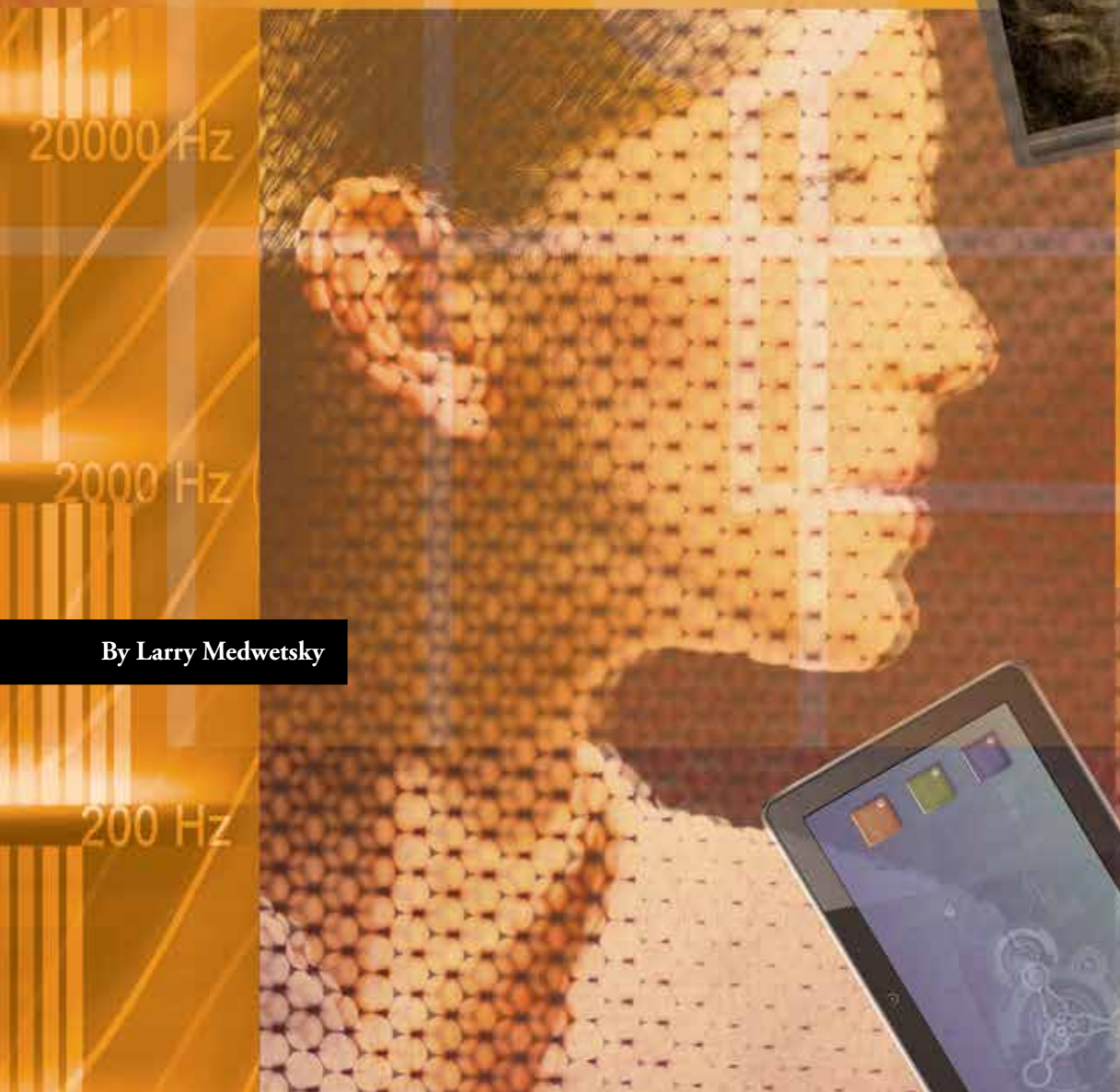
Hearing Aid Connectivity: Bridging a Closer Connection to the World of Sound

As someone who has had a hearing loss for more than 55 years, I truly feel this is a remarkable time for us. Individuals who wore analog hearing aids prior to the development of programmable and digital hearing aids will easily relate to what I will discuss in this article.



By Larry Medwetsky

This article provides a background to the various technology and transmission methods in which hearing aid wireless connectivity has been implemented, and the many ways in which individuals with hearing loss can now benefit from their new hearing aids. The extent of these benefits is to such a degree that individuals with hearing loss are actually experiencing sound in ways that even normal hearing individuals might actually envy.

Analog hearing aids (i.e., the older type of technology that consisted of components such as transistors, resistors, and capacitors, etc.) were essentially limited to making incoming sounds louder, frequencing shaping (i.e., shaping the degree to which sounds were amplified based on the degree of hearing loss), and compressing the large intensity range of sounds into the reduced range of hearing in those with hearing loss.

The advent of programmable hearing aids in the mid-to-late 1980s enabled multiple hearing aid settings (memories) for different listening environments, while at about the same time dual microphone technology was incorporated into hearing aids. This combination of features allowed for greater flexibility for the hearing aid user.

For example, when listening in quiet the user could have the hearing aid set for listening to sounds coming from all directions, while in noisy settings the listener could use a different memory setting whereby the hearing aid was programmed with a different frequency response and the microphones amplifying signals from in front (where the talker typically would be positioned), while attenuating the noise from behind the hearing aid user.

The implementation of digital processing in hearing aids in the 1990s resulted in many additional benefits. These included: miniaturization of hearing aids (yet not relinquishing power); distinguishing between speech/noise; decreasing the annoying whistling/feedback that was sometimes experienced; and, in turn, being able to fit individuals with normal hearing in the low frequencies with what we now refer to as open-fit hearing aids, thereby decreasing/eliminating the occlusion effect (i.e., the feeling where one's voice sounds as if he or she is talking in a barrel).

In recent years, hearing aid wireless connectivity has come to fruition with its numerous benefits. Hearing aid wireless connectivity includes data and possibly audio transmission between hearing aids, as well as the ability of hearing aids to communicate directly with electronic devices (such as the cell phone, TV, MP3 player, computer, etc.), allowing for direct reception from the sound source.

Familiar Wireless Connections

Wireless connectivity has been around for many years. Examples in everyday life include TV remote control devices and garage openers. Even in the hearing health-related field, wireless transmission devices have been available for many years through what is referred to as hearing assistive technology (HAT), such as a hearing loop, FM, or infrared systems.

These HAT systems typically consist of **transmitter**: into which a person either speaks (for face-to face conversations or lectures), or which is connected to the output of an electronic device such as a TV or a PA system (movies, plays); and, the receiver which picks up the transmitted wireless signal and relays it via some coupling method (such as headphones or a neckloop) to the listener.

The means by which the signal is **wirelessly transmitted** can be via radio waves (FM systems), light waves (infrared systems), or electromagnetic field (induction loops). By using these devices one is able to overcome many of the negative effects of (a) distance (such as listening at decreased intensity for sounds emanating from a sound source) or, (b) noise/reverberation that might be present.

Bluetooth® is Invented

The 1980s saw much work devoted to developing wireless technology that could be standardized across the communications industry. In 1994, telecom vendor Ericsson invented what came to be known as Bluetooth® wireless technology. Bluetooth® is a standard that is managed by the Bluetooth Special Interest Group (SIG) which was formed in 1998, and which now has more than 25,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics.

Bluetooth® (BT) uses radio waves and operates within the 2.4 GHz range (i.e., in an ultra-high frequency range and consists of extremely shortwave lengths). BT uses an agreed upon standard transmission protocol. Within this framework, one can have a master BT device that can communicate with a maximum of seven devices. Typically, the master BT device is paired with another BT device. The specific bonding that is done is extremely secure such that no other device can pick up signals from either of these two devices—thus ensuring privacy.

The typical transmission distance for BT devices is 15 to 30 feet. Please note that just because you might observe that a device is BT does not mean it can be paired to communicate with any BT device. For example, a BT garage opener can't be paired with a BT cell phone as they have different transmission/reception codes.

Better Hearing—Wireless Connectivity and Hearing Aids

The BT concept was intriguing to hearing aid manufacturers as they saw this as an opportunity to directly pair hearing aids with electronic

continued on page 20

Connectivity *cont. from page 19*

devices—such as the TV, radio, phone, etc.—while overcoming some of the disadvantages inherent in typical hearing aid use.

However, traditional BT technology requires a great deal of processing, resulting in significant battery drainage in the small hearing aid battery. Consequently, for a long time BT technology was unable to be incorporated into hearing aids.

To address this, hearing aid manufacturers were clever and began to adopt alternate strategies to link hearing aids with outside sound sources as well as to each other.

One of the first wireless connectivity adaptations was **binaural synchronization**, a feature that allows hearing aids to communicate wirelessly with each other via data codes. This feature, incorporated by all major hearing aid manufacturers, allows for the synchronization in binaural hearing aids of aspects such as volume control and program changes.

Another wireless connectivity feature is **binaural streaming**. In this case, the full audio stream is shared between the hearing aids. In order for this to be accomplished, each hearing aid has internal hardware that allows it to communicate with the other hearing aid via radio wave transmission.

Prior to this ability to communicate wirelessly to each other, hearing aids adjusted internal parameters independently of each other, and consequently could be using different digital processing schemes or different timing characteristics.

Binaural streaming allows for the hearing aid algorithms to be linked so that the two hearing aids can carry out the same signal processing paradigms at the same time. For example, in the presence of noise, both hearing aids can transition synchronously from the **omnidirectional mode** (used in quiet settings) to the **directional mode** (amplifying more from where the speech signal is coming from and attenuating background noise emanating from a different direction).

This ability to synchronize as well as stream a full audio signal between the two hearing aids allows for an even greater benefit of directionality, as it incorporates not just the two microphones per ear (i.e., both microphones in each hearing aid), but a *network* of four microphones across the two hearing aids. This creates a more advanced beam of the target signal, and greater speech understanding in the presence of noise as well as decreased listening effort.

Another application of binaural synchronization/streaming is the hearing aid user's ability to listen to a telephone conversation in both ears. In this case, the telephone signal is routed from the hearing aid adjacent to the phone to the hearing aid on the opposite side. This not only allows for the unique ability to hear telephone conversation in both ears, but the possibility (depending on how the hearing aids have been set) to turn off the microphone of the second hearing aid, thus, reducing background noise in the opposite hearing aid and making the overall phone listening experience much easier.

Other benefits of binaural synchronization/streaming include enhanced comfort and listening in windy situations as well as enhanced reception of the talker when the latter is seated in the back of the car and the hearing aid user is in the front seat and facing the opposite direction. In the latter situation, the hearing aids might be able to adjust simultaneously

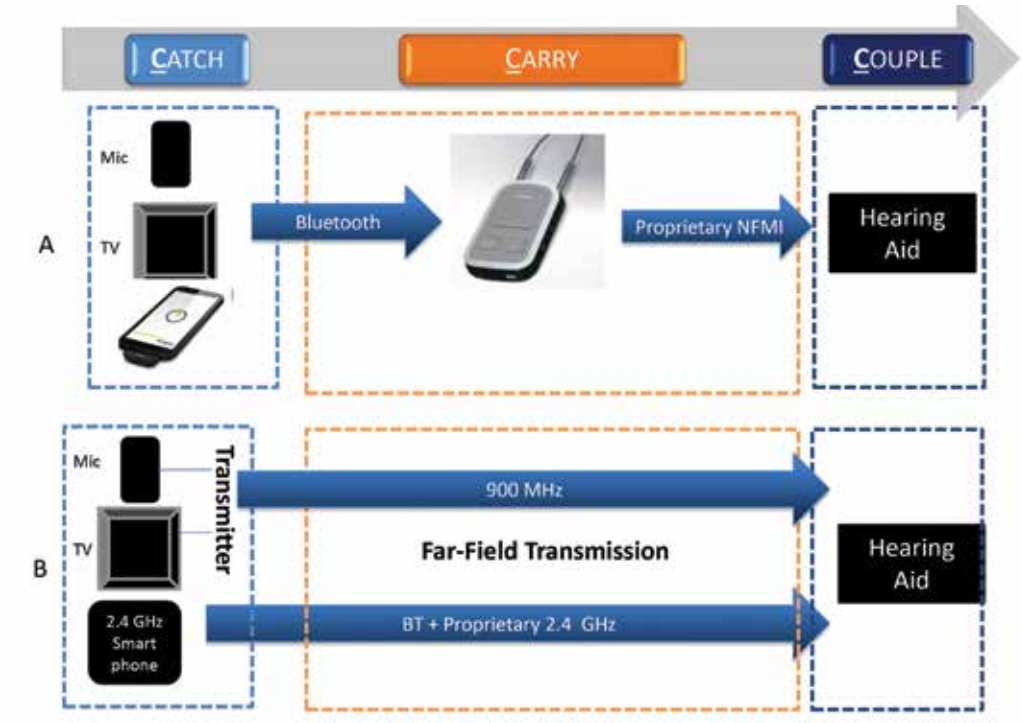


Figure 1A and B. Principle behind wireless connectivity: The sound is captured, carried and coupled to the listener.

Various hearing aid wireless connectivity transmission options: wireless hearing aids that require a streamer part of the time; and, wireless hearing aids that do not require a streamer. This slide shows how a wireless remote mic can be used with each system as well as how wireless hearing aids (and cochlear implants) can also be used to pick up sound from computers, tablets and MP3 players or any audio system. (Figure adapted and printed with the permission of Cynthia Compton-Conley, Ph.D.)

Benefits of Hearing Aid Wireless Connectivity

In addition to the binaural synchronization/streaming discussed in the article, there are numerous advantages of hearing aid wireless connectivity:

- Remote control of one's hearing aids, either via BT (e.g., via a cell phone) or an intermediary device (streamer). This is especially useful if: the hearing aids are too small to accommodate external controls; or, an individual has dexterity issues or difficulty lifting their arms to touch the button on the hearing aid
- Can be paired to various hearing-related applications that one can download to a cell phone or iPad/tablet
- Ability to connect wirelessly to the cell phone for ease of phone calls—including the ability to make hands-free phone calls
- Wireless connectivity to cell phones, iPad/tablets, MP3 players, computers can optimize the listening experience to music and videos
- The use of remote BT microphones that can be paired with an intermediary device or directly with a BT-enabled hearing aid, can enable similar functionality to an FM system such as: a) clipping a mic to the clothing of the talker—be it a lecturer or passenger in a car; b) placing the mic on a table in a noisy restaurant; or c) a coach communicating with an athlete who has a hearing loss during the course of a game. However, the effective listening distance is much less than with traditional FM systems (30 feet versus 200 or more feet).

to enhance reception for the speaker from the rear, while minimizing car noise arising from in front.

Hearing Aids and External Technology

In addition to wireless connectivity between hearing aids, hearing aids can now connect wirelessly to external technology—such as cell phones, television, etc. As mentioned earlier, for a long time BT transmission could not be incorporated into hearing aids because of its significant processing requirements. To overcome this limitation, hearing aid manufacturers developed alternative transmission schemes.

One such technique involved the incorporation of an intermediary BT device—usually worn around the neck. The larger size of these intermediary devices and, in turn, larger batteries—as compared to hearing aids—allowed for the incorporation of BT processing.

In this adaptation, the intermediary BT device is paired with an electronic device (cell phone, MP3 player, TV), be it one that has BT built into the device or one in which a BT transmitter is connected to the device.

An advantage to this strategy is that much of the power consumption required for wireless streaming can be absorbed by the battery in the intermediary device. Once the electronic device and intermediary have been paired, the signal can be transmitted via BT from the sound source to the intermediary, and from there to the hearing aid via another form of signal transmission. The latter transformation is required because traditional BT does not allow for transmission around and across the head.

More Connections

Consequently, two other forms of radio frequency (RF) transmission were implemented for the purpose of communicating to and between hearing aids. One form is known as Near-Field Magnetic Induction (NFMI).

NFMI is designed to contain transmission energy within a localized magnetic field. The magnetic field energy resonates around the communication system, consequently, the transmission distance of NFMI is extremely limited—no more than one meter. This form of transmission can successfully be used for binaural processing in hearing aids, or, for transmission from the BT intermediary device to the hearing aids. Since the transmission distance is so limited, it requires that the intermediary device to be close by—such as wearing it on the neck or perhaps as a remote device on the arm. Figure 1A illustrates the stages of wireless audio streaming for near-field (NFMI) wireless streaming.

A second form of transmission involves a 900 MHz audio stream that can transmit up to 15 feet (and is often referred to as **far-field wireless transmission**), yet, its properties still allow for hearing aid-to-hearing aid transmission around and across the head. The audio stream is converted to a 900 MHz signal/emitted from a proprietary transmitter connected to the electronic media device, and, in turn, transmitted to the hearing aids which it has previously been paired.

Figure 1B illustrates transmission of far-field wireless signals, one of which consists of 900 MHz signals, from the sound source to the hearing aids.

Continued Evolution of Bluetooth Transmission

Recently, the communication industry developed a new Bluetooth standard (version 4.0) which has a low-energy option, one which has significantly less processing requirement—such

continued on page 22

Connectivity *cont. from page 21*

that it no longer poses a significant hearing aid battery drain. Two hearing aid manufacturers (Starkey, ReSound) have incorporated chips with BT 4.0—along with their own proprietary 2.4 GHz transmission codes—into some of their hearing aid lines. This has enabled these hearing aids to communicate directly with cell phones, as well as with other BT enabled devices such as an iPad or iPod, without the need for an intermediary device. It is expected that other hearing aid manufacturers will also implement this mode of transmission within their hearing aid lines.

Figure 1B also illustrates direct BT transmission from various electronic devices to a hearing aid. However, as mentioned earlier, unlike the other far-field transmission hearing aid systems that rely on 900 MHz transmission, hearing aids that incorporate BT 4.0 do not require the purchase of proprietary transmitters to be connected to electronic devices.

Initially, BT cell phone pairing was available with only iPhones, but recently Starkey added android phone capability. It should be noted that although hearing aids with BT 4.0 can be paired with both iPhones and android phones, at the present time there is a significant difference. Hearing aids paired with the iPhone via BT can receive both audio (such as music) and data streams, while pairing with android phones allows only for data stream transmission. Therefore, android cell phones presently can only serve as remote control/hearing aid programming units (since these aspects rely only on data streams), but they can't be used to directly stream audio to the hearing aids. Hence, an intermediary device is required if audio streams are to be transmitted from the android phone to the hearing aid.

Advantages of this mode of wireless connectivity are that:

- they do not require the purchase of proprietary transmitters (cutting down expenses),
- they do not require any worn intermediary device,
- they are not subject to electromagnetic field interference from extraneous electric components such as might occur when using the t-coil of a hearing aid, and,
- when paired with iPhones, they can receive a high quality audio signal directly from the source (be it a cell phone, iPod, or iPad).

What About Hearing Aids Without Wireless Connectivity?

There are many people who do not have hearing aids with wireless connectivity. ClearSounds has developed the Quattro 4.0 solution to meet the various hearing needs of these individuals. The Quattro is a BT-enabled device that can be paired with multiple BT devices, and, in turn, transmit the audio stream via a neckloop to one's hearing aids, or even a headset for those who do not have hearing aids (such as individuals who have normal hearing but have a central auditory processing disorder). Similar to the hearing aids discussed above, the Quattro can be paired with a cell phone or to various electronic devices (such as a TV or computer) via ClearSounds' BT transmitters connected to the output of these devices and paired with the Quattro.

Last, I want to mention that even with the advent of such remarkable technology as wireless connectivity, t-coils still play an important role in assisting individuals with hearing loss in difficult listening settings such as places of worship, (movie) theaters, libraries, etc., through their ability to interface with hearing loops, or with neckloops used with FM or Infrared systems. There are also intermediary devices that have built-in t-coils, thus, allowing an individual to wear very small sized hearing aids, yet, still having t-coil connectivity.

Cheers to Better Hearing

It is truly a remarkable time for those with hearing loss. Never would have I imagined that I would actually be able to hear better in certain settings than my normal hearing family, friends and colleagues. To be able to hear the phone in both ears, listen to the television at settings too soft for even normal hearing individuals, hear someone speak softly at 30 feet away, and understand what someone is saying in a noisy restaurant while normal hearing individuals might be struggling, is truly remarkable. We owe much to the researchers and hearing aid manufacturers who have worked so diligently to help us overcome barriers that previously left us so frustrated that we often just wanted to withdraw from the situation.

Let's raise a toast (I always like a good Piña Colada) for what has transpired and do so in a noisy setting without the frustration of not being able to hear what others have to say in response. ***HLM***

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Mention of products does not imply endorsements by the author or HLAA, nor does exclusion suggest disapproval.