WIRELESS TECHNOLOGY FOR PERSONS WITH HEARING LOSS

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Imagine that you were in need of a pacemaker to keep your heart rhythm at an adequate pace so that your circulation was optimal for survival. Most of us would be completely dependent on the cardiologist to recommend the type of pacemaker and associated features. Assume that your surgery was successful and you are beginning to reap the benefits of your new "bionic" device until you have lunch with your friend and discover that she has also recently received a pacemaker. Her doctor, however, selected one that interfaces with her cell phone so that if she suspects any malfunction or just wants to have a quick system check, a wireless connection for an assessment can be established via an application on her phone. Furthermore, her pacemaker monitors blood pressure and viscosity so that should any abnormalities be detected, an alert is sent to her phone advising her to seek medical attention. The alert is rated as "important" if a slight blockage is detected and "serious" if immediate medical attention is needed. In addition, whenever she is working at a computer connected to the Internet, her pacemaker is sending data regarding blood sugar and potassium levels to her personal online health record, which will generate a text message to her phone before dinner with menu suggestions should a diet modification be indicated. The renewed energy you were beginning to experience has now been transformed into stress over the limitations of the basic pacemaker you received, which will only serve to regulate cardiac rhythms as prescribed by a doctor you see every three months.

Although this futuristic description may seem like an unrealistic example of health-related technology, we are fortunate that when it comes to assistive hearing technology we can experience multiple benefits beyond "basic amplification." Despite the conveniences afforded by sophisticated amplification fitting software and the numerous adaptive algorithms to improve speech recognition in noise, the hearing healthcare provider today has a more challenging task than when hearing aids were fit without computers. Given the rapidly changing options for current amplification systems to be integrated with other communication devices, every purchase decision should include a review of options for patients based on their daily activities, priorities for social communication and possible employment demands. It is time for a paradigm shift from fitting devices that result in improved communication to establishing a hearing technology network (HTN) in which improved hearing is only one of many benefits. A possible HTN is shown in Figure 1. This movement from an "amplification device" to a "hearing technology network" requires a thorough assessment of hearing abilities, as well as lifestyle, technology experience and financial constraints.

A reasonable starting point for this paradigm shift is with an overview of technology options.

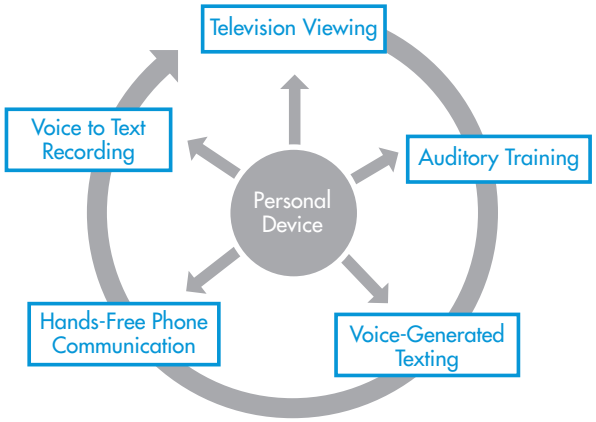

Figure 1: A hearing technology network for someone with impaired hearing.

Next, a comprehensive assessment tool is needed to determine the components that will be recommended for an individual's technology network. The best integration of wireless technology is of no use if the individual cannot confidently operate the components. Therefore, the system must include a structure by which the technology is introduced, experienced in a variety of settings, and adjusted if necessary to facilitate the ease of operation and subsequent regular use.

Technology Network Overview

By definition, a network requires more than a single component. Even if the user with hearing loss prefers to start with only one component, he or she should be presented with the options for integrating that component with others for maximum benefit. It should be obvious that this "network paradigm" is what will ultimately separate the professional audiological service from the discount experience associated with the purchase of a personal sound amplification product (PSAP) from an electronics store or through the Internet. The first component in the network is the base, or the personal device, which can be selected with consideration for the individual's past experience with amplification, as well as requirements for the "new network" in which the base component will operate.

Although there are numerous "network features," only three will be presented as examples of networks for hypothetical users referred to as:

Figure 2: A basic technology network with hearing instrument and mini-remote microphone. SurfLink® Mobile shown with a BTE.

1) **Milly,** who has mild hearing loss, mild communication demands, limited technology experience and a limited budget.

2) **Marge,** who has moderate hearing loss, significant communication demands, moderate technology experience and a moderate budget.

3) **Maxine,** who has significant hearing loss, significant communication demands, considerable technology experience and an unlimited budget.

Let's assume they all have relatively good speech recognition in noise, no cosmetic concerns, equal motivation, bilateral fittings and similarly supportive families. In addition, it is assumed that many personal devices will contain a telecoil for universal access opportunities that may exist in public places and be capable of interfacing with remote devices through digital streaming.

Most would agree that **Milly** could benefit from an entry-level, behind-the-ear hearing instrument with a slim-tube fitting for her mild hearing loss. Her network could include a system that will allow for digital streaming with a remote microphone. In addition to maintaining the batteries in her hearing instruments, she will have to remember to charge one additional device. This remote microphone, shown in Figure 2, will allow her improved hearing in noisy environments. Because she has limited technology experience and is totally dependent on the recommendations provided by the hearing healthcare provider, the proprietary nature of her network will be adequate for her. Her friends with hearing instruments from different manufacturers will not be able to join her network and benefit from her mini-remote microphone. She is not disappointed when her hearing healthcare provider explains that she also has Bluetooth function with this system and can connect with her cell phone. Although, due to Milly's limited technology experience, her hearing healthcare provider may opt to disable the option for Bluetooth telephone streaming. She will most likely use this network with only one other speaker during her weekly visits with her teenage granddaughter.

Marge has greater communication demands related to her moderate hearing loss and has increased experience with technology. She would like hands-free operation of her cell phone and also improved signal-to-noise ratio from a remote microphone. A receiver-in-canal instrument that can interface with a Bluetooth-streaming device would likely be selected for her. Because she frequently misplaces things, she selects a network that includes a streamer that can be worn around her neck, clipped to her belt or carried in her purse. She also appreciates the remote microphone and plans to use it in noisy places. She expects no difficulty in remembering to charge her cell phone and this remote device each night.

Because of significant communication challenges associated with her severe hearing loss, **Maxine** has used a variety of wireless technologies over the years. Her work as a realtor requires frequent phone calls while previewing homes and taking notes, so she is interested in hands-free connectivity with her smartphone. With her frequent travel schedule, she prefers to limit the number of chargers she must carry. She was excited to learn that her wireless hearing aids would communicate with a single device that allows for hands-free telephone use and provides a remote microphone. The additional convenience of a directional microphone on her remote microphone outweighs any disadvantage of additional battery drain experienced during wireless audio streaming. Her wireless accessory also serves as a remote control for her hearing instruments.

All three ladies are pleased with their HTNs, which include bilateral, well-fit, behind-the-ear instruments with a single accessory that meets the differing range of their needs: a remote microphone for Milly, a streamer with Bluetooth connectivity for Marge, and a directional, long-range remote microphone with Bluetooth connectivity for Maxine. They especially enjoy sharing the "perks" of their networks with their husbands who purchased PSAPs and did not know that there were HTNs that would reduce their communication challenges in several ways. When questioned about how their providers determined the best network for them, they explained how their quick, comprehensive assessment led to the optimal arrangement.

Needs Assessment for a Personal Technology Network

As we have a multitude of options available for hearing networks, selecting the best combinations of devices can be a daunting task without the use of a comprehensive yet quick assessment of the consumer's needs. One tool that was developed based on recommendations by Mark Ross, a strong advocate for addressing communication challenges with assistive technology, is known as the TELEGRAM (Thibodeau, 2004). By asking simple questions in seven areas including telephone, employment, legislation, entertainment, groups, recreation and alarms, one can determine the sophistication of the technology needed by the individual with hearing loss. The final letter is a reminder to ask about the "members of the household" in order to understand the consumer's possible support system and most frequent communication opportunities. In a recent study of users with adult hearing instruments and cochlear implants, the use of the TELEGRAM resulted in increased knowledge, awareness and motivation to purchase assistive technology within the hearing healthcare provider's office (Schaper & Thibodeau, 2013). Based on the TELEGRAM results, an HTN may be selected that allows connectivity with a remote microphone, cell phone and television. It is possible that in the future, alerting devices such as doorbells or smoke alarms may also be included in the HTN.

T - Telephone
E - Entertainment
L - Legislation
E - Employment
G - Groups
R - Recreation
A - Alarms
M - Members of the Household

Technology Network Operation and Maintenance

The sophisticated hearing healthcare professional will not only comprehensively assess every individual's communication challenges to determine the best HTN, but will also follow the established guidelines for fitting and evaluating the components to ensure optimal performance. Two documents exist that provide detailed procedures for electroacoustic and behavioral evaluation of the benefits of HTNs: the American Academy of Audiology (AAA) Guidelines for Clinical Practice for Remote Microphones (AAA, 2008) and the American National Standards Institute (ANSI) Specification of Performance Measurement of Hearing Assistance Devices/Systems (ANSI, in review). In both documents, electroacoustic testing is recommended with the hearing instrument (HI) first and then with the remote microphone placed inside the test box. If the HTN is sensitive to orientation effects such as an induction neckloop, the testing should be conducted with the HI in a position that approximates the actual use arrangement. An example of optimal electroacoustic results obtained with an FM system and integrated FM receiver on the HI is shown in Figure 3. Curves 1 and 2 were obtained with 65dB SPL, digital speech input and curves 3 and 4 were obtained with 90dB SPL pure-tone input. The pairs of curves (1 and 2; 3 and 4) are closely aligned, which suggests "transparency" (i.e., that the FM system will provide the appropriate signal-to-noise ratio advantage for the listener without altering the relative frequency relationship).

The final step to successful benefit from the HTN is the counseling and orientation for the user. Chisolm et al. (2004) and Boothroyd (2004) advocate systematic instruction and frequent coaching sessions to facilitate success with FM systems. Given that the HTN involves more than the basic ear-level HI, counseling beyond the typical HI fitting appointment is needed. Thibodeau (2007) found that FM users benefited from a four-week program where participants and their communication partners learned to use the HTN in a variety of settings, practiced troubleshooting and completed journals to document their experiences. The Application of Advanced Listening Technology in Adults (AALTA) program allowed listeners to learn in a group format, successfully problem-solve technology difficulties, and gain confidence with the HTN in the clinic and in a typical, real-world setting, such as a restaurant.

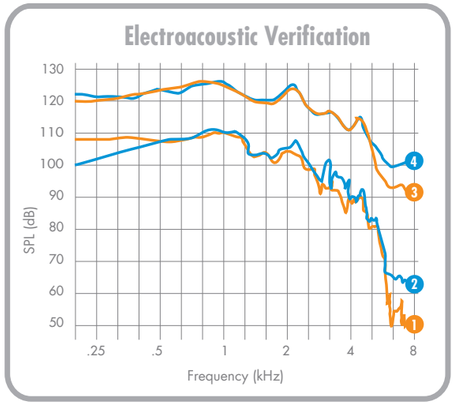

Figure 3: Electroacoustic verification of a Hearing Technology Network includes an FM microphone and an integrated FM receiver on the HI. Note: Curves 1 and 2 were obtained with 65dB SPL digital speech input and curves 3 and 4 were obtained with 90dB SPL pure-tone input. Curves 1 and 3 were obtained with the HI attached to the coupler in the test box and the FM transmitter on mute outside the testbox; curves 2 and 4 were obtained with the FM transmitter in the testbox and the HI attached to the coupler outside the test box.

Summary

Persons who are candidates for technology to improve their communication challenges should receive a comprehensive assessment to determine the technology that will address all their needs in a coordinated network. Depending on their technology experience, they may need only a simple network with a mini-microphone that connects to the HI or they may prefer a more sophisticated network that allows connectivity with a cell phone and a long-range, directional microphone. The components of the network should be verified for appropriate output and gain according to published guidelines. Regardless of the HTN, success will depend on the instruction and counseling the patients receive. A systematic program over several weeks that allows practice, group interaction, and instruction specific to the consumer's HTN will facilitate maximum benefit.

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