way, hearing aids can be personalized and "trained."

Personalization with Learning Algorithms (Trainable Hearing Aids) – To Help the Hearing Aid User

Unlike data logging, this is something that can be very useful for an individual user of hearing aids. If a person with hearing loss selects a certain program for a listening environment, and the hearing aids are worn, this can teach the hearing aids to automatically set to this program when a similar listening environment occurs. The hearing aids can actually learn, within certain limits, what works best for what situation.

Many hearing aids manufacturers are working hard to define a number of environmental classifications. If a listening environment meets certain criteria, the hearing aids instantly responds and adjusts to optimize the communication.

Digital Wireless Technology

Perhaps the greatest change in the last several years that can assist hearing aid users to hear better in noisy environments is a wireless joining of the hearing aids with an external assistive (listening) device. This can be a remote microphone, an FM or infra-red system, or even a room loop system that communicates with the hearing aids by way of the telecoil. This is certainly not new and has been around for decades. What is new is the nature and extent of the wireless capabilities for the hard of hearing person.

As far back as the mid-1980s, hearing aids could be controlled, and in some cases programmed with a hand held device that communicated by infra-red or radio frequency (RF). By the mid-1990s, hearing aids were communicating with each other – the settings on the left side hearing aid were simulated on the right side hearing aid. As one side's directional microphone pattern changed, the other side's pattern also changed, all via wireless communication.

Hearing Aids With and Without Streamers

Although growing yearly, at least since 2013 the vast majority of all hearing aids that have been marketed have had the capability to “stream” audio from the television, telephone, MP3 players, and assistive listening devices, to the hearing aids. Well, not directly. The hearing aid user needed to wear a streamer – a box usually worn around the neck which received the signal and then relayed it to the hearing aids. Hearing aid users could now listen to conversation, and with a push of an icon button, they could listen to their phone, and with a push of another icon button, listen to the television.

These hearing aids (and streamers) used a technology called NFMI which stands for Near Field Magnetic Induction. The word “Near” in this technology provides some clue as to its limitations. NFMI uses magnetic technology, much like a hearing aid telecoil and induction loop, but only is effective within 3–5 feet. A strength of the NFMI system is that it uses very little current drain and its use does not appreciably decrease the hearing aid battery life.

To receive signals from sound sources at greater distances, a relay device using a far-field technology must be used and this is where RF or Radio Frequency comes in. A hearing aid wearer can now have access to a Bluetooth enabled device such as a telephone or MP3 player. In this scenario, a signal is transmitted using an open standard Bluetooth protocol from a source that can be quite a distance away; anywhere from 30 feet to several hundred feet away. The primary disadvantage of any form of RF transmission is that it is very “power hungry.” Using Bluetooth will significantly degrade one’s battery life. It should be pointed out that while Bluetooth is the most common form of long wireless RF transmission many hearing aid manufacturers have come out with their own proprietary system that has been designed with the hearing aid in mind. In these forms of transmission the battery drain is less and the transference of information is quicker.

The Bluetooth protocol that was originally used in North America used a 900 MHz transmission frequency. A rule of thumb is that the lower the transmission frequency, the larger the antenna is required to transmit and receive it. Recently, however, a new standard at the 2.4 GHz frequency range has been implemented. This higher frequency RF form of transmission can use a much smaller antenna. Subsequently, when a 2.4 GHz RF transmission is used, no streamer is required- the transmission can be received directly by the hearing aid without the need for a neck worn streamer box.

Given the smaller antenna requirement for the 2.4 GHz RF transmission, we expect to see more of the small completely in the ear canal (CIC) hearing aids having remote control capabilities in the near future.

RF using a Bluetooth protocol is still very power hungry and hearing aid battery life is still very much an issue. A relatively new Bluetooth protocol has been developed called Bluetooth4, and it is sometimes referred to as “low battery consumption Bluetooth.” This has allowed several hearing aid manufactures to make their hearing aids compatible with certain Smart phones such as the

iPhone 5. The iPhone can be used to remotely program the hearing aid and to control some properties of its function. The battery life is still a very significant issue, however, and work is being done to improve on this limitation. For those readers who would like more information on this topic, the Wikipedia entry is fairly up to date and can be accessed at http://en.wikipedia.org/wiki/Bluetooth.

Conclusion

Hearing aid technology has gradually progressed and the use of digital technology has enhanced hearing aid development significantly. We are now at the threshold where hearing aids can communicate with any number of external devices including Smart phones. We are, however, only in the infancy with what we can do with these Smart phones. These external, hand held devices are currently only capable of remotely controlling some aspects of the hearing aids. While poor battery life continues to plague wireless Bluetooth technology, some hearing aid manufacturers have designed wireless protocols that are more efficient overall. It’s only a matter of time before this is resolved and wireless technology in general will allow improved communication in noisy environments.