
21

ADVANCED PRACTICES: ASSISTIVE TECHNOLOGY IN THE AGE OF SMARTPHONES AND TABLETS

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Introduction

With advances in wireless hearing technology, the term *Hearing Assistive Technology Systems* (HATS) must be considered in a broader context. In the past, HATS referred to analog devices used by persons with hearing loss to facilitate reception and identification of speech and nonspeech signals. Although HATS technically encompass all technology used by individuals with hearing impairment, the personal hearing aid has generally been considered the primary technology, while HATS have been considered only when communication difficulties still telecoil remain. Perhaps it is time to designate these analog devices as A-HATS. With the increased digital connectivity options for personal hearing aids, many benefits of A-HATS are already available in the personal device when connected wirelessly. The time has come to consider Digital Hearing Assistive Technology Systems, D-HATS, as a continuum of benefits from features within the personal hearing aid to wireless connections to devices or the internet. Of course, there will always be some need for the traditional analog devices such as the flashing lamp to signal a door knock because of the inevitable range of experience with digital technology. However, as baby boomers continue to age with increased vitality and life expect-

tancy, the diversity in technology experience among those seeking solutions for hearing challenges may diminish. The active senior citizen is likely to have a cell phone that connects to his/her car for hands-free phone conversations. In addition, they have probably experienced some type of real-time video exchange to stay in touch with grandchildren whose parents are adept at wireless technology, smart homes, and useful applications (apps) for almost everything from "Amplifiers" to "Zumba Fitness."

The audiology profession continues to grow with millennials who have never fit an analog hearing aid. Because they have considerable experience with wireless technology that monitors activity, safety, diet, and sleep; streams music, audio, and video signals; and facilitates instant communication, the likelihood that they will incorporate HATS, specifically D-HATS, is rising. The gradual merger of the digital experiences of the audiological service provider and the audiology consumer will undoubtedly stimulate the need for new auditory rehabilitation assessment tools, increased communication partner interaction, and appropriate individualized informational counseling for the consumer to reach maximum benefit of the available options.

The beneficial features of D-HATS can be incorporated in the initial stages of the rehabilitation process. With the use of a comprehensive assessment

scale, the possible situations where hearing assistance is needed may be determined. The results of the latest MarkeTrak IX survey showed an increased satisfaction with hearing aids (from 74% to 81%) and a decreased number of in-the-drawer hearing aids (from 12% down to 3%) relative to MarkeTrak VII (Abrams & Kihm, 2015). It is possible that this is related in part to the hearing aid being used for more than just amplification as connectivity options have expanded over the past 10 years.

It is interesting to note some historical influences on the terminology. Vaughn, Lightfoot, & Arnold (1981) argued that the advent of smaller hearing aids resulted in certain communication limitations and that it was imperative that greater attention be focused on communication centered environments and effective listener and talker devices. As the industry moved toward smaller hearing aids, the distinction between hearing aids and other devices such as hearing-assistive technology developed. There evolved a focus on fitting hearing aids by the audiologist and assistive technology received less attention in clinical practice. The technology became so separate, in fact, that in 1982, the notion of an Assistive Device Demonstration Center was recommended (Fellendorf, 1982). Nearly 15 years later, Sandridge and Lesner (1995) encouraged audiologists to no longer ask whether to provide assistive listening devices (ALDs), but rather to ask how to incorporate ALDs within one's service delivery. Wayner (2004) was probably the first to recommend that assistive technology be considered part of the fitting process. It was an underlying belief that most persons with hearing loss could receive some benefit from amplification and that hearing aids were only one of a number of devices for successful rehabilitation and improved communication. Now, the connectivity options with hearing aids are viewed as a major "door opener" for the person with hearing loss (Leavitt et al., 2016). Hearing aids are capable of receiving signals from remote tablets, cell phones, and microphones. Therefore, the notion that assistive devices are a separate category that require a special focus in an audiology practice may disappear. To explore these benefits with patients, an audiology practice does not need a separate room with examples of HATS to demonstrate benefits available for phone conversations, television, or alerting signals like those recommended in the past (Wayner, 2004). In fact, the most basic wireless connectivity in hearing aids that existed even in analog hearing aids, i.e., the telecoil also known as t-coil, is now joined by an array of wireless protocols including near-field mag-

netic induction, 2.4 GHz Industrial Scientific Medical (ISM) band, and 900 MHz ISM band. Regardless of the sophistication of the technology or programming options, the basic process for obtaining and successfully using D-HATS remains the same. Initially, there must be an assessment of the communication difficulties that will lead to recommendations. There must be verification of the technology to document appropriate settings and, finally, validation must occur to ensure that the user receives the intended benefits. To summarize the benefits of meeting an individual's HATS needs when devices are moving from analog to more digital options, lighthearted illustrations are provided in Appendices 21-A and 21-B. Of course, the overall challenge is to integrate these steps into the routine clinical practice, much like checking one's blood pressure during a physical exam, so that D-HATS are considered a continuum of options from a single personal device to a network of devices and apps to address communication of both verbal and nonverbal signals. Before a review of the assessment, verification, and validation of D-HATS, a discussion of the major wireless transmission protocols will provide a foundation upon which to compare the various wireless technology options. These range from longstanding methods such as magnetic induction (telecoils) to more recent very high-frequency protocols (Bluetooth Low Energy, LE).

Wireless Transmission Protocols

A variety of wireless transmission protocols have been used to benefit those with hearing loss. These include magnetic induction, low-frequency radio signals such as near-field magnetic induction (NFMI); midfrequency radio signals such as FM 72-76 MHz, 216-217 MHz, and 900 MHz; and high-frequency transmission 2.4 GHz Bluetooth, Bluetooth LE, and proprietary protocols. All wireless transmissions have a transmitter and a receiver. How the audio signal from the transmitter gets to the receiver defines the type of wireless system.

Electromagnetic Transmission

The oldest wireless system used by those with hearing challenges involves electromagnetic transmission, which has been in use since the late 1930s. The first wearable hearing aid that contained an induction

receiver, i.e., a telecoil, was reported to be the Multitone VPM in 1938 (Bauman, 2015). In an induction loop system, an audio signal from a source such as a microphone creates an electromagnetic signal that induces current to flow through an induction receiver such as the telecoil in a hearing aid. The transmission is direct rather than depending on a carrier signal. Therefore, there is no tuning required but simply positioning the induction receiver, i.e., hearing aid with a telecoil, within the induction loop. The distance from the telecoil to the loop needed for adequate transmission depends on the strength of the electromagnetic signal. Some are low-level such as a loop worn around one's neck that transmits a signal to the telecoil in the hearing aid from a receiver attached to the neck loop. A room loop, however, is a much stronger electromagnetic field that may be installed in the ceiling or floor; thus, one may be sitting several feet from the actual loop. The signal is universal in that any manufacturer's hearing aid with a telecoil can receive the induction signal from a loop.

The input to an induction loop is typically from a microphone and amplifier or another audio source, and the current fluctuations that travel through the loop of wire create a magnetic field that mirrors the frequency and intensity of the original signal. The telecoil in the hearing aid is sensitive to the changes in the magnetic field, which causes a current to flow through the amplifier of the aid. The listener with hearing loss can switch his/her hearing aid to telecoil to receive the audio signal from the source and improve speech perception in background noise, over distance, and in reverberant environments.

Despite the simplicity and generally low cost, there can be several negative effects of telecoils such as spillover of the signal from adjacent room loops and the pickup of stray electromagnetic energy from power lines, computer monitors, and even some smart watches. Furthermore, signals transmitted via telecoils tend to be noisy, have reduced low-frequency energy relative to the original signal, and vary in intensity with head movements (Thibodeau, McCaffrey, & Abramson, 1988). Because of the universality of telecoils, there is a significant movement to have loop systems installed in many public areas throughout the U. S., hence efforts have been called "Loop America" or "Time to Loop America". These efforts include web-based resources that allow the visitor to learn about loops and find public venues, such as churches or theaters, that are looped for the hearing impaired. The symbol used to alert the public of loop systems is shown in Figure 21-1.



Hearing Loop

Switch hearing aid to T-coil

Figure 21-1. Signage used in public places to alert visitors that a loop system may be accessed by using the telecoil in their hearing aids. *Source:* <http://www.hearingloop.org/logo.htm>

FM Transmission

Perhaps the next significant advancement in wireless transmission was the use of frequency-modulated (FM) transmission. In FM systems, the signal from the audio source is transmitted via a carrier frequency, such as 72-76 MHz or 216-217 MHz. This carrier frequency can be selected by the user on either a wide-band or narrow-band range of frequencies. For example, a wide-band carrier frequency may be 72.1000 MHz to 72.1250 MHz and designated by the manufacturer as Channel "A" and a narrow-band carrier frequency may operate on 216.0125 MHz to 216.0375 MHz and be designated as Channel "1." The signal of interest picked up by a microphone is used to modulate the frequencies of the carrier wave in a pattern to correspond to the original signal. The receiver must be tuned to the same channel so that the transmitted FM signal can be demodulated to recover the original signal.

The first FM receivers operated on wide-band carrier frequencies and were body worn. In 1996, FM receivers were introduced into behind-the-ear hearing aids, which were limited to receiving only one or two channels and had somewhat cumbersome antennae.

With advances in technology, the transmitter microphones became more sophisticated with noise reduction and directional pickup techniques, which resulted in significant improvements in speech recognition in noise (Thibodeau, 2010). Furthermore, the receivers became small enough to be attached to most behind-the-ear hearing aids with a connector called an audio shoe. The audio shoe is specific to the manufacturer of the hearing aid, but all have the universal 3-pin Euro plug to accept the miniaturized FM receiver. One manufacturer has designed receivers that integrate with their specific behind-the-ear models so that it always remains on the hearing aid.

When applied as a solution for communication challenges for those with hearing loss, the signal is higher quality, less noisy, and has less interference than the electromagnetic transmission systems. Although FM systems have been successfully used in school classrooms to improve reception of the teacher's voice, some major drawbacks are the limited number of channels available for transmission, depending on how close the transmitters are located; and the fact that the receivers draw power from the hearing aid, thus shortening the battery life. Reddy and Thibodeau (2018) reported battery life was reduced about 50% when used in a wireless arrangement for 12 hours per day. FM systems frequently used in public venues are typically body-worn receivers offered to visitors with headphones, earbuds, or a neck loop, which would require the visitor to have a personal device with a telecoil.

Near-Field Magnetic Induction

The transmission protocols discussed thus far involve analog signals. The remaining transmission protocols to be discussed all involve a digital signal being encoded and transmitted wirelessly to a receiver that decodes the signal. The first application of wireless digital signal used in hearing aids was introduced in 2009 and is known as Near-Field Magnetic Induction (NFMI). It operates on carrier frequencies even lower than those used for FM and typically falls between 3 and 15 MHz (Galster, 2010). This frequency band easily travels through and around the human head and body, making it ideal for communication between bilateral hearing aids for synchronizing program or volume changes and spatial processing of acoustic signals to enhance the signal-to-noise ratio. This type of transmission involves a proprietary code developed by each manufacturer.

Because the transmission range is generally about 1 meter, NFMI may also be used to send signals from an intermediary device that can be small enough to fit in one's pocket or can be connected to a loop worn around the neck, as shown in Figure 21–2. These intermediary devices are called streamers, so as not to be confused with induction loops. Although both can be worn around the neck and communicate with the personal hearing aid, the induction neck loop requires a universal telecoil in the aid so it can be used with an aid by any manufacturer. However, the streamer requires a hearing aid with NFMI capability by the same manufacturer. Superior to the induction loop, the streamer allows for greater consistency of the signal across the frequency range and with head movement.

The streamer is ideal for housing other wireless receivers that require greater power and space than can occur within an ear-level hearing aid, such as a 2.4 GHz Bluetooth connection to a cell phone. They can even be interfaced with FM or digital-modulated (DM) receivers for streaming signals from FM/DM wireless microphones to one's hearing aids. Because the NFMI streamer can act as a receiver and a transmitter, it is important to use clear terminology with clients about wireless transmission. Most streamers are capable of connecting with cell phones through Bluetooth 2.4 GHz universal protocol, but they transmit the audio information via a NFMI proprietary protocol to the hearing aid.

900 MHz Transmission

To avoid some issues with NFMI such as the limited transmission range, wireless transmission protocols on the 900 MHz frequency band were developed for long-distance audio streaming that could operate on typical hearing aid power levels. Starkey developed this protocol in 2012, called SurfLink, to allow hearing aids to connect directly to a television or other media source up to 20 feet away without any intermediary device on the user. The hearing aid can be programmed to detect the 900 MHz signal so that no pairing is necessary. Users can enter a living room and automatically hear the television if it is connected to a SurfLink 900 MHz transmitter. The 900 MHz transmission protocol has also been used to transmit signals from remote microphones that can be worn by a communication partner in noisy environments. In addition, the SurfLink family of accessories includes a device that can establish a Bluetooth connection with a cell phone and then transmit the call to the hearing



Figure 21-2. Streamers that communicate with hearing aids via nearfield magnetic induction. *Sources:* A. Photo courtesy of Oticon A/S. B. Image © Sonova AG. Reproduced here with permission. All rights reserved.

aid via the 900 MHz protocol. It is important to recognize that the line of hearing aids compatible with SurfLink are different than the “made for iPhone” aids described in the next section although they both allow for wireless phone communication. Recall that the hearing aids compatible with SurfLink require communication with the 900 MHz transmitting device, which provides the wireless connection to cell phones through the Bluetooth protocol described next.

2.4 GHz Transmission

The 2.4 GHz frequency band is designated by the Federal Communications Commission for public use. Since the launch of the 2.4 GHz frequency band in 2001, many technologies utilize this technology, such as Bluetooth, Wi-Fi, phones, and video game controllers. Each of these technologies uses a communication protocol for sending and receiving data that may be standardized or proprietary.

The 2.4 GHz transmission method was first used in 2005, when Starkey introduced the first wireless connection to cell phones with Bluetooth capability (*Audiology Online*, 2005). The Ear Level Instrument (ELI) was an attachment to the base of a behind-the-ear hearing aid that essentially doubled the hearing aid’s size and weight while significantly reducing the battery life. For these reasons there was limited interest in the ear-level 2.4 GHz option until a new protocol was developed, referred to as Bluetooth LE.

The first aids that were capable of communicating with cell phones through Bluetooth LE were announced by G. N. Resound in 2013, referring to them as “made for iPhone” or MFi aids. At this time, there are seven manufacturers that have hearing devices that communicate directly with cell phones without an intermediary device as shown in Table 21-1. This means that persons can send and receive phone calls and stream audio signals from Bluetooth-enabled devices that are paired with their hearing aids.

Table 21–1. Manufacturers of Hearing Aids and Cochlear Implants That Provide Direct Connectivity With Smart Phones

Manufacturer	Hearing Instrument Style				Cochlear Implant
	BTE	ITE	ITC	RIC	
Phonak MFA				Audeo Marvel T/R Audeo B direct	
Oticon MFi	Oticon Opn BTE PP T Oticon Siya BTE PP T	Oticon Opn T Oticon Siya T		Oticon Opn T/R Oticon Siya Series T	
Widex MFi				Beyond Fusion T/R	
ReSound MFi	LinX 3D Enzo 3D	LinX 3D	LinX 3D	LinX Quattro R LinX 3D R	
Starkey MFi	Livio Series Livio AI Halo i Series			Livio Series Livio AI Halo iQ Series Halo 2 Series	
Signia MFi	Motion 13 Nx Motion P 13 Nx Motion Charge & Go R	Insio Nx	Insio Nx	Pure 13 Nx T Pure 312 Nx Styletto R	
Cochlear MFi					N7

Note. MFA = Made for All phones; MFi = Make for iPhones; BTE = behind-the-ear; ITE = in-the-ear; ITC = in-the-canal; RIC = receiver-in-the-canal; T = telecoil; R = rechargeable

As the name implies, the MFi aids only work with Apple products. Given that 88% of cell phones sold as of 2018 were Android phones (Statista, 2019), there was certainly a need for direct wireless connectivity to these products. In 2017, Phonak announced a new protocol based on a proprietary chip that allowed pairing with Apple or Android phones (Hearing Review, 2019). The SWORD chip allowed running protocols in parallel so that the chip allowed connectivity to the hearing aids and compatibility with both Bluetooth LE and Bluetooth Classic protocols. The hearing aids with the SWORD chip were referred to as “made for all” or MFA aids. However, unlike the MFi aids, the connection was only between the phone and a single designated hearing aid. In 2019, bilateral phone connection to both iPhone- and Android-based phones was possible in the MFA aids by sending the signal from the connected hearing aid to the second hearing aid via NFMI (Figure 21–3).

Although a great solution for wireless connectivity to cell phones that are typically close by but

not in the same room as the listener, the Bluetooth protocol is not ideal for transmitting in face-to-face conversation because the transmission delay can be more than 100 ms. Therefore, other digital protocols utilizing the 2.4 GHz band for wireless transmission of signals to aid those with hearing challenges were developed. In 2013, Phonak introduced a proprietary adaptive digital wireless transmission technology called Roger, where audio signals are digitized and coded in small bursts that are transmitted repeatedly in the 2.4 GHz band. This is known as *frequency hopping*, which avoids interference issues and has audio delays less than 25 ms. Unlike Bluetooth receivers, Roger systems have an unlimited number of connections and wider transmission bandwidths up to 7300 Hz. The Roger transmission protocol allows hearing aids to be connected to coordinated receivers; thus, the user benefits from improved wireless reception from remote microphones and other audio sources hardwired to Roger transmitters such as tablets, televisions, and MP3 players. Roger systems may also



Figure 21–3. Current Made-for-iPhone hearing aids that communicate directly with phones through Bluetooth Low Energy transmission protocols. *Source:* Photo courtesy of Starkey Hearing Technologies.

be referred to as DM systems in contrast to the older FM systems.

Summary of Transmission Protocols

Hearing aids have been able to communicate wirelessly with other audio signals generated outside the device since the 1930's when telecoils were introduced. However, within the past 20 years, there has been exponential growth in the development of wireless connectivity options for persons with hearing loss. It is critical for the hearing care professional to have knowledge of the array of options and describe them accurately to their patients. The most appropriate type of transmission system for an individual depends on many factors. Therefore, a comprehensive assessment is needed to determine if the user will need to connect wirelessly to devices to solve multiple communication challenges or if they only have a single issue, such as hearing a smoke alarm when unaided. By exploring the patient's current use of both hearing aids and wireless systems, their acceptance of advanced connectivity options with amplification may be estimated as the various solutions are explored.

Needs Assessment

There is a variety of assessments that evaluate the communication difficulties facing a person with hearing loss. One common, efficient tool is the Client Oriented Scale of Improvement (COSI) (Dillon, James, & Ginis, 1997). This assessment is particularly useful

because the individual provides the five most difficult communication situations, which are rated before and after amplification. Although this and other scales, such as the Abbreviated Profile of Hearing Aid Benefit (APHAB) (Cox & Alexander, 1995), are very helpful in documenting the benefits of amplification, they only indirectly evaluate the need for D-HATS. There are no questions to prompt exploration of hearing alarms like the smoke detector or alarm clock. In addition, traditional scales do not assess one's knowledge of laws that provide these accommodations in hotels while traveling. A tool that was developed in a convenient format for the audiologist to use with every client to ensure a comprehensive assessment of communication needs is known as the TELEGRAM. Tools are most useful if the name in some way implies their function. In this case, the novel acronym was chosen to convey the desire to improve communication across distances. The TELEGRAM was designed to be completed following the routine audiologic evaluation (Thibodeau, 2004). As shown in Figure 21–4, the TELEGRAM is intended to be a prompt for the areas that must be considered: Telephone, Employment, Legal issues, Entertainment, Group communication, Recreation, Alarms, and Members of the family. Obtaining information regarding one's functioning in each of these areas will lead to recommendations for HATS or other rehabilitative strategies. The questions provided in Table 21–2 were based on critical areas recommended by Ross (2004) to be explored with every patient. Associated rating scales are suggested to quantify the difficulties. By providing a graphic form that is analogous to the audiogram, the audiologist should find it easy to document a patient's current functioning and determine areas of need.

Table 21–2. TELEGRAM Rating Scale Key

Topic	Question	Rating
T	Are you having difficulty with communication over the telephone ?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Can't use the phone <i>Use "L" to designate Landline and "C" to designate Cellphone.</i>
E	Are you having any difficulty with communication in your employment or educational environment?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Stopped working
L	Do you know about legislation that provides assistance for you to hear in public places or in hotels when you travel?	Knowledge 1 = Vast, 2 = Considerable, 3 = Some, 4 = Limited, 5 = None
E	Are you having difficulty with hearing during entertainment activities that you enjoy such as television, movies, or concerts?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Stopped Going
G	Are you having difficulty with communication in group settings?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Can't hear at all in groups
R	Are you having difficulty with hearing during recreational activities such as sports, hunting, or sailing?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Stopped the activity
A	Are you having difficulty hearing alarms or alerting signals such as the smoke alarm, alarm clock, or the doorbell?	Difficulty 1 = None, 2 = Occasional, 3 = Often, 4 = Always, 5 = Can't hear alarm <i>Use "S" for Smoke Alarm, "D" for Doorbell, and "A" for Alarm Clock</i>
M	Are you communicating with members of your family?	1 = Live with Normal Hrg Adult, 2 = Live with Young Children, 3 = Live with Teenagers, 4 = Live with Adult with Hrg Loss, 5 = Live Alone <i>Check all that apply</i>

dix 21–C so that current information regarding federal and state programs may be obtained when considering solutions for a particular individual's needs.

Telephone

When considering options for telephone communication, one must account for the fact that 95% of Americans now own a cell phone of some kind. The

ownership of smartphones is now up to 77% from 35% in 2011 (Pew Research Center, 2019a). This increase even applies to the use of technology by baby boomers, among whom usage has increased from 25% in 2011 to 67% in 2018 (Pew Research Center, 2019b). However, it is still important to distinguish problems with landline phones versus cell phones because the solutions may vary depending on the features of the personal hearing aid. For example, difficulty with landline phones may be addressed by a

phone amplifier or by increasing the gain of the telecoil, whereas difficulties with cell phone communication may be addressed by setting up direct audio input or a Bluetooth connection. Several resources for solutions for phone communication are provided in Appendix 21–D.

For someone with mild communication difficulties on the landline phone who does not wear hearing aids, a simple phone amplifier that fits over the handset may be sufficient. Others may need a phone that provides an amplified handset or a visual indicator. The design features of the phone, such as cordless or large numbers, will need to be considered relative to the patient's needs.

Persons with MFi and MFA hearing aids will most likely use the connectivity features to enhance phone communication. The seven manufacturers shown in Table 21–1 provide devices that are capable of direct connectivity to phones through the 2.4 GHz transmission protocol (either Bluetooth LE for the iPhone connectivity or proprietary protocol for the Android connectivity). This feature is available in styles that fit behind or in the ear. Some of these are rechargeable and/or have a telecoil option. Unlike using a landline phone with older hearing aids, these MFi and MFA hearing aids that communicate wirelessly with smartphones allow bilateral reception of the signal from the phone, resulting in significantly improved speech recognition (Picou & Ricketts, 2011).

For those users without direct cell phone connections, the next consideration might be the acceptance of a body-worn connection to the cell phone, such as an induction loop that can interface with a telecoil in the aid or a proprietary streamer. These options will involve remembering not only to wear the accessory but also to charge it regularly. Each of these can connect to a smartphone via the classic Bluetooth protocol and have the option for increasing volume of the signal from the phone. The phone must be paired with the neck loop device to establish communication, which is a short process of turning both devices on and following “seeking” instructions on the cell phone. When paired, the audio signals from the cell phone will be sent to both hearing aids.

If the TELEGRAM assessment indicates difficulty hearing in noise, then a system with a remote microphone might be considered; such a device can be paired via the classic Bluetooth protocol to convey phone communication directly to the hearing aid, as shown in Figure 21–5, or to a neck loop or receiver connected to a hearing aid or cochlear implant. Although these microphones also require a dedicated charging cord, some have charging docks that can be



Figure 21–5. A remote microphone that connects via classic Bluetooth to a cell phone. Photo courtesy of ReSound.

interfaced with the television to send the audio signal to receivers on the hearing aids while charging.

For those with more severe hearing loss who rely on visual communication, the older devices known as the Telecommunication Device for the Deaf (TDD) have often been replaced by use of instant messaging between cell phones or caption phones. With text messaging, the information is typically typed in abbreviated format because of the limitations of the small keyboard and displays on cell phones. In addition, the conversation is not in real time and the sender or receiver may not be able to respond immediately. Therefore, many persons prefer to have a landline phone that provides captions where conversations can be stored and voice mail can be captioned. Because these phones involve both computer speech recognition and human oversight, the accuracy may be greater than in text messaging between phones. These devices, referred to as captioned telephones, are provided for those with hearing loss at no cost other than the fee required for internet access. Further information regarding these cell phone options may be obtained through the links provided in Appendix 21–D.

Another telephone accommodation made possible via smartphone technology allows the persons with hearing loss to see the other person in the conversation. There are several ways to do this through cell phone applications or internet access to websites. The links for programs such as Skype, FaceTime, and Tango are provided in Appendix 21–D. Skype is a video and instant messaging application that is available with any smartphone as long as both users are connected to the Internet. Another application, FaceTime, allows video messaging between iPhones (model 4 or later) over a Wi-Fi connection. Tango

and SnapChat are also video messaging applications that are accessible from a variety of smartphones and that utilize mobile internet as well as Wi-Fi. Despite the increasing popularity of these video messaging applications, there may be visual delays or degraded images, the effects of which are unknown (Cromartie et al., 2012).

The ability of the listener to hear the phone ring should also be considered. A common solution for the inaudibility of the typical high-pitched ring of a landline phone is to select a phone with an amplified ringer and/or visual alert. An accommodation that does not involve HATS is to recommend the user purchase a cordless phone with a high-volume ringer and with multiple receivers that can be placed in rooms of frequent use. There are also applications that can run on cell phones that will result in flashing or vibrating signals when the phone rings. Most users of cell phones will use the vibrate feature to be alerted to incoming calls.

Employment

Communication difficulties at the workplace can be minimized in a variety of ways. This section of the TELEGRAM is included to prompt discussion of chal-

lenges at work that can be addressed through specific programs on the personal hearing aids or perhaps through group amplification systems. In addition, there may be challenges with phones at work that can be reduced through HATS. A referral to a state government program that provides services to assist with employment may be necessary. Every state in the U. S. has government programs that provide services such as assistive technology, college tuition, and interview and résumé coaching to facilitate gaining employment. HATS required in the workplace depend on the type of job. Through exploring the challenges in the workplace, many possible solutions can be offered. In addition to phone solutions mentioned above, communication issues may be addressed through the use of a remote microphone system. Such a system includes a wireless microphone that communicates directly with the hearing aid or implant or that communicates with a receiver that connects to the hearing aid or implant as shown in Figure 21–6. The advantage is significant improvement in speech recognition in noise as a direct result of microphone location (Lewis et al., 2003; Schafer & Thibodeau, 2006; Thibodeau, 2010, 2014, 2016). Some microphones can be worn by the speaker, whereas others can be held by the listener and pointed directly at the speaker for optimum reception. A particularly useful feature in



Figure 21–6. A DM transmitter (A) and integrated receiver attached to base of a hearing aid (B). *Source:* Images © Sonova AG. Reproduced here with permission. All rights reserved.

small meetings is the use of a conference microphone that can be placed in a central location to pick up conversation ranging around the table. Thibodeau (2019) found that the Roger Select microphone resulted in 61% improvement in sentence recognition in noise compared to the use of hearing aids alone for persons with moderate to severe hearing loss when the source originated randomly from one of five speakers around a conference table.

Legislation

As part of a comprehensive service to persons with hearing impairment, audiologists should determine the person's awareness of laws and state programs that provide assistive devices. Persons with hearing impairment can use this information to become advocates for their needs in employment, travel, or educational situations. Probably the most useful legislative action is the American With Disabilities Act (ADA). The ADA requires employers and/or businesses that provide services to the public to make accommodations for persons with disabilities such as hearing loss. These services could include amplified telephones, infrared devices in theatres, vibrating alarm clocks in hotels, or an FM system with a conference microphone in staff meetings. Knowledge of legislation regarding phone communication is also important. The Telecommunications Relay Service (TRS) mentioned earlier allows persons with hearing or speech disabilities to place and receive telephone calls and is available in all states for local and/or long-distance calls. The Federal Communications Commission (FCC) has adopted a convenient code, 711, for access to TRS regardless of the state. However, ADA requires equal access in the case of an emergency. Therefore, a person who relies on a TDD should dial 911 directly and not make a TRS call via 711. More information regarding 711 services may be found in the websites provided in Appendix 21–C.

Many states have legislation that provides telephone assistance for persons with hearing loss. In Texas, for example, the state provides the Specialized Telecommunications Assistance Program (STAP) for people who are deaf or hard of hearing. Eligibility requirements for the program include proof of Texas residency and an application signed by a physician or audiologist documenting that the person has impaired hearing. A STAP voucher is mailed to the recipient's home and then brought to a certified vendor. A variety of devices is offered at these sites, such

as amplified telephones, signaling devices, and telephone listening systems.

Entertainment

Entertainment is often provided in group formats, such as theatrical productions or concerts, thus requiring the assistance of a large-area system. Three main systems may be used in large auditoriums, including infrared, FM, and induction loop. The first two transmission methods involve receivers offered by the establishment at no cost to the person with hearing impairment. Whether the client watches television at home or attends concerts, the audiologist should determine the need and recommend possible solutions. Many hearing aid manufacturers provide an accessory to connect to the television that will send the audio signal via digital streaming to the hearing aid through the 900 MHz or 2.4 GHz transmission protocols. These are typically designed specifically to transmit to the matching receivers within the hearing aids by the same manufacturer. Another solution for improved reception of the sound from the television is to purchase a TV band radio that can be placed next to the chair of the person with hearing loss. By having the radio speaker close to the listener, the signal-to-noise ratio is improved. In addition, personal earphones may be used with the radio to reduce unwanted ambient sound.

Many persons with significant hearing loss can only enjoy movies at the theatre when there is open captioning. Information can be accessed on a smartphone about which movies are showing in local theatres that have captioning. An application can be downloaded onto one's phone, iPad, or iPod Touch that will provide information about the types of captioning available and show times at the theatres. The information is also available through a website link, shown in Appendix 21–D.

Groups

Communication in groups is often difficult because of distance from the speaker and noise and/or reverberation in the background. Remote microphone systems have been shown to reduce the deleterious effects of these factors and may be interfaced with the personal hearing aid in two primary ways. First, a small FM or DM receiver may be attached to the hearing aid or implantable hearing device processor through a

direct audio input connection. The receiver may be secured to the aid with an audio shoe or directly attached to the aid as shown in Figure 21–6. Second, the FM or DM signal may also be received via an induction neck loop or a streamer with an appropriate receiver attached and worn on the body. In group situations, such as a lecture where there is one primary speaker, the remote microphone can be worn by the presenter. For small group conversations, the remote microphone may simply be pointed toward the speaker of interest. New developments in remote technology allow the use of multiple transmitters to one receiver. This will allow members of a group to use their own microphone and communicate directly with the person with hearing loss. Conveniently, one manufacturer provides a wireless option compatibility search called the “Roger Configurator” on their webpage. Connectivity options for Roger technology is provided for several hearing aid and implant manufacturers (Phonak, 2019).

The use of a neck loop accommodation to improve hearing in group public settings has received much attention through a national campaign known as “Get in the Hearing Loop” supported by the Hearing Loss Association of America (HLAA) and the American Academy of Audiology (AAA). A large percentage of hearing aids and cochlear implants dispensed today include a telecoil. Many public places, such as theaters and airports, provide induction loops, which send an electromagnetic signal from a source to the telecoil of the hearing aid or implant. The plan for the campaign was launched in June 2010 with the hope that audiologists would dispense a greater number of hearing aids that include telecoil functions. In addition to increasing consumer awareness, the HLAA and AAA have also educated owners of public facilities about the benefits and relative ease of providing additional amplification to patrons with hearing impairment through the use of induction loops.

Another option for improving speech recognition in groups is to use the cell phone as a microphone to transmit to the MFi hearing aids through the feature called “Live Listen.” Because of the noticeable transmission delay associated with the Bluetooth transmission protocol, the user will want to mute the hearing aid microphone if possible. Other options with the cell phone include apps listed in Appendix 21–D that will amplify sound picked up by the microphone on the cell phone and deliver it to the user via wired earphones. Some of these may be downloaded at no cost to the user and provide considerable benefit as a backup or precursor to hearing aid use.

Recreation

Hobbies, of course, vary with personal preference and the dependence on hearing for full enjoyment should be considered. For example, if a retired couple enjoys traveling in a recreational vehicle across the country, communication may be limited because of road noise. An 8-hour trip could be significantly more enjoyable with a hardwired amplifier with an extended microphone cord to be worn by the speaker. Some persons prefer to use the FM/DM system described earlier for more freedom of movement. A less expensive option may be a mini microphone that is designed for short range transmission and communicates directly with the hearing aid through digital streaming without the need for additional specialized receivers as shown in Figure 21–5. These mini microphones are paired with manufacturers’ hearing aids and are not universal like FM technology. Providing a tour guide with an FM transmitter can significantly improve the quality of an organized vacation for a traveler with hearing loss. Assistive technology should always be explored for those with hobbies that involve noise such as woodworking or boating, depending on their communication needs. For example, an amplified phone and intercom system may reduce frustrations for a wife trying to communicate with her husband, who spends considerable time in a woodworking shop. Individuals may be wearing ear protection in these noisy environments, further necessitating assistive technology, such as the vibrating signals described in the next section.

Alarms

Hearing-assistive technology is often a necessity to detect alarms, phone ringers, and warning signals in the environment. Most common alarm-type signals include doorbells, alarm clocks, and smoke alarms. A single device can be used for all these alarms that converts the auditory signal into a some type of notification. These alerts can be conveyed through a band worn on the wrist, a dedicated display, or a flashing lamp pattern. Recently, apps have been developed for the smartphone to alert the user to alarms in the environment. Some apps are specific to a single sound such as a doorbell or a smoke alarm and others are designed to signal multiple signals based on the ability of the smartphone’s microphone to detect and identify the sound. The accuracy may vary with sensitivity of the microphone on the phone and noise in the

environment so it is best to read reviews and arrange specific trials before relying solely on a smartphone app for an alerting system.

With cameras that can be placed at the front door or in a baby's room, alerts can be conveyed via the associated app on the cell phone, signaling that movement or sound has occurred. The apps can be set to record the activity over a period of time or send an alert when certain activity has occurred, such as a doorbell.

Although not considered technology, the benefit of hearing dogs or hearing-ear dogs should not be overlooked when considering options for hearing alarms. Hearing dogs are specially trained to help an individual hear the specific alarms in their environments. The dogs are selected from animal shelters and are trained over several months before being matched with an individual. They then receive more specific training for that person's environment.

Members of the Household

Members of the household certainly provide hearing assistance and should be considered when addressing the needs of the person with hearing impairment. If there is a spouse or life partner, he or she should be an integral part of the technology and communication strategy training. Small children or teenagers present a special set of challenges with high-pitched voice and rapid speech. HATS may be an integral solution for these challenges, but simple communication rules, such as not talking until in the same room or facing the listener, will often be of great assistance. Solutions can also be creative, such as wearing a button or t-shirt with a printed reminder like "Thank you for facing me when you speak!"

Fitting and Verification

After determining the need for assistive technology, the particular device should be verified in some way. Just as considerable time and expertise may be spent on achieving the optimal gain and output of an ear-level device for face-to-face communication, the optimal output when connected wirelessly for communication should also be verified. The techniques to do this vary with the device. Ideally, verification can include both electroacoustic and behavioral measures. Those that deliver the signal via the personal hearing

aid, such as an FM or DM system with a direct audio input FM or DM receiver, can be evaluated using existing electroacoustic test equipment and couplers. When the coupling does not allow use of standard couplers, behavioral evaluation should be performed.

There are two documents that relate to the verification of HATS. The ANSI standard for "Specification of Hearing Assistance Devices/Systems" (ANSI, 2014) addresses the electroacoustic evaluation of technology that is packaged as a personal system (rather than large-area group systems). Recommended electroacoustic measurements are similar to those for hearing aids in the ANSI S3.22 standard, but have specific requirements for placement of the transmitting microphone and the receiver. These procedures allow comparison to manufacturer specifications, as well as comparison across equipment models, because prescribed input levels and equipment arrangements are used (Schafer, Thibodeau, Whalen, & Overson, 2007). Many devices can be evaluated with existing couplers used to test hearing aids whereas other devices, such as those with headphones, may not. The manufacturer will then report the coupling method used to obtain the electroacoustic results.

The second document is the "AAA Clinical Practice Guidelines: Remote Microphone Hearing Assistance Technologies" (AAA, 2011). This comprehensive guide focuses on hearing-assistive technology for individuals from birth to 21 years. It is an expansion of the original guidelines developed by an American Speech-Language-Hearing Association (2002) Task Force, which focused on real-ear, electroacoustic, and behavioral evaluation procedures. As technology has expanded, the need for a more comprehensive document emerged. The AAA guidelines include information to consider in determining candidacy, device selection, fitting and evaluation, and staff in-service. A supplement is included with specific protocols for the evaluation of ear-level FM systems when used with children who wear hearing aids or cochlear implants or who have normal hearing. Additional supplements will be forthcoming to address evaluation of soundfield and induction loop systems.

Although written for fitting children, these protocols are applicable to adult candidates. When fitting wireless systems, it is important that electroacoustic verification be performed to measure that the wireless signal is received at a level above those of the environmental signals processed through the hearing aid, thus resulting in a favorable signal-to-noise ratio (S/N) (Bondurant & Thibodeau, 2011). This is determined by comparing the output of the hearing

aid alone to that of the combined hearing aid and wireless microphone system when tested with a 65 dB SPL complex input. The two curves should be closely aligned. Then, when the FM microphone receives the typical input of 80 dB SPL from the speaker, the optimal S/N will be accomplished. If the two curves are not similar, adjustments may be made in the receiver to compensate for the offset. The AAA task force has proposed a taxonomy that includes the type of measure (electroacoustic), the system receiving the input (hearing aid or FM), and the input level (65 dB SPL). For example, the first measurement is EHA65 (electroacoustic hearing aid 65 dB SPL input), which is an electroacoustic measure performed with the hearing aid in the test box and a 65 dB SPL input. The next measure is EFMHA65 or EDMHA65, which is performed with the FM or DM microphone in the test box to receive the input and the hearing aid outside the test box. In summary, the difference between the output curves for EHA65 and EFMHA65 or EDMHA65 should be close to zero.

With various options for using smartphones with hearing aids, there will undoubtedly be new protocols for verifying performance. For example, for those who choose to use the smartphone in a traditional way by holding it close to the microphone of their hearing aid, the impact of the smartphone case on the intensity of the voice of the caller should be evaluated. Fray and Thibodeau (2018) devised a procedure to evaluate two difference cases for smartphones and found that, in some cases, the signal was reduced by 37 dB relative to the signal picked up by the hearing aid microphone. The output measured from the hearing aid when connected to the phone without the case that is placed in the test box is compared to the output of the hearing aid when connected to the phone with the case that is placed in the test box as shown in Figure 21–7.

Although the benefit of assistive technology is best measured in one's real-life environment, the AAA Guidelines include procedures for behavioral verification of remote microphone technology. The

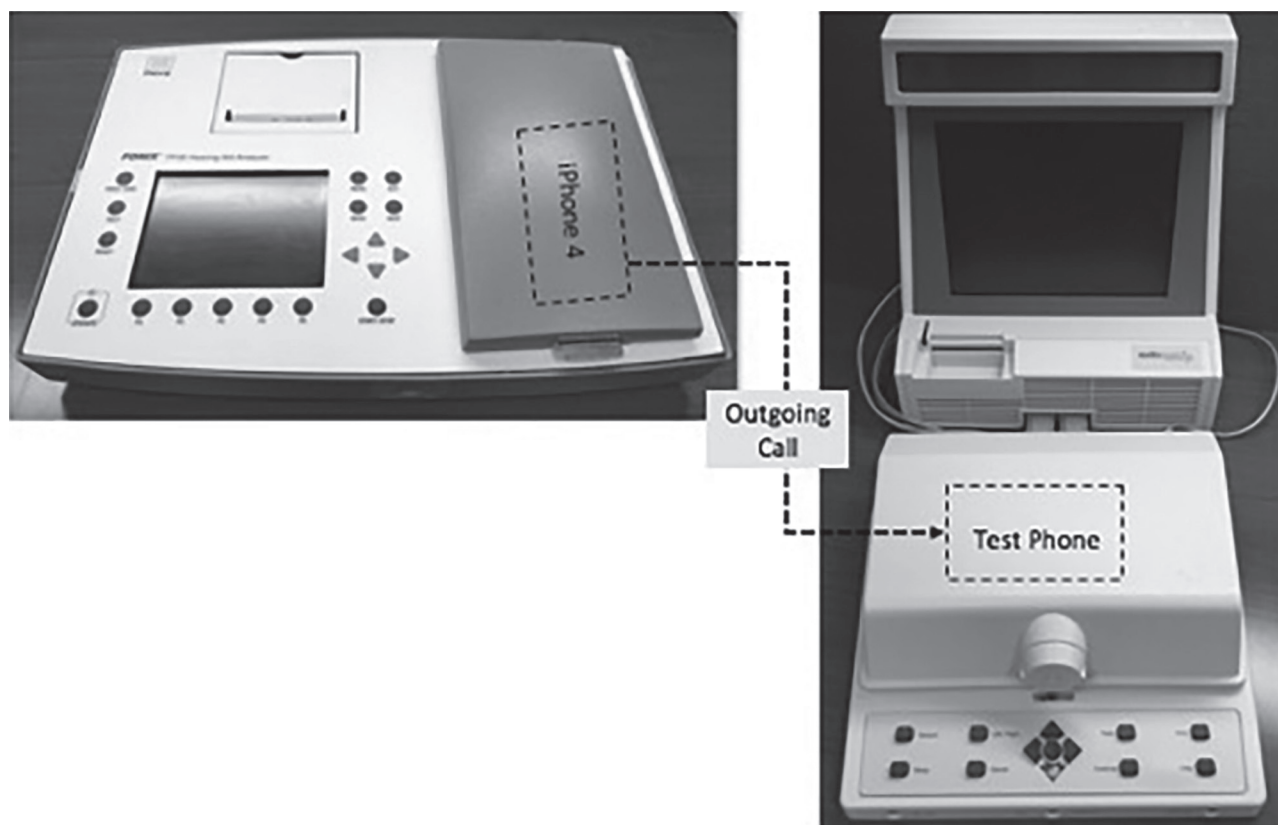


Figure 21–7. Electroacoustic analysis of the effect of phone cases where one phone is placed inside a test box to receive the stimulus (*left*) and transmit to a second phone that is inside another test box (*right*). The second test box is also used to measure the output of the hearing aid when paired with the second phone.

listener with the technology is seated in the sound booth at 0 degrees azimuth, while the examiner with the microphone is seated at the audiometer outside the booth. Using appropriate speech recognition materials, the first score is obtained via live-voice presentation in a 0 dB S/N. Following the proposed terminology, this condition is BHA50/50, which designates a behavioral evaluation with the hearing aid alone (BHA) with speech and noise presented at 50 dB HL (50/50). The next condition is BFM/HA50/50 of BDM/HA50/50, which is similar to the first measure except now the examiner has turned on the remote microphone. When BHA50/50 does not result in a score below 80%, the noise may be increased to create a poorer S/N so that the benefit from the assistive technology can reach significance. The 20% change in scores required for significant difference is based on a 25-word list. The average benefit for 10 adults when tested using this protocol with FM technology was 34% (Thibodeau, 2007).

Following verification, the individual and possibly a family member will need instruction on the care and use of the chosen technology. Although some HATS can be very simple to operate, such as a vibrating alarm clock, others may involve multiple components, such as an FM or DM system that interfaces with one's personal hearing aids or implantable device. Not only is there technology added to the hearing aid, but there is also a remote microphone, which may also have several features. In addition to the verbal instruction and practice at the auditory rehabilitation appointment, written materials should be provided for review at home.

Validation

Once HATS have been appropriately fit, the final step is validation. This is necessary to determine if the individual receives the intended benefits. Although a hearing aid with wireless microphone connectivity could be precisely fit and significant benefit shown in the FM fitting evaluation, if the individual forgets how to operate the device when he/she gets home and does not use the system, then the intended benefits are not realized. Therefore, the TELEGRAM or COSI should be administered 3 to 6 months following the fitting to determine if there is reduction in the degree of difficulty. In a study using the TELEGRAM, it was determined that all individuals showed improvement in six of the seven areas (Thibodeau,

2007). By reviewing the TELEGRAM at the annual audiologic evaluation, the benefit received through the technology that was recommended the previous year can be documented and new recommendations made if necessary.

Integrating Into Clinical Practice

Prendergast and Kelley (2002) reported that more than 80% of audiologists were providing information regarding HATS to their patients. Given all the currently available connectivity options, audiologists would be more likely to mention D-HATS than before, when these options were considered part of a separate program. There is no longer a need for a separate room for incorporating HATS into one's practice like that suggested by Lesner and Klinger (1995) who offered considerations such as room size, furnishings, environment, and organization of special equipment. Rather, once the speech and nonspeech communication needs and the level of technology are determined, the audiologist can determine possible network options. All D-HATS can be demonstrated or illustrated through the use of a small tablet that could be available in every fitting room. Some rooms are already equipped with wall-mounted screens for patient education during the fitting process. For those who still need access to A-HATS, many resources can be offered with minimal effort by providing a simple resource brochure of commonly used A-HATS for the telephone, television, and alarm clocks (Oaktree Products, 2019). These brochures can be customized with contact information and provided to each patient following the recommendations provided on the TELEGRAM.

In addition to incorporating these HATS resources into clinical practice, the benefits of group sessions focused on HATS should be considered. Offering information sessions regularly to review hearing aid connectivity features and D-HATS could not only lead to greater satisfaction with a purchase, but also to new referrals. Consumers may increase their acceptance of HATS when sharing communication frustrations and HATS solutions in group discussions (Thibodeau & Cokely, 2003). Furthermore, overall clinical efficiency is increased when device explanation occurs in group formats (Chisolm, McArdle, Abrams, & Noe, 2004). One format involves four weekly, 1-hour meetings focused on trials with wireless technology. The program is referred to as Appli-

cation of Advanced Listening Technology in Adults (AALTA) and is offered with support from manufacturers of wireless technology so that individuals may have personal experiences, which can then be shared in the weekly AALTA meetings (Thibodeau, 2007).

Summary

The needs of the adult with hearing loss extend into many aspects of life. The first solution that is considered is to provide amplification that can restore audibility of acoustic information. There are many instances, however, in which noise, reverberation, and distance render the acoustic signal inaudible, regardless of the amplification technology. In addition, hearing aids are not worn all hours of the day, and yet there are alarms that can convey life-saving information, such as a smoke detector, that may need to be recognized at any time. Therefore, it is part of basic audiologic care to consider the assistive technology that a person may need for everyday life. Despite the basic needs of persons with hearing loss, audiologists can no longer view assistive technology as just accessories. A routine tool is proposed as part of the basic audiologic evaluation to prompt the audiologist to address these needs. The format of the TELEGRAM allows for a quick review of problems that can lead to recommendations for technology or acquiring knowledge (such as learning about legislative issues). Once the needs are identified, the next challenge is for the audiologist to provide the technology or guidance to use existing technology, such as their smartphone or a tablet, by which patients can find solutions. After the appropriate technology is received, the audiologist's responsibility includes follow up to ensure that it is being used properly and is effectively meeting patient needs. The progress can be noted on the TELEGRAM so that areas may be reassessed at subsequent evaluations.

Hearing aids alone are sufficient for some persons with hearing loss, but many patients can also benefit from the many features that now connect those aids to solve hearing and communication challenges. Audiologists are best suited to see that the process of acquiring and fitting assistive technology occurs efficiently without weeks or months of frustration. With this comprehensive audiologic care, those with impaired hearing may reduce their communication challenges and continue to live enjoyable and productive lives.

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Appendix 21-A
**ILLUSTRATION OF BENEFITS OF ANALOG HEARING-ASSISTIVE
TECHNOLOGY (A-HAT)**

THREE DEAF PIGS

The first pig built a house of straw.

The wolf came.

He yelled for the pig to come out.

The pig could not hear him.

The wolf blew down the house and ate the pig.

The second pig built a house of sticks.

The wolf came.

He yelled for the pig to come out.

The pig could not hear him.

He thought it was a tornado.

The wolf blew down the house and ate the pig.

The third pig built a brick house with flashing lights and all the necessary deaf devices.

The wolf rang the bell and the lights flashed.

He called the zoo, using the TTY relay service.

A zoo keeper came and put the wolf in a sign language class.

The wolf learned to communicate and became friends with the pig.

Author Unknown

Appendix 21-B
**ILLUSTRATION OF BENEFITS OF DIGITAL HEARING-ASSISTIVE
TECHNOLOGY (D-HAT)**

THREE DEAF PIGS

The first pig built a house of straw.

The wolf came.

He yelled for the pig to come out.

The pig could not hear him.

The wolf blew down the house and ate the pig.

The second pig built a house of sticks.

The wolf came.

He yelled for the pig to come out.

The pig could not hear him.

He thought it was a tornado.

The wolf blew down the house and ate the pig.

The third pig built a brick house with a front-door webcam connected to his cell phone and all the necessary apps.

The wolf rang the bell and the pig received an alert on his smartphone while he was watching a captioned movie on Netflix.

He immediately sent a text to the zoo.

A zookeeper came and put the wolf in a computer class.

The wolf learned to type and became Facebook friends with the pig.

Author Unknown

Appendix 21–C

RESOURCES FOR SERVICES FOR PERSONS WITH HEARING LOSS

Legislative and State Programs Regarding Accommodations for Those With Impaired Hearing

<https://www.fcc.gov/accessibility>

<https://www.hearingloss.org/hearing-help/financial-assistance/state-agenices/>

Professional Organizations With Information Regarding HATS

Hearing Loss Association of America

<https://www.hearingloss.org/>

American Speech-Language-Hearing Association

<https://www.asha.org/public/hearing/hearing-assistive-technology/>

American Academy of Audiology

<https://www.audiology.org/>

Alexander Graham Bell Association

<https://www.agbell.org/>

Academy of Rehabilitative Audiology

<https://www.audrehab.org/>

National Deaf Center

<https://www.nationaldeafcenter.org/topics/assistive-technology>

National Institutes of Health

<https://www.nidcd.nih.gov/health/assistive-devices-people-hearing-voice-speech-or-language-disorders>

Appendix 21-D

RESOURCES FOR HEARING-ASSISTIVE TECHNOLOGY SYSTEMS

General Hearing-Assistance Technology

<http://www.oaktreeproducts.com>

<http://www.dogsforbetterlives.org>

<http://www.harc.com>

<http://www.hearingloss.org/programs-events/get-hearing-loop>

Hearing-Assistive Technology via Smartphone Applications or Internet Access

Captionfish—Guide to movie theatre showings with captioning.

<http://www.captionfish.com/>

AVA—An app to transcribes conversations in real time.

https://www.ava.me/download/?_branch_match_id=603694227730547044

Live Transcribe—An app for Android platforms to transcribe conversations in real time.

<https://www.android.com/accessibility/live-transcribe/>

Otter—An app for IOS platforms to transcribe conversations in real time.

<https://apps.apple.com/us/app/otter-voice-meeting-notes/id1276437113>

Ear Machine—Amplifier of conversation with tone and pitch adjustments.

<http://www.earmachine.com>

Hear Boost—Amplifier of conversation with record feature.

Android link: <https://play.google.com/store/apps/details?id=com.audiofix.hearboost>

iPhone link: <https://itunes.apple.com/us/app/hear-boost-enhanced-recorder/id1437159134?mt=8>

Frequency/Digital-Modulation Systems

Audio Enhancement—<https://audioenhancement.com/audio/>

Comfort Audio—<http://www.comfortaudio.com/us/>

Comtek—<http://www.comtek.com/tour-guide>

Etymotic—<http://www.etymotic.com>

Oticon—<http://www.oticon.com/solutions/opn-wireless-connectivity>

Phonak—<http://www.phonak.com/com/en/hearing-aids/accessories/accessories-overview.html>

Williams Sound—<http://www.williamssound.com/personal-listening-products>

Captioned Phones Available at No Cost for Persons With Hearing Loss

CaptionCall—<https://captioncall.com>

Clear Captions—<https://clearcaptions.com>

CapTel—<https://www.captel.com>

Apps for Phone Communication

Video Messaging via Internet Access

Skype—for all phones via Internet access:

<https://www.skype.com/en/get-skype/>

FaceTime—for iPhones (model 4 or later):

<https://support.apple.com/en-us/HT204380>

Tango—for all phones:

iPhone link: <https://itunes.apple.com/us/app/tango-live-video-broadcast/id372513032>

Android link: <https://play.google.com/store/apps/details?id=com.sgiggle.production>

Internet Protocol Services for Phone Conversations

IP-Relay for Cell Phones

iPhone link: <https://itunes.apple.com/us/app/sprint-ip-relay/id542802329>

Android link: https://play.google.com/store/apps/details?id=com.sprint.trs&hl=en_US

Hamilton Mobile CapTel for Cell Phones

iPhone link: <https://itunes.apple.com/us/app/hamilton-mobilecaptel/id370615084?mt=8>

Android link: https://play.google.com/store/apps/details?id=com.hamilton.ui&feature=nav_result#?t=W251bGwsMSwxLDMsImNvbS5oYW1pbHRvbi51aSJd

Sprint CapTel for Cell or Landline Phones

<https://sprintcaptel.com>

