Bluetooth—A Mouthful of Opportunities

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Wireless technology changes everything. As we make wires obsolete, we figure out how to connect many more things. This article is about Bluetooth—one of the main ways we wirelessly connect devices to each other.

The purpose is to help you understand the various types of devices you can connect using Bluetooth, some of the challenges that come with it, and focus on how Bluetooth is relevant to hearing better.

There are a number of wireless technologies, each designed to do different things. Some are *consumer technologies*—typically associated with products you get from Amazon and Best Buy. These products adhere to standards so you can feel confident buying headphones of one brand to work with a smartphone from another brand. Some are clinical technologies—more typically associated with medical devices purchased on the advice of a professional, such as an audiologist.

For years these technologies seemed to exist in different worlds. But that's been changing recently. Recommendation #8 of the 2016 National Academies

of Science, Engineering, and Medicine report[1], *Hearing Health Care for Adults: Priorities for Improving Access and Affordability,* co-sponsored by HLAA, calls for better interoperability of hearing systems with standard communication platforms. And a push is already underway. Bluetooth is the subject of this article because it has already started to span both worlds. Before talking about Bluetooth, here's a summary of other wireless technologies you might recognize.

- **Cellular wireless** connects cellphones to their service providers. Big cellphone antennas powered by huge amounts of electricity send and receive data to and from your phone. Each tower covers a large area and connects to many phones at once.
- **Wi-Fi** connects devices to personal or commercial internet service. To connect to your home or work internet, you can use a wire or you can use Wi-Fi. Wi-Fi routers plug into a phone or cable line, which allows data from the internet to the router. and can cover a few rooms at a time. The router then connects the internet to your laptop, TV, smartphone or many other of your "internet of things."

requires separate hardware—like a "streamer" worn around the neck or plugged into a TV transmitter.

Bluetooth is used to connect battery-powered devices to each other. The first Bluetooth devices allowed "hands-free" cellphone calls from your car's radio or from little one-ear headsets. Now your headphones, fitness trackers and even coffee mugs can connect to your smartphone using Bluetooth.

Many Kinds of Bluetooth

Bluetooth can be particularly confusing because there are many types, the devices need to be paired to each other for privacy, and it uses low-power communication.

There are three main kinds of Bluetooth, designed to do different things:

1) **Hands-Free Profile:** This is the first kind of Bluetooth that you might have ever experienced. It was used before smartphones even existed to connect regular cellphones to car audio and wireless headsets, and is still used for that purpose today. It doesn't need to sound very good because phone calls generally aren't high-fidelity. But it needs to be fast enough such that there isn't a big delay between what is said and what is heard. Delays cause awkward interruptions. Products that use HFP can be small and their batteries can last a few hours.
2) **Stereo Audio Bluetooth—A2DP (Advanced Audio Distribution Profile):** This is used for high-fidelity sounds, such as music or audio from your favorite Netflix show. The signal has a long delay between what's sent and what's heard but typically isn't a problem because the sounds aren't live, and in the case of watching video, the timing can be aligned. Products that use A2DP and are larger (like over-the-ear headphones) can have a long battery life. Small products (like in-ear headphones) are challenged even to last a couple of hours.
3) **Bluetooth Low Energy (BLE):** Traditionally, this has been used to send small amounts of data, such as how many steps you've taken in a day, or to make volume adjustments to your headphones or hearing

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- **Telecoils (or t-coils)** connect hearing aids to a hearing loop installed in a room or venue.to. Unlike other technologies we discuss in this article, t-coils transmit information in a way that isn't private or coded. Sound is transmitted from the source using an analog signal to whatever telecoil-enabled device is inside the hearing loop. The loop can be as big as a room, or as small as a telephone earpiece. HLAA has published a great deal about this technology.
- **FM Systems** connect a single talker to many listeners. Several companies make special systems to help transmit a single signal (such the voice of a teacher) to a group of receivers (such as students in a classroom wearing hearing aids or cochlear implants). While the signal used to be like an FM radio, it is now digital.
- **Hearing aids and cochlear implants** which are wireless allow them to connect various accessories available from their respective manufacturers to things such as cellphones and televisions. This usually

aids. There isn't yet a standard way to send audio over BLE so several big companies came up with special ways to do this until a standard can be developed:

- Apple "Made For iPhone" (MFi)[2]—Hearing aid and cochlear implant manufacturers who license MFi from Apple are able to send audio using BLE. The audio isn't as good as A2DP, and the delay isn't terrible. While the hearing aids do connect to iPhones without having to use a streamer, they are not hands-free, as users must still answer and hang up calls on the phone as well as hold their phones near their mouth so people on the other end of the call can hear them.

  The MFi hearing aid program has been around for a number of years, and almost all hearing device brands have an MFi-compatible model (see table). About 40 percent of U.S. smartphone users have Apple products[3] so for people who use an iPhone and love to stream calls, music and video and don't care so much about being hands-free for calls, these are a great option.

- One hearing aid manufacturer recently developed a product that supports Bluetooth protocol and uses the Hands-Free Profile, which will allow users to pair almost all Bluetooth-enabled phones (even old-school flip phones) directly to their hearing aids. It also provides a hands-free experience as users can answer and end calls with the push of a button on the device and the microphone is used to pick up their voices so people on the other end of the call can hear them.

  There are a few drawbacks to this technology, however. It will stream the call only to one hearing aid (although the microphone of the other aid is reduced to limit background noise when on a call) and the hearing aids cannot be used for streaming music, podcasts, or audio for video unless paired to another device. One cochlear implant manufacturer has announced this technology will become available for users of one of their current and future processors.

  This technology would be great for people who are on their phone throughout the day and want a truly hands-free option, and/or use an Android or older non-smartphone and don't care so much about on-the-go audio streaming.

- In August 2018, Google announced the Audio Streaming for Hearing Aids (ASHA)[4] protocol for Android devices. The audio will likely be similarly low-fidelity but will allow direct-to-hearing aid connections. At the time of the announcement, only one hearing aid manufacturer announced compatibility (see table).

Table represents what you can do using just a phone and smartphone. If you use a separate streaming device, there are even more possibilities.

Manufacturer/Types of Devices	Phone Calls	Music and Audio for Video	Processor Control
Consumer brands (such as Beats, Bose, Sony)	Yes, using HFP	Yes, using A2DP	Yes, using BLE
Phonak hearing aids	Yes, using HFP	No	Yes, using BLE
Cochlear Limited (bone-anchored devices and cochlear implants), Oticon, ReSound, Signia, Starkey, Widex	Yes, Apple only	Yes, Apple only	Yes
MED-EL cochlear implants	No	No	No

Paired to Each Other

To ensure you don't hear someone else's phone calls, Bluetooth devices are "paired" to each other. This process ensures privacy. While one device can be paired to multiple others, information can only be sent to one at a time. While this seems simple enough, it's not as easy as it sounds. Each smartphone and listening device manufacturer has special ways to get into "pairing mode" that are rarely intuitive; and even when you're doing it right it often has to be re-done.

When it doesn't work, it's hard to know if the smartphone is the problem or if it's the listening device. When you call customer support, you'll be asked, "Do you have the latest firmware?" or "Have you tried rebooting it?" Our best advice is to ask most any high school student. But if that fails most manufacturer's websites have instructions or there are typically many YouTube videos available to help.

Low-power Communication

When power is tight because devices are trying to be both small and have long battery life, the distance (range) over which the connection works will be short. Bluetooth communication is slowed down and confused by the human body. Sometimes simply putting your smartphone in your back pocket is too challenging for small hearing aids nestled up next to the head.

Despite its flaws, Bluetooth connectivity is a technology marvel. When you've got it working, the user experience can be a joy. HL

References

1. National Academies of Sciences, Engineering, and Medicine. 2016. *Hearing Health Care for Adults: Priorities for Improving Access and Affordability.* Washington, DC: The National Academies Press.
2. support.apple.com/en-us/HT201466
3. counterpointresearch.com/us-market-smartphone-share
4. source.android.com/devices/bluetooth/asha

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