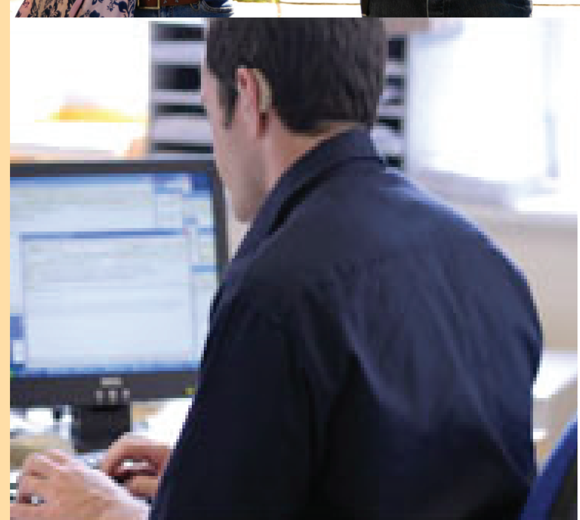
Demystifying Hearing Assistance Technology

A Guide for Service Providers and Consumers



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Note: Versions of these chapters can also be found in the PEPNet publication *Hard of Hearing Students in Postsecondary Settings: A guide for service providers* on the PEPNet Resource Center Website at *www.pepnet.org* or *http://prcorder.csun.edu/media/1219hh-students/index.html*. This book is also available at *www.wou.edu/~davisc*. In addition to the technology information presented here, the publication includes information on demographics, transition, vocational rehabilitation, and disability services.

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Introduction

The incidence of hearing loss is growing in the United States. Statistics indicate that approximately 30 million people in the U.S. have a hearing loss. As the “Baby Boomer” generation ages, the number of adults with hearing impairment is expected to increase annually. While 10% of the general population experiences hearing loss, fully 40% of those over 65 do. A recent Newsweek article (Noonan, 2005) predicted that by 2030, at least 78 million people will experience hearing loss. Coping with hearing loss on the job and in educational settings is becoming more and more of an issue for individuals as they find themselves needing to stay in the workforce longer and/or to continue their education.

The materials in this manual were developed in response to service providers’ and employers’ requests for assistance in evaluating the access needs of individuals who are hard of hearing. For better or worse, eligibility determination for people who experience hearing loss is not formulaic. Individuals who are hard of hearing fight the general misconception that they hear “pretty well” and that if they would just try harder, there would not be a problem. This lingering mindset plagues America. No one wants to be identified as having a hearing loss (as evidenced by the fact that advertising focuses on the smallest and least noticeable hearing instruments). Few want to use hearing aids (as evidenced by the small number of people who wear hearing aids as compared to the number who could benefit from them). The population at large participates in the minimalization of what it means to have a hearing loss. Even the labels used to categorize hearing loss perpetuate this myth: mild, moderate, severe, and profound. Without amplification, even a mild hearing loss affects a person’s ability to hear numerous speech sounds. However, many times individuals are deemed eligible for services only if they have a severe or profound loss, which means they can hear few, if any, speech sounds. What should be surprising is that service providers are not immune to these misconceptions about hearing loss, either, resulting in few individuals receiving much-needed communication access accommodations unless they have been diagnosed with a profound loss.

Hearing and understanding less than 100% of what is said may not be problematic in brief social interactions which require little more than a smile or nod in response. But the inability to send and receive information accurately in the classroom or the workplace can lead to failure, loss of employment, lowered earning potential, and social exclusion.

In the work or academic environment, what is the minimal amount one realistically needs to comprehend in order to succeed? What is the impact functionally to miss or have difficulty hearing 10% of speech sounds?

In researching the various topics, the authors went straight to the source—individuals who live with hearing loss and use assistive technology themselves. Three strong messages were heard repeatedly: first, need cannot be determined by an audiogram alone; second, the listening situation and environment (as well as the individual) must be taken into consideration in order to correctly determine access needs; and third, without adjustments on the part of all individuals participating in the communication process, technology alone will not solve communication access problems.

While much of the technology described here may also be used by individuals who are Deaf—that is, those who regard themselves as members of a Deaf community and use American Sign Language (ASL) or some other form of manual communication—the primary purpose of this book is to help service providers understand the needs of individuals with hearing loss who rely on oral/aural methods or print to meet their communication needs and who do not sign. While the term “hard of hearing” is often used as a label for this population, the reader should realize it does not imply a particular degree of hearing loss. Many people who obtain cochlear implants refer to themselves as hard of hearing. Clearly, at the time of this writing they would not be eligible for such implants if they were not audiologically deaf. There is a push to change this terminology to be more inclusive of the range of hearing loss by the national consumer organization for this population. Originally titled “Self Help for Hard of Hearing,” they have recently changed their name to “Hearing Loss Association of America.”

This manual is divided into three parts: **audiological considerations in the management of hearing loss, hearing assistance technology**, and **resources**. **Part I** provides the groundwork for service providers about the auditory system and hearing loss, the role of hearing healthcare professionals, best practices, and hearing aids and implantable auditory devices. There is also a sample audiological report.

Part II focuses on how to extend one’s hearing ability (aided or not) through hearing assistance technology. The first section explores communication access in terms of what information the individual with hearing loss may receive auditorily, and how characteristics of the environment will impact the individual’s ability to function. Next, the various types of communication access options are described: assistive listening devices, speech-to-text services, alerting devices, and telecommunications options. Finally, information for the service provider about determining the appropriateness of a service is offered.

Part III contains references and resources and is an extensive list of information provided to assist readers who may need more in-depth information in a specific topic area. Because these are largely websites, there is always the danger that the links will become inactive or that the web address will be sold to a different vendor. If a link does not bring up the information you expect, try using your favorite search engine (e.g., *www.google.com*) to search the title or key words. Additionally, PowerPoint presentations have been developed on many of the topics presented in this manual. You will find links to these presentations that may be useful if it is your responsibility to educate others in these areas.

While service providers and employers are the target audience for this book, the materials will be useful to individuals who themselves have hearing loss and their families. It is our sincere hope that the information presented here will assist you in making a positive difference in the life of someone with hearing loss. Feedback and comments are appreciated and may be sent to *davisc@wou.edu*.

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I. Audiological Considerations in the Management of Hearing Loss

Dave's Story

At age 43, Dave woke up one day dreading going to work. Over the past several years, he noticed that he was having increasing hearing difficulty as an employee at Exponential Computer Services. At work, Dave had a cubicle and strained to understand his customers on the phone among the dizzying number of other phone conversations going on in the same room. Dave had trouble following conversations at busy company meetings and he would miss important details and deadlines. When called upon to speak with his supervisor, Dave would pass off his difficulties as stress at home and inability to sleep well. The situation at home was no better than at work. Dave's wife would berate him for ignoring her when she called from another room. The truth, however, was that Dave simply did not hear her over the sound of the television. Dave knew he was at the end of his rope and needed to get his hearing checked out. He made an appointment that afternoon to meet with Dr. Melinda Smith, a local audiologist. Admittedly, Dave was nervous about his appointment with Dr. Smith. He knew that his father had hearing loss, but he attributed it to his father's old age. The last thing Dave wanted to learn was that he, too, had a hearing loss. Dr. Smith called Dave from the waiting area and had him follow her to a room where they discussed his concerns about hearing and collected his medical history. From there, Dr. Smith proceeded with a hearing evaluation for Dave. He was diagnosed with a moderate to moderately-severe sensorineural hearing loss, where he had more difficulty understanding high frequency sounds in speech and difficulty understanding in the presence of background noise. Dr. Smith recommended hearing aids.

Before services can be provided by vocational rehabilitation and the Student Access Center, applicants must have documentation of their hearing difficulties. From this documentation, recommendations can be made on how best to manage their hearing loss. Whether the individual comes with a long history of hearing loss or is dealing with late-onset hearing loss (as in Dave's case), many discover for the first time that their hearing health and the search for related services falls squarely in their laps. Therefore, it benefits both the individual and the service provider to learn about common characteristics associated with hearing loss and the hearing healthcare professionals with whom they may come in contact. This information will serve to empower individuals with hearing loss, prepare rehabilitation specialists to manage cases dealing with hearing loss, and provide guidelines for both groups to work with hearing healthcare professionals.

Characterizing Hearing Loss

Overview of the Auditory System

The auditory system can be divided into four major regions: outer ear, middle ear, inner ear, and auditory nervous system (Figure 1). The outer ear is made up of the auricle (visible fleshy extension on both sides of the head) and the ear canal. The outer ear primarily serves to catch sounds and funnel them through the ear canal towards the eardrum. By natural design, the outer ear provides amplification to the sounds in the human speech frequency range. The middle ear is an air-filled compartment that contains the eardrum and ossicles (three middle ear bones). The normal eardrum is sealed at its edges and effectively separates the outer and middle ears. As the name suggests, the eardrum moves as sound waves strike it. The ossicular chain includes the malleus, incus, and stapes, which transmit the movements of the eardrum to the inner ear, or cochlea. The cochlea is a fluid-filled organ containing two types of hair cells responsible for the transmission of sound to the brain. There are approximately 12,500 outer hair cells and 3,500 inner hair cells in each ear, called sensory hair cells. When the ossicles transmit the vibrations of the eardrum to the cochlea, pressure waves are set up within the structures of the cochlea. These pressure waves cause the inner hair cells to fire signals to the hearing nerve. The expansion and contraction of the outer hair cells in response to pressure waves allows for the amplification of soft sounds. Most descriptions of the auditory system stop at the inner ear, however, the ability to hear does not. Healthy hearing also depends on functioning neural circuitry from the hearing nerve to the hearing centers of the brain, called the auditory nervous system. After inner hair cells fire, the hearing nerve sends signals to various cell groupings in the brainstem and brain. It is considered that a person is first aware of having heard sound when these signals reach the brain.

Clearly, any disturbance along the auditory system pathway can result in hearing loss and/or auditory processing difficulties. The characterization of hearing loss begins with identifying the type, degree, and configuration of hearing loss, which can be readily captured by an audiogram. From the audiogram, we can begin to imagine the impact of hearing loss. All of these topics are described below.

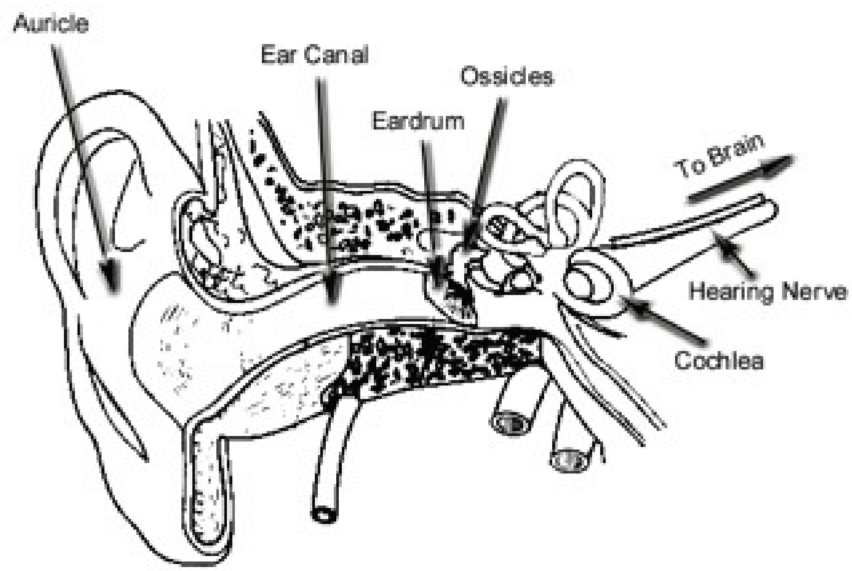

Figure 1. Anatomy of the auditory system.

Types of Hearing Loss

Conductive Hearing Loss. Conductive hearing losses (CHL) are characterized by a reduction in hearing ability despite a normally functioning cochlea. This type of hearing loss is caused by impaired sound transmission through the ear canal, eardrum, and/or ossicular chain. Conductive hearing losses are frequently temporary and/or fluctuating in nature. Ear infections and ear wax impaction are two common causes of this type of hearing loss.

Sensorineural Hearing Loss. Sensorineural hearing losses (SNHL) are characterized by decreased hearing ability due to disorders involving the cochlea and/or the auditory nervous system. This type of hearing loss is usually irreversible. Sensorineural hearing losses can be further divided into sensory and neural losses. A sensory hearing loss occurs when the damage to the auditory system is located within the cochlea. Noise-induced and age-related hearing losses are typically sensory in nature. A neural (retrocochlear) hearing loss occurs when the damage to the auditory system is beyond the level of the cochlea, ranging anywhere from the hearing nerve to the brain. A tumor on the hearing nerve can be one cause of a neural hearing loss.

Mixed hearing loss. Mixed hearing losses occur when both conductive and sensorineural components are present. As in conductive hearing losses, the conductive component of a mixed hearing loss may be temporary and/or fluctuate.

Decibels and Frequencies

When talking about sounds, we often use the terms decibel (dB) and frequency to describe them. The term decibel is a measurement of the loudness of sounds, while the term frequency refers to pitch. Increases in loudness will result in a higher decibel, and similarly, increases in pitch correspond to a higher frequency. The softest decibel level that the average (normally) hearing person can hear is about 0 dB HL.[1] It should be noted that 0 dB HL does not mean the absence of sound. Rather, it means the softest sound audible to most hearing listeners. Sounds that are uncomfortably loud both to people with normal hearing and those with hearing loss are around 100-105 dB HL. Speech tends to fluctuate between 40 and 60 dB HL in everyday conversations.

The frequency range of hearing is estimated to be between 20 and 20,000 Hertz (Hz) in young persons with normal hearing, encompassing a wide range of pitches to which we might be sensitive. Examples of low frequency (low pitch) sounds include drums and bass guitars, while high frequency (high pitch) sounds include flutes and violins. Speech sounds tend to fall in a region between 250 and 8000 Hz. During a hearing evaluation, pure tones of specific frequencies are used. In the real world, however, we often encounter complex sounds containing many frequencies.

Interpreting the Audiogram

An audiogram is a simplified graph of symbols representing the softest sounds that a person can hear across a defined range of pitches (Figure 2A). Specifically, auditory thresholds (softest detectable sounds) are plotted between -10 and 110 dB HL at octave or mid-octave intervals from 125 to 8000 Hz.

The results of a hearing evaluation graphed on an audiogram can be used to identify the type, degree, and configuration of hearing loss. Types of hearing loss, as described above, include sensorineural, conductive, and mixed. The degree (or severity) of hearing loss is calculated by taking the average of air-conduction pure tone thresholds obtained at several different frequencies and then matching that number to a category of severity. The frequencies most commonly used are 500, 1000, and 2000 Hz. Some sources include higher frequencies (e.g., 3000 or 4000 Hz) in the average in order to encompass the higher frequency speech areas.

[1] 0 dB HL (hearing level) references the softest sound intensity that stimulates normal hearing. Decibels can be measured and reported under several different conditions (e.g., intensity level [IL], sound-pressure level [SPL]). All decibel references in this manual are referring to HL.

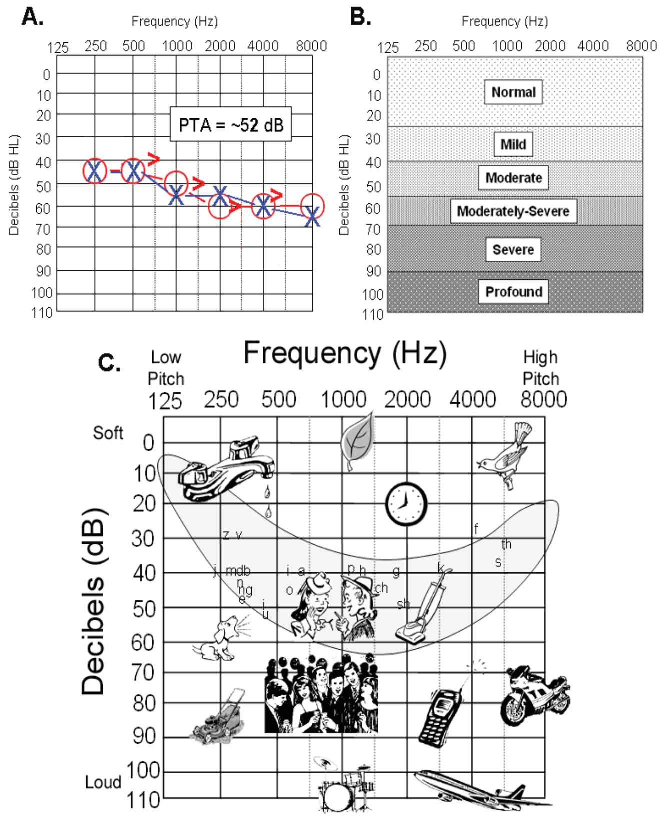

Figure 2. A. Dave's audiogram, B. Degrees of hearing loss, and C. Common sounds audiogram with speech banana.

Figure 2A shows Dave's audiogram (O = right ear, X = left ear). He has a similar loss in each ear. His pure tone average (PTA) is approximately 52 dB HL for each ear. The degrees of hearing loss are generally described as normal (< 25 dB HL), mild (26 to 40 dB HL), moderate (41 to 55 dB HL), moderately-severe (56 to 70 dB HL), severe (71 to 90 dB HL), and profound (> 90 dB HL) (Figure 2B). Calculating Dave's PTA at 500, 1000, and 2000 Hz suggests that he has a moderate hearing loss. Notice that the PTA is an average across specific, measured frequencies. It does not mean that Dave can only hear sounds louder than 52 dB HL at all frequencies. It can be seen from Figure 2A that low frequency sounds must be 45 dB or louder for Dave to hear, while high frequency sounds at 2000 Hz must be 55 dB or louder. Sometimes, the PTA is converted to a percentage in order to estimate the degree of hearing handicap.[2] Unfortunately, it is difficult to estimate the degree of hearing handicap using pure tone thresholds alone;

[2] The World Health Organization (2000) suggests that the terms "disability" and "handicap" be changed to "activity limitation" and "participation restriction."

therefore, it is not recommended that percentages be used.

Figure 2C shows an audiogram depicting on average where speech and other common sounds normally fall. The letters in Figure 2C represent either vowels (a, e, i, o, u) or consonants (e.g., z, v, j, d, b, ch, sh, k, f, th, and s). Together, the speech sounds form what is commonly referred to as the “speech banana” because of its shape. Notice the distribution of vowels and “voiced” consonants in the low and middle frequency range and “voiceless” consonants in the middle to high frequency range. Superimposing Dave’s thresholds over the audiogram in Figure 2C would suggest that he will have difficulty picking up many mid to high frequency speech sounds without hearing aids. The low frequency speech sounds are likely going to be heard but at very soft levels. The final way to analyze the audiogram is to determine the configuration (or shape) of the hearing loss (Figure 3). Each box in Figure 3 illustrates a general pattern that audiogram thresholds might follow. Careful observation would suggest that Dave has a sloping audiogram. Some individuals may have a “cookie-bite” audiogram suggesting that their low- and high-frequency hearing is much better than their middle-frequency hearing. Most individuals tend to have high-frequency sensorineural hearing losses of a sloping, noise-notched, or high frequency configuration.

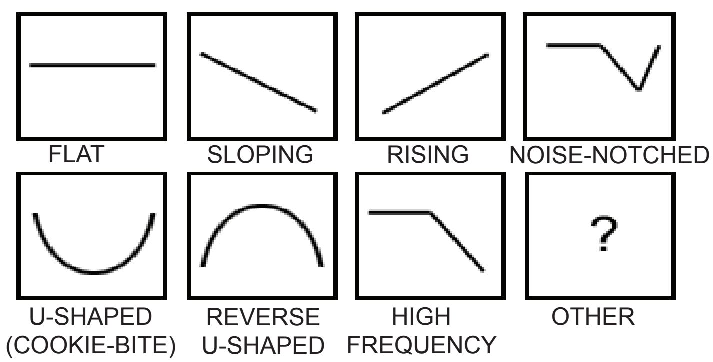

Figure 3. Configurations of hearing loss.

Limitations of the Audiogram

By itself, the audiogram cannot tell us how the individual will perform in the real world. For example, two individuals with identical audiograms may perform very differently from one another. One may be a successful hearing aid user utilizing both auditory and visual cues for communication, while the other may receive too much auditory distortion from amplification to use hearing aids successfully for speech communication purposes. While tests of speech perception (e.g., “Say the word ‘yard’”) in quiet and in noise can greatly enhance the diagnostic value of the audiogram, the results obtained in a sound booth do not always translate directly to how an individual will perform in the real world. Behavioral outcome measures such as hearing handicaps or performance questionnaires often help to shed light on real world complaints, perceived handicap, needs, and wants. These supplements to the audiogram are briefly discussed in the section titled "Best Practices in the Evaluation of Hearing and Rehabilitation."

The foregoing discussion is not meant to undermine the importance of the audiogram. Rather, the audiogram must be taken as a small piece of the entire picture of the individual with hearing loss. Age at onset of hearing loss, duration of hearing loss, specific impairment of auditory structures, use of hearing aids (or lack thereof), background experience, family dynamics, and personality profiles all contribute to behavioral differences among individuals with hearing loss. Consequently, the various hearing technologies[3] presented here have the potential to benefit individuals with hearing loss though their actual needs may differ greatly.

Impact of Hearing Loss

Hearing, or auditory processing, involves the use of many hearing skills in a single or combined fashion. The sounds that we hear can be characterized by their intensity (loudness), frequency (pitch), and timing. Impairment of any of the auditory structures can have a detrimental effect on how we perceive sounds, particularly speech sounds. Thus, hearing loss is not just the inability to detect soft sounds. With hearing aids or cochlear implants, for example, some of these abilities may be restored, but others may not. Therefore, it is unacceptable to assume that once fitted with a hearing aid or cochlear implant hearing is normal again. Also, the impact of hearing loss is not limited to just the loss of certain skills. Hearing loss may also have non-auditory effects as well.

Audibility. Perhaps the most debilitating effect of hearing loss is reduced audibility. Reduced audibility means that sounds will either be too soft or completely undetected. Without audibility, the individual can feel cut off from the world. Individuals with hearing loss who can benefit from hearing aids will have partial and sometimes full restoration of audibility depending on the degree and configuration of their hearing loss. Unfortunately, an improvement in audibility does not always mean improved speech understanding.

[3]The term "hearing technology" is a broad term that encompasses hearing aids, implantable devices, and assistive listening devices. This section covers hearing aids and auditory implantable devices, while **Part II** covers other devices that may help individuals with hearing loss.

Audibility of sounds is affected by the distance between the sound source and the listener. As a general rule, sound levels (dB) decrease by 50% for every doubling of distance from the sound source. Students with hearing loss may put themselves at a significant hearing disadvantage if they choose to sit far away from their professors.

A final aspect of reduced audibility is a limited dynamic range and loudness recruitment. For individuals with hearing loss, loudness grows rapidly from their threshold to the point of their loudness discomfort level. This is known as *loudness recruitment*. Thresholds are often elevated (poorer) in those with hearing loss, but their tolerance for loud sounds is about the same as would be expected for individuals with normal hearing. Therefore, the window of audibility (or *dynamic range*) is reduced. The effect of reduced or limited dynamic range and loudness recruitment become important issues in hearing aid fittings and cochlear implant programming.

Frequency Resolution. Individuals with hearing loss may have difficulty discriminating sounds of different frequencies. This is a result of reduced frequency resolution. The challenges are manifested by a difficulty identifying the difference between two sounds of similar frequency such as two adjacent keys on a piano and a difficulty participating in small group discussions when there are many other group discussions going on simultaneously. Also contributing to loss of frequency resolution is the fact that loud, low frequency sounds can cover up weaker, high frequency sounds. Loud, low frequency sounds can cause difficulty for both normal hearing listeners and individuals with hearing loss, and this can be noticed when trying to communicate in the campus cafeteria or at a collegiate ballgame.

Temporal Information. The sounds that we hear, although reproducible, have a finite presence. In other words, we hear them and they quickly fade away. Thus, sound has a time component. A reduction of temporal (time) resolution is evident in three ways. First, individuals with hearing loss may be unable to detect the differences in similar words such as “bad” and “dad”. The differences between the two words are only on the order of a few milliseconds in the voicing of the consonants, but these few milliseconds are critical to our ability to understand speech (Phillips, 1999). Secondly, speech sounds and noise have rapid and ever-changing fluctuations in loudness. Speech and noise often co-exist, so there may be moments when they overlap and other times when they do not. Because of the co-existence, individuals with hearing loss may be unable to catch the sounds of speech when noise levels become too high, even for brief periods of time. Lastly, reduced temporal resolution can be noted in highly reverberant conditions. Reverberation refers to a persistence of sound in an enclosure (e.g., gymnasium) as a result of the sound's reflection off hard surfaces (e.g., bare walls, windows, ceilings, and floors). Reverberant rooms have the effect of creating multiple copies of the same sounds. It has been shown that individuals with sensorineural hearing losses have poorer speech understanding abilities in reverberant conditions compared to those with normal hearing (Irwin & McAuley, 1987).

Binaural Hearing. Having two ears with comparable function has been shown to provide several advantages over having one functional ear alone. In general, these advantages often translate well to the use of two hearing aids, two cochlear implants, or having assistive listening device input to both ears. First, an identical input at both ears can result in the perception of sounds being twice as loud when compared to having the same input in one ear alone. The perception of sound doubling as the result of using two ears is called *binaural summation*. Second, *sound localization*, or the ability to identify where a sound is coming from, requires two ears. The brain uses differences in sound intensity, frequency, and timing to determine where a sound is coming from. Finally, because speech and noise often co-exist, binaural hearing can permit an increase of 2-3 dB of speech (signal) over the noise (or signal-to-noise ratio). Thus, individuals with significant hearing loss in one ear, or those who use only one hearing aid, for example, may be putting themselves at a greater disadvantage than they would if they had input to both ears. Bess and Tharpe (1984) have reported that children with unilateral hearing loss are more likely to fail a grade level than children with two normal hearing ears. An evidenced-based literature review (1966 to 2003) on the effects of unilateral hearing loss suggests that there is a 22% to 35% rate of students repeating at least one grade (Lieu, 2004). In addition, Lieu (2004) reports that between 12% and 41% of students receive some form of educational assistance and many students exhibit delays in speech and language development. This suggests that college students with unilateral hearing loss may have difficulty despite the fact that they have one good ear. Consumers should not underestimate the importance of aiding both ears when a loss is present in each.

Psychosocial Aspects of Hearing Loss and Related Health Issues. Hearing loss has the potential to reduce psychosocial functioning and can lead to increased feelings of isolation, depression, loneliness, anger, fear, frustration, and disappointment (Crandall, 1988; Bess et al., 1989). When psychosocial function is reduced, the individual's physical health may also be affected (Lichtenstein et al., 1988; Mulrow et al., 1990). Evidence for improved psychosocial functioning, quality of life, and health status can be seen in numerous reports of the use of hearing aids and cochlear implants (Cohen et al., 2004; Mo et al., 2005).

Fatigue. Any difficulty in hearing can lead to a greater reliance on vision and increased listening effort for speech understanding. *Speechreading* involves using both visual cues and auditory cues for the purpose of understanding speech. Unfortunately, speechreading does not come easily to everyone with hearing loss, and some may never reach fluency. Whether an individual speechreads well or not, listening becomes more of an active process. An incredible amount of energy is expended in listening alone and it is common for individuals with hearing loss to feel physically drained by the end of the day. Students who speechread in class may need preferential seating (e.g., front row seating or side seating) in order to have optimal communication access. It may also help students with hearing loss to schedule long breaks between their classes to curb fatigue.

Tinnitus. When the sensory hair cells of the cochlea are damaged, sometimes the individual with hearing loss may experience tinnitus. Tinnitus is perceived as a ringing, roaring, clicking or chirping sound that originates somewhere in the head. It may be fluctuating or constant, and it may be in one or both ears. For most, tinnitus is not a problem. However, for some, tinnitus may be so severe that it affects their quality of life (Møller, 2000; Brown, 2004). Individuals with severe tinnitus have complained of inability to concentrate, inability to sleep, and loss of motivation. Severe tinnitus has torn families apart and, in rare cases, has led to suicide. Tinnitus may also be a sign of a significant medical problem. Therefore, if tinnitus is ever bothersome, an audiologist or otolaryngologist should be seen.

Balance Disorders. In some cases, individuals with hearing loss may also have balance disorders. The fluid-filled inner ear houses not only sensory cells responsible for hearing (i.e., the cochlea), but also sensory cells that help us maintain head and body positions while standing and while in motion. The sensory cells in our inner ears work in close conjunction with muscles controlling the eyes and muscles in our neck, torso, and ligaments. Some persistent balance disorders are only apparent during motion, such as getting up out of a chair or while driving. Other balance disorders may arise during fluid disturbances in the inner ear as a result of Meniéres disease and Endolymphatic Hydrops. During Meniéres or Hydrops attacks, the individual may feel dizzy, nauseous, and unable to move until the attack is over. Any time there is concern about balance, an audiologist or otolaryngologist who specializes in balance disorders should be consulted.

Role of Hearing Health Care Professionals

Hearing health care professionals play key roles in the management of hearing loss. It is important that a professional perform a comprehensive hearing evaluation on anyone who has concerns about his or her hearing. Hearing evaluations should also be performed annually or any time a change in hearing is noticed in order to monitor hearing levels. When hearing changes, accommodation needs may also change. The hearing professional will be able to thoroughly explain the hearing evaluation results and recommendations to the individual as well as to vocational rehabilitation and the Student Access Center. The hearing evaluation is the first step in the aural rehabilitation process; therefore, it should be performed by a qualified professional.

Audiologists

Audiologists are independent healthcare providers who are specially trained and qualified to provide a comprehensive array of services to individuals with hearing and balance disorders. These services include the identification, assessment, diagnosis, treatment, and prevention of hearing and balance impairments. Many audiologists specialize in specific areas of the field and partake in research related to their area of expertise.

To help individuals with hearing loss, audiologists select, fit, and dispense hearing aids and other assistive listening devices. Audiologists also program implantable devices and provide aural rehabilitation to individuals receiving these devices. Audiologists work very closely with other medical professionals including primary care physicians, otolaryngologists, neuro-otologists, oncologists, speech-language pathologists, occupational and physical therapists, and psychologists. When the hearing or balance problem requires medical or surgical evaluation or treatment, audiologists refer patients to physicians.

Audiologists hold master's or doctoral degrees in audiology. Audiology is currently transitioning to a doctoral-level profession. Effective January 1, 2012, all new audiologists entering the workforce will be required to have a doctoral degree. All fifty states regulate audiologists via licensure or registration requirements.

Audiometrist/Audiometric Technicians

Audiometrists are technicians who work under the supervision of an audiologist or otologist and are trained in the use of an audiometer to establish hearing thresholds.

Hearing Instrument Specialists

Hearing instrument specialists (HIS), also known in some states as hearing instrument dispensers (HID) or hearing aid dispensers (HAD), are individuals who dispense or fit hearing aids. Dispensing hearing aids involves assessing hearing solely for the purpose of selecting, fitting, and selling hearing aids which are intended to compensate for impaired hearing. Individual states have different entry level requirements for licensing fitters or dispensers of hearing instruments. However, the nationally accepted credential for hearing instrument specialists is certification by the National Board for Certification in Hearing Instrument Sciences (NBC-HIS).

Otolaryngologists

Otolaryngologists are commonly referred to as ear, nose, and throat (ENT) physicians. ENTs hold medical degrees and are specially trained in the medical and surgical treatment of patients with diseases and disorders of the ear, nose, and throat as well as related structures of the head and neck. ENTs are able to prescribe medications and perform surgery including cochlear implantation. Otologists and neuro-otologists are otolaryngologists who have received advanced fellowship training in diseases and disorders of the ear.

Vendors

Vendors provide consumers with communication products in a retail environment. Communication equipment including TTYs, amplified telephones, signalers and vibrating clocks, personal FM systems, hearing protection devices, and hearing aid accessories are commercially available from a variety of companies. The products available through vendors do not require a prescription from an audiologist, hearing instrument specialist, or physician, making them very convenient to the public.

Mail Order or Online Hearing Aid Sales

Consumers should be cautious of both mail order and online hearing aid sales. In most cases, purchasing hearing aids in this manner does not provide any of the essentials needed for the successful management of hearing loss. In fact, some mail order and online companies do not require so much as a hearing test prior to purchasing. When working directly with hearing health care professionals, consumers receive appropriate evaluation, referral for medical treatment (if and when necessary), instruction in the proper care and use of hearing aids, follow-up service, as well as other rehabilitation services. Unfortunately, these crucial aspects of hearing healthcare may be eliminated when purchasing mail order or online hearing aids.

It is important that consumers do their research if they plan to purchase an amplification device in this manner. In many situations, there is no time or money saved due to the additional (sometimes hidden) charges for necessary options including an extended warranty, directional microphone, telecoil, or power aid. Consumers should also be aware of the fact that many audiologists and hearing instrument specialists may not adjust or service hearing aids that were purchased through the mail or online as they may be inappropriate for the individual's hearing loss.

Regardless of where hearing aids or other amplification devices are purchased, it is important to see a hearing health care professional first. The importance of proper follow-up care with such a professional cannot be stressed enough. This should not be overlooked when purchasing mail order or online hearing aids.

Best Practices in the Evaluation of Hearing and Rehabilitation

Dave admitted to being disappointed at the results of his hearing evaluation, but he was determined to do whatever it took to get back to easier communication with his co-workers, customers, and family. Dr. Smith asked some questions to identify Dave's potential listening situations, and they selected a set of hearing aids most appropriate for his needs. Because Dave was frequently in meetings, on the phone, and was around a lot of noise, Dr. Smith selected behind-the-ear (BTE) digital hearing aids with directional microphones, a noise reduction circuit, a feedback circuit, a telecoil, and custom earmolds. Additionally, Dr. Smith indicated that Dave might also benefit from several types of assistive listening devices which would work with his hearing aid telecoils to help him understand speech better at meetings and in noisy situations. He decided to also try a separate hand-held microphone system that transmits directly to his hearing aids. A week later, Dave returned to see Dr. Smith for the fitting and programming of his new hearing aids and transmitter-microphone. Dr. Smith demonstrated how the directional microphones worked for meetings and noisy places and how the telecoils enhance speech on the telephone. She also described other situations in which the transmitter-microphone may be appropriate. During the first week of Dave's return to work with his new devices, he experienced greater listening ease with his new hearing aids, and the transmitter-microphone was especially helpful at meetings. With his telecoils, he didn't have to strain to understand his customers over the phone! He was also surprised how accepting his co-workers and family members were of his new devices. What he hadn't realized was the stress and challenge others had experienced in communicating with him.

Hearing Evaluation

A comprehensive hearing evaluation is the first step in the aural rehabilitation process. The evaluation should begin with an in-depth case history in which the hearing health care professional asks questions related to the individual's medical history, family medical history, noise exposure, medications, and anything else associated with the primary complaint. We believe that the minimum test battery should include the following: otoscopy, immittance testing, pure tone air- and bone-conduction testing, speech reception threshold testing, and word recognition testing.

Otoscopy involves inspection of the ear canal and eardrum with an otoscope. An otoscopic examination should also include inspection of the individual's entire head, neck, and outer ear. Findings during otoscopic examination should be reported on the audiogram or in the hearing evaluation report. *Immittance testing* includes tympanometry and acoustic reflex testing. The battery of immittance measurements are designed to assess middle ear function and aid in the identification and classification of middle ear disorders. In addition, immittance testing provides some information regarding disorders of the auditory and related nervous systems. Pure tone testing is used to determine the type, degree, and configuration of the hearing loss and is evaluated via both air- and bone-conduction. Headphones or insert earphones are used to present the different tones during air-conduction testing whereas a bone oscillator placed behind the ear (on the mastoid bone) is used during *bone-conduction testing*. *Air-conduction testing* determines the degree and configuration of hearing loss while bone-conduction testing determines the type of hearing loss present by comparing air- and bone-conduction thresholds. A significant difference between air- and bone-conduction scores would suggest a conductive hearing loss. A *speech recognition threshold* (SRT) is the lowest level at which 50% of two-syllable spondee words (e.g., baseball) can be identified correctly. Like pure tone thresholds, speech reception thresholds are measured in decibels (dB HL) and should correspond closely to the pure tone average (PTA) discussed previously in this section. *Word recognition testing* is performed in order to obtain a measure of one's ability to identify monosyllabic words (e.g., yard) presented in a quiet environment. The word recognition score is based on the percentage of words correctly understood.

The above tests are considered to be part of the *minimum* recommended test battery. In some cases, additional testing may be warranted. These tests may include, but are not limited to, otoacoustic emissions (OAE) testing, auditory brainstem response (ABR) testing, and central auditory processing ([C]APD) evaluations. OAE testing provides objective information about the integrity of the outer hair cells within the cochlea. ABR testing is an objective measure that provides an estimation of hearing sensitivity as well as an assessment of the integrity of the hearing nerve and brainstem auditory pathways. (C)APD testing provides information about the integrity of numerous levels of the auditory nervous system and other higher-order processes.

Hearing Aid Evaluation

After the hearing evaluation has been performed and it is determined that an irreversible hearing loss is present, a hearing aid evaluation should be scheduled. This evaluation should include additional pure tone and speech testing to determine the most comfortable listening levels (MCL) as well as the uncomfortable listening levels (UCL). These measures are necessary for a successful hearing aid fitting. This information ensures that a hearing aid will never amplify sounds to the point of being uncomfortable or painful.

During the hearing aid evaluation, the individual's communication needs and wants should be assessed. It is important to identify his or her perceived social and emotional consequences of hearing loss. Several scales of communication function are available including the Abbreviated Profile of Hearing Aid Benefit (APHAB; Cox & Alexander, 1991), Client Oriented Scale of Improvement (COSI; Dillon, James, & Ginis, 1997), and the Hearing Handicap Inventory for Adults (HHIA; Newman, Weinstein, Jacobson, & Hug, 1990 – available online at *http://orders.oip.msu.edu/product_p/445.01.htm)*.

Amplification options including the various hearing aid styles and the latest technological advances should be presented at the evaluation. A telecoil (or T-coil) is an electrical component that can be added to many hearing aids that permits the user to couple the hearing aid with audio devices such as telephones and headphones. It is strongly recommended that telecoils be included with all hearing aids (Ross, 2004), though there may be situations prohibiting the inclusion of telecoils. If earmolds are to be made for use with behind-the-ear hearing aids, their impressions should be made properly and the appropriate earmold style should be selected. Care in taking earmold impressions and selecting appropriate styles will optimize earmold and hearing aid fit (Ingrao, 2005; Pirzanski & Berge, 2003). Hearing aids and other assistive listening devices should be selected based on the individual's type, degree, and configuration of hearing loss; but more importantly, they should address the information gathered during the needs assessment.

During the hearing aid evaluation, it is important that the individual be informed that the U.S. Food and Drug Administration (FDA) has determined that it is in his or her best health interest to have a medical evaluation by a licensed physician (preferably a physician who specializes in diseases of the ear) before purchasing a hearing aid to check for any of the following conditions:

1. Visible, congenital, or traumatic deformity of the ear
2. History of active drainage from the ear within the last 90 days
3. History of sudden or rapidly progressive hearing loss within the last 90 days
4. Active or chronic dizziness

5. Unilateral hearing loss of sudden or recent onset within the last 90 days
6. Audiometric air-bone gap equal to, or greater than, 15 decibels at 500 Hz, 1000 Hz, or 2000 Hz
7. Visible evidence of earwax (cerumen) or any foreign body in the ear canal
8. Pain or discomfort in the ear

Federal law allows fully-informed individuals age 18 and older to sign a waiver declining the medical evaluation. The audiologist or hearing instrument specialist may refer the individual to a physician before the hearing aid evaluation.

Hearing Aid Fitting

During the hearing aid fitting, the actual physical fit of the device should be verified. Hearing aids should never cause physical discomfort to the user. The hearing aids will then be programmed and adjusted to meet the individual's specific hearing needs.

The difference between the aided and unaided response is called the *functional gain*. Functional gain testing alone is not an appropriate method of assessing new hearing aid technology. Functional gain or "aided" testing is a hearing aid verification procedure that was used routinely in the past. This testing method is performed in a sound booth environment and utilizes behavioral testing to assess hearing aid performance.

Real ear measures (REM) should be performed to verify hearing instrument function. In this test, a tiny microphone is placed in the ear canal next to the earmold or hearing aid in order to measure the performance of the hearing aid in the individual's ear. Responses are analyzed to determine the audibility of different sounds. Unlike functional gain testing, these measures provide information about the audibility of speech signals as well as maximum sound pressure levels delivered to the ear.

Proper care, use, and maintenance of the amplification device should all be explained during the fitting appointment. Follow-up appointments are a necessary part of the aural rehabilitation process as well. Hearing aids and other assistive listening devices may need to be fine-tuned and additional testing may be necessary. Kits that help keep hearing instruments free from moisture and reduce breakdown are recommended (e.g., like those found at *www.dryandstore.com*). Wearing hearing aids for the first time will likely be overwhelming. For some, psychosocial adjustment training may be necessary. This is a time to discover what the individual's attitudes may be toward his or her hearing loss and the use of hearing aids, and a time to help the individual deal with misconceptions and dissonant thinking with respect to hearing loss. Communication strategies may need to be taught to new users, especially for use in challenging listening environments. Whenever someone wears hearing aids for the first time, or receives a new set of hearing aids, the brain must be retrained to adapt to the new input. Listening demands are likely going to change as the individual learns to listen with his or her hearing aids. Because of this, it is important to obtain regular follow-up care.

Audiologic Report

A thorough, clearly written audiologic report is a critical piece of the rehabilitation puzzle. Hearing health care professionals should be able to provide the individual with a written report that includes both the results and recommendations from his or her hearing evaluation. The results should confirm hearing complaints and the recommendations should offer a suggested course of action. The individual can then sign a release of information form in order for the results to be sent to vocational rehabilitation agencies, Student Access Centers, and aural rehabilitation programs. (Dave's sample audiological report is provided at the end of **Part I**.)

Aural Rehabilitation

Aural (or audiologic) rehabilitation includes any effort intended to minimize and/or alleviate the effects that hearing loss may have on communication. Audiologists work to provide their consumers with the support needed to maximize the use of their residual hearing. Aural rehabilitation services focus on helping individuals adjust to their hearing loss. Topics include how to communicate effectively and overcome communication breakdowns, use and care of hearing aids, and use of assistive listening devices. During rehabilitation, users can learn about other assistive devices that preserve or increase independence (e.g., vibrating alarm clocks). Aural rehabilitation may be provided individually, in small groups, or in a combination of both. Even those with longstanding hearing losses can benefit from aural rehabilitation as hearing technology is always being developed or improved. Table 1 summarizes the recommendations for the best hearing evaluation practices.

Table 1. Best Practices

Hearing Evaluation

Minimum Test Battery
- Otoscopy
- Immittance (tympanometry and acoustic reflexes)
- Pure tone air- and bone-conduction audiometry
- Speech recognition threshold testing
- Word recognition testing

Special Tests (as needed)
- Otoacoustic emission (OAE) testing
- Auditory brainstem response (ABR) testing
- Central auditory processing ((C)APD) testing

Hearing Aid Evaluation

- Most comfortable listening (MCL) and uncomfortable listening levels (UCL)
- Needs assessment (APHAB, COSI, or HHIA)
- Amplification options including hearing aids and assistive listening devices
- Medical evaluation or medical waiver

Hearing Aid Fitting

- Real-ear measures
- Proper care, use, and maintenance
- Follow-up care

Aural rehabilitation

- Psychosocial adjustment
- Communication strategies

Hearing Aids and Auditory Implantable Devices

Hearing Aids

Because of the reduced dynamic range and loudness recruitment common in individuals with hearing loss, hearing aids must amplify soft sounds greater than they do loud sounds. The conventional use of the term *hearing aid* usually refers to a device that is coupled to the ear and any previously inaudible sounds are captured, amplified, and directed at the eardrum. Thus, hearing aids rely on all the parts of the ear and attempt to deliver as clear a sound to the damaged ear as possible. In general, the greater the severity of the hearing loss, the greater the need for amplification.

In this section, various styles, types, and features of hearing aids are described. Some of the features depicted in this section also pertain to auditory implantable devices. As the various features of hearing aids are described, it is important to keep in mind that an individual's success with hearing aids may depend on a large number of factors, and only some relate to the hearing aid itself. Specifically, there is no "one-size-fits-all" solution for everyone. Additionally, users may have particular preferences for certain styles or types of hearing aids that may not be appropriate for their hearing loss or ear size. In sum, the selection of hearing aids will depend on the primary hearing difficulties, the type, degree, and configuration of hearing loss, the individual's listening needs and wants, and the availability of technology. Table 2 delineates the various styles, types, and features that are described below.

Hearing Aid Styles. Hearing aids come in several styles (Figure 4) to meet individual lifestyles. The styles from largest to smallest include: behind-the-ear (BTE), in-the-ear (ITE), in-the-canal (ITC), and completely-in-the-canal (CIC). The latter three are typically called *customized hearing aids*, because the hearing aid components are fit into a cast of the individual's own ear. A BTE is the only style that requires an earmold to deliver the sound from the hearing aid to the ear canal. The newest style of BTE on the market is called an open fit hearing aid. Open fit hearing aids are designed for those with high frequency hearing loss and normal to near normal thresholds in the low and middle frequency ranges. This type of hearing aid keeps the ear canal open in order to reduce a plugged-up sensation. With open fit BTEs, the traditional earmold is replaced with a thin tubing and dome-like (or customized) attachment that fits in the ear canal. For other

Table 2. Hearing Aid Features

Style
- Open fit
- Behind-the-ear (BTE)
- In-the-ear (ITE)
- In-the-canal (ITC)
- Completely-in-the-canal (CIC)

Types
- **Processing**
  - Analog
  - Digitally-programmable analog
  - Digital
- **Non-Traditional**
  - Bone-conduction hearing aid
  - CROS/BiCROS
  - Frequency compression/transposition

Available In Most Hearing Aids (Analog or Digital)
- Telecoil
- Directional microphones
- Venting

Available In Only Digital Hearing Aids
- Noise reduction/suppression
- Adaptive directionality
- Feedback cancellation
- Automatic telecoil

hearing aids, the style that is chosen will depend on several factors. First, the audiologist or hearing instrument specialist will need to assess the individual's communication needs, and may ask "Will a telecoil for use with assistive listening devices be required? Will the individual benefit from directional microphones?" Telecoils, directional microphones, and other related components require space in the hearing aid. Therefore, in some cases a larger hearing aid style is needed to house all the components and to maximize benefits for the user. Second, the hearing aid style that is chosen may depend on the size and shape of the ear canal. If the ear canal is too small or too curvy, a larger hearing aid style may be required. Third, does the individual have a tendency to produce a lot of ear wax (cerumen)? Hearing aid styles that sit in the ear tend to have a higher risk of breakdown when excessive ear wax is present as opposed to BTE styles. With BTEs, only the earmold is exposed to ear wax, and it can be easily cleaned by the user. Finally, does the individual have a tendency to misplace things or have difficulties with vision or dexterity? Hearing aids that are larger in size are generally easier to handle, change batteries, clean, and operate.

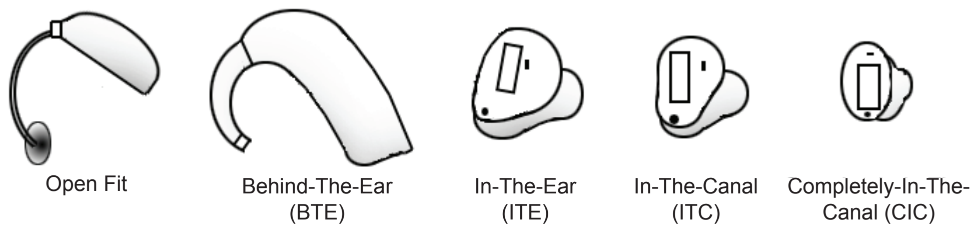

Figure 4. Hearing aid styles.

Analog versus Digital Hearing Aids. Minimally, all hearing aids contain a microphone (also called a "mic"), amplifier, receiver (a small speaker) and power supply. The microphone picks up the incoming acoustic signal from the environment and converts it to an electric signal. The amplifier takes the electric signal and makes it louder. The receiver takes the magnified electric signal and converts it to an acoustic signal to be directed at the eardrum. The amplifier is perhaps the most critical aspect of the hearing aid because it has the ability to make both the voltage and current stronger proportionate to the size of the battery used.

Hearing aids fall into three broad categories: analog, digitally-programmable analog, and digital. All three types contain a microphone, amplifier, receiver, and power supply. Analog hearing aids rely only on electrical parts and controls to manipulate the incoming signal. Digitally-programmable analog hearing aids work similarly, but are programmed and adjusted using computers. Some drawbacks of analog technology include potential distortion, greater internal noise, and much less flexibility in fine-tuning the acoustic signal for the hearing aid user. Digital hearing aids have built-in chips that function like computers. These chips perform fast calculations and are capable of performing multiple sophisticated tasks. Some high-end digital hearing aids have multiple programs (or memories) and some can perform data logging. Having *multiple programs* permits the hearing aid to have different processing strategies for different listening situations, such as a quiet classroom versus a cafeteria. *Data logging* is a feature in which the auditory environment is constantly sampled and stored in the hearing aid. Data logging permits the audiologist or hearing instrument specialist to assess the types of listening situations the individual experiences in his or her daily life. This information may be useful to adjust the hearing aids later and optimize the use of the programs for the most common listening situations.

There is at least one major caveat with digital hearing aids. Long-term users of analog hearing aids may have difficulty adjusting to a digital hearing aid. This difficulty may be because they are used to the sound quality offered by analog hearing aids. What digital hearing aids attempt to improve (i.e., the reduction of background noise), may be perceived by the analog user as a loss of sound volume. Fortunately, some digital hearing aids can be programmed to behave very much like analog hearing aids when needed.

At this point, it is necessary to understand three things. First, both analog and digital hearing aids come in all styles except for the open fit style, which is digital only (Figure 4). Second, both analog and digital hearing aids can have telecoils, directional microphones, and multiple channels. Certain features such as data logging, noise reduction, feedback cancellation, and multiple programs are only available in digital hearing aids. Finally, many hearing aid manufacturers are likely going to eliminate analog hearing aids in the future. In fact, many have already begun to phase them out of their product lines.

Channels. Both analog and digital hearing aids can divide the incoming signal into different frequency regions so that they can be manipulated independently of one another. This is particularly useful when the configuration of hearing loss is not flat (i.e., the dB loss is not equal across frequencies) (see Figure 3). Equally important is the need to allow the hearing aid to amplify certain regions, such as those that carry speech (primarily mid-to-high frequencies), while minimizing the amplification of regions that carry background noises (primarily low frequencies). These independent regions or channels are recombined before they leave the hearing aid's receiver. The number of channels varies among hearing aids and among their manufacturers. Hearing aids with more channels are generally more expensive. They provide greater flexibility in fitting the hearing aid more closely to the hearing loss. For those in complex listening environments, hearing aids with multiple channels may be just what is needed for success.

Telecoil. A telecoil is a small coil of wire that produces voltage when a magnetic field flows through it creating an electric current that has the same pattern as the incoming signal. Many audio devices[4] generate magnetic fields as a by-product. Users of hearing aids with telecoils benefit significantly from them. When the magnetic field of the audio device reaches the telecoil, the telecoil intercepts the signal and the hearing aid components amplify the signal according to the individual's hearing loss. When the telecoil is used, the hearing aid's microphone is typically turned off. This enables the user to enjoy sound from an audio device without being distracted by excessive background noise.

User access to a telecoil may vary with different hearing aids. Some telecoils are started simply by flipping a tiny lever (also called a T-switch) from M (microphone) to T. In some digital hearing aids, the user may have to press a button to change to the telecoil program. Some sophisticated digital hearing aids automatically switch to telecoil in the presence of a strong magnetic field, such as a phone earpiece. Telecoils also allow hearing aid and cochlear implant users to take advantage of assistive listening devices, which can provide additional assistance when listening in noise. These devices are discussed in **Part II**.

Noise Reduction. A common complaint of hearing aid users is the interference of background noise. Whenever hearing aids are used, both desired speech and unwanted noise are amplified. This is an inevitable problem even with the most sophisticated hearing aids (Levitt, 2001). Noise reduction (or noise suppression) is one solution to minimizing this annoyance to amplified sounds. Interestingly, Palmer, Bentler, and Mueller (2006) have indicated that normal hearing listeners are just as annoyed by noise as hearing aid users. Improving room acoustics would be of benefit to everyone.

Because speech and noise overlap when they enter a microphone, any attempt to reduce the noise is likely to reduce parts of speech as well. The simplest form of noise reduction is amplifying low-frequency sounds less than mid- and high-frequency sounds;

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[4] It should be noted that some digital cell phones may be problematic for both analog and digital hearing aid users. Digital cell phones operate using radio waves, which generates a pulsing magnetic field around the antennae. This is perceived by the hearing aid user as a buzzing sound. Another source of interference comes from the backlight display. Interested readers are directed to: *http://tap.gallaudet.edu/Voice/DigitalCellFAQ.asp*.

however, some of the lower frequency components of speech may become inaudible. Hearing aid manufacturers are always trying to develop ways to reduce noise. Success will depend upon the component's ability to truly separate speech from noise, or at least to predict the composition of noise. Nonetheless, current noise reduction features offer listening comfort in noisy situations for many individuals.

Directional Microphones. A solution for the enhancement of speech in the presence of background noise is the use of directional microphones. Such hearing aids have a microphone facing the front and one facing the back. These microphones can be activated differently depending on the listening situation. Because background noise is generally similar in front of the user as it is behind, directional microphone technology has the ability to detect signals common to both microphones and attempt to reduce it. Research by Amlani (2001) suggests that directional microphones provide statistically significant advantages over single microphone hearing aids.

There are three potential drawbacks to directional microphones. First, the hearing aid user must face the source of the sound he or she wishes to listen to. When a group meets in a noisy environment, the hearing aid user will have to readjust his or her head or body position with each new speaker particularly if he or she is to the side. A second potential disadvantage is a situation where the hearing aid user is facing a speaker but another speaker is directly behind the user at some close distance, such as a small group discussion in a large class. A hearing aid with directional microphones may not be able to effectively amplify the speaker in front because of the competing speaker directly behind the user. A final drawback is a decrease in the benefits of directional microphones in reverberant conditions involving echoes (Studebaker, Cox, & Formby, 1980; see also section "Temporal Information"). Regardless, directional microphones do work in the right situations and have increased user satisfaction and communication (Kochkin, 1996). Newer directional microphone processing technologies have been designed to track moving sources of background noise and minimize them with some success. Research has shown that directional microphones are more effective than noise reduction, but the two in combination provide better results for the user in noise compared to either one alone (Chung, Zeng, & Waltzman, 2004).

Boots, DAI, FM, Bluetooth, and Wireless Setups. Telecoils are not the only way to extend the versatility of hearing aids. At the request of the hearing aid candidate or at the suggestion of the audiologist or hearing instrument specialist, hearing aid styles can be selected with the option of coupling them in some way to audio and assistive listening devices. Some hearing aid styles directly couple audio devices to the hearing aid's circuitry by direct audio input (DAI), or by a separate part that attaches to the back of a hearing aid called a *boot*. More recently, by using frequency-modulated (FM) type systems and Bluetooth technology either by an internal electronic part or small boot, many hearing aid users have enjoyed wireless forms of connecting audio and assistive listening devices.

Earmolds. In order to deliver amplified sounds to the ear, the hearing aid must be coupled in some way to the outer ear. Behind-the-Ear (BTE) hearing aids require a separate earmold, which is an acrylic, vinyl, or silicone cast of the user's ear. The earmold has a piece of clear rubber tubing that is connected to the hearing aid that sits on top of the ear. The earmold is the most critical component in the success of hearing aid fittings (Ingrao, 2005; Pirzanski & Berge, 2003). A poorly made or poorly selected earmold style may cause pain in the ear canal, create unnecessary feedback, cause an intolerable occlusion effect (i.e., a plugged up sensation), or may cause hearing aid performance to go down. Some earmolds may have to be modified by the audiologist or hearing instrument specialist to create a more comfortable fit.

Feedback Cancellation. When earmolds or custom hearing aids do not fit well or have not been designed or selected appropriately, feedback can occur. Hearing aid feedback is a whistling sound created that can annoy others and embarrass the user. Feedback occurs any time the amplified sound coming out of the receiver re-enters the microphone. (The hearing aid user may not be aware of the whistle, depending on his or her hearing loss.) As a result, the hearing aid increasingly amplifies the sound leak causing the hearing aid to whistle. When this occurs, most hearing aids wearers will turn down their volume control, which puts them at a disadvantage without the amplification they need. For most hearing aid users, some leakage of sound will happen, but it will not lead to feedback if the exiting sound is no louder than the incoming signal. Therefore, it is not necessary for all hearing aid users to have a tight-fitting earmold (or customized hearing aid). Generally, the greater the hearing loss, the tighter the fit required. It should be noted that some digital hearing aids have a feedback cancellation (or feedback resolution) feature that permits the hearing aid to catch any sources of feedback and minimize it with little effect on the overall gain and sound quality. Vinyl or silicone earmolds need replacing about once a year or when significant changes in hearing occur to minimize the likelihood of feedback.

Venting. Some earmolds and custom hearing aids have open ports called vents to minimize the perception of ears feeling blocked (i.e., the occlusion effect). A simple experiment will illustrate the need for venting. Try speaking with your fingers in your ears and then with your fingers out of your ears. Notice how you perceive the sound of your voice inside your head with your fingers in your ears. For many hearing aid users, this sound is annoying. Adding vents relieves the hearing aid user of some of the occlusion. There is a tradeoff: greater hearing losses require a smaller vent (or no vent at all) or the hearing aid will create feedback.

Non-Traditional Hearing Aids. Some non-traditional, but important types of hearing aids include bone-conduction hearing aids, CROS or BiCROS hearing aids, and frequency compression and transposition hearing aids. Bone-conduction aids deliver sound directly to an otherwise normal cochlea in the presence of conductive hearing loss. These instruments require an elastic, metal headband with a bone oscillator that is placed directly on the skull behind the ear. CROS (contralateral routing of signals) or Bi (bilateral) CROS hearing aids are designed to deliver sounds from an unusable and unaidable ear on one side of the head to the ear with better hearing (i.e., with normal hearing or some hearing loss). Finally, frequency compression and transposition hearing aids attempt to shift otherwise inaudible high frequency sounds to a frequency range where hearing is better (typically a lower frequency) (Andersen, n.d.; Parent, Chmiel, & Jerger, 1997). In other words, the hearing aid user will hear high frequency sounds but at a lower pitch.

Auditory Implantable Devices

Miniaturization of technology, improved understanding of how the hearing mechanism works, and advances in surgical techniques have paved the way for the use of auditory implantable devices for partial restoration of hearing. The devices described in this section include:

- Cochlear implants (CI)
- Bone-anchored hearing aids (BAHA)
- Middle ear implants (MEI)
- (Penetrating) Auditory brainstem implants (ABI/PABI)

Motivated patients who meet strict candidacy criteria will have their auditory device surgically implanted by an otolaryngologist and programmed by an audiologist. Following implantation and subsequent programming, some individuals may require extended periods of auditory rehabilitation while others perceive immediate benefits. Below is a brief description of each device, its associated candidacy criteria, the implant procedure, and expected outcomes. Because of the widespread use of cochlear implants, it will be introduced first and in greater depth and will be followed by a discussion of bone-anchored hearing aids. A discussion of middle ear and auditory brainstem implants will follow.

Cochlear Implants. Cochlear implants (CI) are considered by many to be the most successful of all available prosthetic devices for those with auditory impairments (Møller, 2001). Service providers should be aware of the access needs of cochlear implant users as their numbers are growing dramatically. In the US alone, there are about 37,000 CI users (National Institute on Deafness and other Communication Disorders, 2005) and approximately 3,000 surgeries are performed each year.

The success of implantation is due primarily to the shape of the cochlea and the arrangement of the auditory nerve fibers that innervate the sensory hair cells throughout the cochlea. Cochlear implants are designed to bypass the cochlea when most sensory hair cells are damaged, missing, or have inappropriate connections with the hearing nerve. This is typically evidenced by lack of benefit from hearing aids, regardless of how loud the hearing aids have been turned up. The multiple-electrode array that is surgically inserted into the cochlea will ultimately stimulate the surviving auditory nerve fibers of the hearing nerve. In this way, a connection to the hearing centers of the brain is re-established and partial hearing is restored. Given time, most CI users experience appreciable advantages over their hearing aid use.

The candidacy criteria for cochlear implants have evolved over the years due to advances in both hardware and software technology. With this in mind, cochlear implant candidacy often revolves around three basic questions:

- Are there any medical or health inconsistencies or physical problems with the auditory structures that prohibit cochlear implantation?
- Will the individual receive more benefit from the cochlear implant as compared to hearing aids or no prosthesis at all?
- Does the individual have a strong support system of family, friends, and

professional services as well as appropriate motivation and reasonable expectations?

These questions are often addressed by a team comprised of a surgeon, audiologist, and psychologist. Other members of this team may include educators, disability counselors, and vocational rehabilitation specialists. Current guidelines permit adults to undergo cochlear implantation if their open-set sentence recognition abilities are 50-60% or less with appropriately fitted hearing aids. An open-set test item is one in which words or sentences are presented without cues or hints. This contrasts with a closed-set test where you may be asked to select the correct word or sentence from a set of choices. Individuals who do not wear hearing aids or have their own may be required to undergo a three-month hearing aid trial period. Beyond the candidate criteria, all cochlear implant devices in the United States must be approved for use by the FDA.

The cochlear implant procedure involves a medical evaluation, audiological evaluation, surgery, recovery, fitting and programming of the implant, several follow-up adjustment appointments, and participation in an aural rehabilitation program. The cochlear implant has two main parts: an internal processor with electrode array and external processor with headpiece. The internal processor is surgically attached under the scalp to the skull behind the ear with the electrode array threaded into the cochlea. Some two to four weeks after the surgery, the external processor, which has digital components, will be fitted and the headpiece will be affixed onto the scalp in the area of the internal processor (see Figure 5). (The external headpiece and internal processor have small magnets that allow the headpiece to stay on the head in the area of the internal processor.) The external processor works very much like a digital hearing aid; however, it picks up sound from the environment and transmits the signal via frequency-modulated (FM) radio waves across the scalp to the internal processor where it is converted to electrical impulses.

Figure 5. BTE cochlear implant: external processor and magnetic headpiece.

Partial restoration of hearing through a cochlear implant comes in the form of improved auditory thresholds (often improved to 15 to 20 dB HL at multiple frequencies) and enhanced ability to differentiate one frequency from another. It is important to understand that cochlear implants do not restore all normal hearing abilities. Even the most successful cochlear implant users may continue to have difficulty understanding speech in background noise without visual cues, and when people speak rapidly or too softly. Cochlear implant users may also continue to face great problems localizing sound and responding to sounds from far distances, although bilateral cochlear implantation may help with this. The perceived success of cochlear implantation is very individualized and often depends on the user's expectations and past experiences hearing sound. For example, a cochlear implant user with poor speech recognition performance may derive significant benefit and satisfaction for non-speech sounds that are minimally necessary to perform a job. (The reader is referred to Atcherson et al., 2003 for more information on cochlear implant decision-making and example patient outcomes.) Just as with many hearing aids, assistive listening devices and audio equipment can be used with cochlear implants to enhance the reception of speech signals via audio or telecoil options.

Bone-Anchored Hearing Aids. Individuals with conductive or mixed hearing losses, and outer and middle ear pathologies or malformations often have limited amplification options. Conditions such as chronic ear drainage, abnormal narrowing of the ear canals, or absent ear canals may limit the individual's ability to wear and benefit from traditional types of hearing aids (Spitzer, Ghossaini, & Wazen, 2002). In many types of conductive hearing loss, the cochlea functions normally, but sound is reduced in level as it passes through the outer and middle ears. Those familiar with audiological testing may recall the use of a bone oscillator headset to test for hearing thresholds. The bone-vibrator is placed directly on the skull behind the ear and sound is transmitted directly to the cochlea through vibrations of the skull. A bone-anchored hearing aid works similarly, delivering sound directly to the cochlea when traditional hearing aids are not appropriate. Bone-anchored hearing aids operate on the same principle as bone-conduction hearing aids, except there is not a headband binding the oscillator to the skull.

The bone-anchored hearing aid has three parts: a titanium implant, a protruding screw, and an external processor. The titanium implant is anchored directly into the skull in the area behind the ear and the screw is attached to the implant. A small hole is cut in the skin to allow the screw to pass through at the point where the external processor is attached. The external processor then serves as the bone oscillator. When the cochlea is normal, bone-anchored hearing aid users can expect to have nearly normal hearing abilities.

Middle Ear Implants. Middle ear implants (MEI) make up another class of tools for the partial restoration of hearing (Spindel, 2002). Middle ear implants should not be confused with a surgical technique designed to replace faulty or broken middle ear bones (one cause of conductive hearing loss). Instead, middle ear implants are devices that deliver amplified, vibratory signals to the cochlea through a normally-functioning middle ear. Unlike traditional hearing aids, middle ear implants elicit a broader range of frequency signals than hearing aid receivers. Because the device works directly with the middle ear structures, there is nothing in the outer ear to obstruct sounds or cause feedback. Similar to cochlear implants, middle ear implants have an internal processor that is surgically attached to the skull behind the ear and an external processor that delivers sounds to the internal processor. Unlike the cochlear implant, the success of middle ear implants depend on the surviving cochlear structure. Specifically, they may be suitable for those with stable moderate to severe sensorineural hearing losses.

Auditory Brainstem Implants. Auditory brainstem implants (ABI) operate similarly to cochlear implants except that they are only used in individuals who have missing, damaged, or severed hearing nerves, or following surgical removal of a tumor from the hearing nerve. Unlike cochlear implants, the auditory brainstem implant electrode array is attached directly to a group of auditory neuron cell bodies in the brainstem called *the cochlear nucleus*. The cochlear nucleus is the first of any brain area to receive signals from the sensory hair cells of the cochlea. Currently, the auditory brainstem implant remains limited because of the complex organization of frequency representation in the cochlear nucleus and the difficulty in electrically stimulating frequency-specific neurons in the cochlear nucleus. Researchers have been working on a new electrode array that has penetrating electrodes to stimulate neurons in the cochlear nucleus (House Ear Institute, 2006). At present, auditory brainstem implant consumers can expect to receive communicative benefits as they add visual cues to their hearing. Some consumers may develop the ability to recognize words without a heavy reliance on visual cues (Colletti & Shannon, 2005).

Summary

Hearing loss can reduce or eliminate various hearing skills necessary to be successful at work or in school. For this reason, it is imperative that suspicions of hearing loss, or hearing changes, be checked out by a qualified hearing professional. Much information can be gathered from a comprehensive hearing evaluation. The audiogram, related test results, and reported communication difficulties will help indicate specific hearing needs. From there, an amplification or implantable device may be recommended to compensate for the hearing loss. The technology that is available today has the potential to enhance certain hearing skills, but they do not restore hearing completely. Even with hearing aids or implants, individuals with hearing loss should continue to implement and refine strategies for communication access based on past experiences, maintain communication with hearing and rehabilitation professionals, and stay abreast of new technology associated features in order to maximize their communication access.

Dave's Sample Audiological Report

EARS TO YOU HEARING AND BALANCE CENTER

Name: Dave I. Kanthear	**Evaluation Date:** 06/06/06
Address: 1234 Anyroad Drive	**D.O.B:** 6/25/63
Phone: (101) 101-1100	**Sex:** Male
Referred by: Self	**Age:** 43 years
	Patient ID # 12345

History and Observations

Mr. Kanthear came to the *Ears To You Hearing and Balance Center* for a hearing evaluation. Mr. Kanthear's primary complaints were difficulty understanding on the telephone at work, difficulty following conversations at meetings, and difficulty hearing his wife at home when she calls from other rooms. Mr. Kanthear indicated that his father had age-related hearing loss. Other than occasional ear infections as a child and appendix removal 11 years ago, he reported that he is generally healthy. He did not report any problems with headaches, or head injuries. Mr. Kanthear reported he does take an occasional Advil for back pain. Additional history was unremarkable.

History Evaluation

Otoscopic Examination: Otoscopy revealed clear ear canals with normal appearing tympanic membrane landmarks bilaterally.

Immittance Testing: Jerger Type A tympanograms were obtained for the right and left ears, indicative of normal middle ear function bilaterally. Ipsilateral and contralateral acoustic reflexes (reference stimulus ear) were performed at 500, 1000, and 2000 Hz. Ipsilateral and contralateral reflexes were present at elevated levels or absent at the presented frequencies in both ears.

Pure Tone Audiometry: Pure tone results were obtained using insert earphones. Testing revealed a moderate sloping to moderately-severe sensorineural hearing loss, bilaterally. Uncomfortable loudness levels (UCLs) for pulsed tones were obtained at 95-115 dB HL for 500-4000 Hz bilaterally.

Speech Audiometry: Speech recognition thresholds (SRTs) were obtained at 55 dB HL bilaterally, which are consistent with pure tone findings in both ears. Word recognition scores were 96% correct in the right ear and 92% correct in the left ear for monosyllabic words presented at adequate listening levels in a quiet environment. Most comfortable listening levels (MCL) to speech were obtained at 70 dB HL in the right ear and at 75 dB HL in the left ear. Uncomfortable loudness levels to speech were obtained at 100 dB HL in both ears.

Summary and Impressions

Today's results indicate that Mr. Kanthear exhibits a significant sensorineural hearing loss with normal middle ear function in both ears. Acoustic reflexes were consistent with Mr. Kanthear's degree of hearing loss in both ears. Mr. Kanthear demonstrated excellent word recognition ability for words presented at amplified levels in a quiet environment. Today's findings are consistent with Mr. Kanthear's hearing complaints. This was Mr. Kanthear's first visit; therefore, previous test results were not available for comparison. Mr. Kanthear appears to be an excellent candidate for amplification and may potentially benefit from additional assistive listening devices.

Recommendations

We discussed the results of today's evaluation with Mr. Kanthear and agreed upon the following recommendations:

1. He is an excellent candidate for hearing aids and should consider consulting with me, or another audiologist about amplification options.

2. He should use communication strategies as discussed at today's appointment (for example, active listening, requesting clarification).

3. He should return annually to monitor hearing, or sooner if concerns arise.

____

Melinda Smith, Au.D., CCC-A
Doctor of Audiology

II. Communication Access Options: Hearing Assistance Technology [5]

Sydney, a student access provider, relays the following story about Irina, a hard of hearing student:

> Irina was a returning student, married with children, who had a severe hearing loss. She thought she was doing well in her classes until she got her midterm grades. Not understanding why she was doing so poorly, she decided she must be missing information in class discussions. She used two hearing aids, read her materials in advance, attended class, let her instructors know she had a hearing loss, and sat in the front. Not knowing what else to do, she appeared in the Student Access Center requesting a tape recorder. Her plan was to ask her children or her husband to listen to it with her and repeat what was said to her so she could find out what she was missing. She had been wearing hearing aids over 20 years and no one had ever told her about assistive listening devices.

Many individuals who have a hearing loss are unaware of assistive technology (beyond hearing aids) that can be useful in difficult listening situations. This section concentrates on the variety of technologies available and provides a brief overview of how many of them work. Understanding the pros and cons of each option assists the user in choosing the most appropriate option and troubleshooting when problems occur. Before we discuss the technology, it is important to evaluate both the goal of providing the accommodation and to identify some of the myths and misconceptions that may be held by decision makers concerning what an individual who identifies as hard of hearing (rather than deaf) actually hears.

[5] Undoubtedly, the technology options described in this chapter will change. For current information, check catalogs from companies selling assistive technology, check with consumer organizations, and join electronic mailing lists for individuals with hearing loss. Brand names are mentioned to assist the reader in locating more information, not as recommendations.

Defining Communication Access

Confusion among service providers arises due to a number of misconceptions or beliefs: (1) the label "hard of hearing" indicates the individual does not have a serious impairment, (2) people who can hear well enough to make a phone call would not qualify for an accommodation, (3) an academic accommodation would not be necessary if one is not needed in the intake or application interview, (4) clear speech indicates that the person does not have a severe hearing loss, (5) people who speechread do not need additional assistance, and (6) hearing aids provide satisfactory access.

While some individuals will be able to enjoy music among other sounds, the goal of most accommodations is for the individual to understand spoken language and auditory alerts. Thus, hearing aids focus on the speech frequencies, not the entire range of frequencies perceptible to the human ear. While individuals with cochlear implants may be able to hear a wider range of frequencies, being able to perceive the difference between two similar frequencies (such as two consecutive notes on a keyboard) is still problematic for most (Ross, 2006b).

Because service providers may err in determining need based on conversation or an intake interview, this concept is worth exploring. How does conversation differ from other listening situations? Hearing aids are very effective in quiet, one-on-one situations.[6] In an intake interview, the counselor is usually using his or her best listening skills and maintaining eye contact. This gives the listener full access to the speaker's face. In addition to the fact that this conversation is likely to take place in a quiet, more optimal listening environment, it is a conversation with give and take. Facial expressions and body language greatly facilitate understanding. In a training or school lecture or a meeting at work, there is usually much less give and take in the conversation. There is limited eye contact, minimal opportunity for response or feedback, and it is less likely to occur in an optimal listening environment. At the same time, the listener is held completely responsible for the information presented.

How Much is Enough?

With few exceptions, there is little argument that in academic, employment, and

[6] While newer hearing aids and cochlear implants are greatly improved over older models and provide many benefits in some noise, it is important to remember that not everyone will have the newest and the best equipment, and noise, by its nature, is variable and difficult to control.

social settings, hearing and understanding speech is vital to our functioning. So how much speech does one need to hear in order to have access to the entire message or to succeed? Hearing 75% or 80% sounds like a lot–but is it enough? Remember what is at stake in evaluating a request for an accommodation. For a student or employee, being able to understand what is being said is vital to that individual's success as a student or worker. This is, in fact, true of any social situation that goes beyond the anticipated, "Hi, how are you?" or a controlled conversation on a known topic.

So what is a person hearing and how much information is needed to understand the entire message? Hearing loss in the higher frequencies is the most common type of loss. In looking at a mapping of common speech sounds by frequency or pitch and decibel (dB) or loudness, it can be seen that even a mild high frequency loss means the individual loses the sounds *s, f, t, h, p, th, ch*. These are extremely common sounds. Additionally, in English the *s and t* sounds provide plural and past tense information and the difference between can and can't. When these key sounds are missing, the message becomes ambiguous. So, if you can hear most sounds, isn't that enough? Examine the following sentence:

> In looking a a ma   ing of common   ee   ound by   requen y or   i   and
>
> de ibel (dB) or loudne   , i can be   een   a   even a mild igh requen y
>
> lo   mean   e individual lo   e   e ound   .

The above sentence is the third sentence in the previous paragraph. Only the high frequency sounds listed above have been removed. Even though the reader is reading and not listening, it is easy to see that the individual is not missing a word here or there, but missing sounds in many words. Not counting the list of sounds, 74% of the letters of the original sentence could be heard. At the same time, only 43% of the words are left intact. What percent of the message would the individual understand? Being able to hear 75% of a message may seem adequate, but it is functionally devastating, especially in a classroom environment. Clearly, individuals with hearing loss fill in a great deal of information. It is easy to see how lost one might become in a lecture or presentation of information if the opportunity to stop the speaker and ask for clarification was not possible or socially appropriate.

Sound and Setting

Besides information presented in lecture formats, another major listening challenge for individuals with hearing loss is group discussions. It is important to appraise the variety of information a person with normal hearing picks up auditorially to understand why this is a challenge. In a large group of people, we are able to locate the direction a sound is coming from, identify whether the speaker is male or female, and whether the speaker is a child or adult. We might even recognize the voice so we know who we are looking for. These differentiations will probably be distorted for the individual with a hearing loss. With normal hearing, we also glean other information that may help us socially. The person may have an accent that we could comment on, may speak passionately about the topic, or may come across as insecure or even condescending. We also hear grammatical information and cues about when to interrupt or ask a question. Without these cues, we can easily make a social misstep which others might see as rude or socially inept behavior.

The final piece to understanding the bigger picture of the challenge of hearing is the issue of background noise. Most hearing aids amplify a range of sounds specific to the individual's hearing loss. If a person has a loss in high frequencies but not the lower ones, most hearing aids will amplify only the high frequencies (see **Part I** for additional information). Cochlear implants function differently and are designed to bypass non-functioning cochlear hair cells to directly stimulate the auditory nerve. Both hearing aids and cochlear implants use a microphone to collect sound. *Neither the hearing aid nor the cochlear implant can discriminate between desired sound and background noise.*

Restaurants, meetings, and classrooms are generally very noisy, not only because of the number of participants, but because of other sounds in the environment, such as heating or air conditioning units and overhead projectors. Many of the sounds that individuals with normal hearing can ignore are amplified for both hearing aid and cochlear implant users and compete with speech.

How much louder does the target sound need to be than the background noise? In research conducted by Blair (1990), students with normal hearing understood clearly as long as the speech was 6 dB louder than the background noise. Students with hearing loss, though, required speech to be 15-25 dB louder than the background noise. This concept is known as the *signal-to-noise ratio*. Thus, clarity (especially in noisy situations) is a major issue for hard of hearing individuals. With cochlear implants, it is a question of the brain interpreting the signals it receives. Some people gain only the ability to differentiate among environmental sounds. Others can recognize speech under some circumstances, and still others are able to understand speech in most circumstances. While new users are "retraining their brains" to understand the new sounds they are receiving, it is important to provide practice time with a clear speech signal that is not mixed with background noise.

In addition to a strong signal-to-noise ratio, two other properties of sound impact the listener's ability to receive it—distance and reverberation. *Distance* from the sound source has a dramatic impact on the ability to hear. The greater the distance from the sound, the softer the amount of pressure that is exerted on the eardrum, and the less intense (loud) the sound is. Consider that the average speech is about 65dB. At about 4 feet (the first row in a classroom, for example), the intensity drops to about 53dB, and at 16 feet (about the fourth row), the intensity is only 41dB. With or without a hearing aid, it would be beneficial to sit closer to the sound source and would help reduce eyestrain when speech reading (Blair, 1990).

Reverberation is the third characteristic of sound that hearing aids and cochlear implants cannot overcome. Reverberation is measured by the time required for the intensity of a sound to drop 60dB once it has stopped being produced. The longer the time, the more of an echo, and the muddier sound becomes (see Figure 1). Assistive listening technology can help overcome these problems.

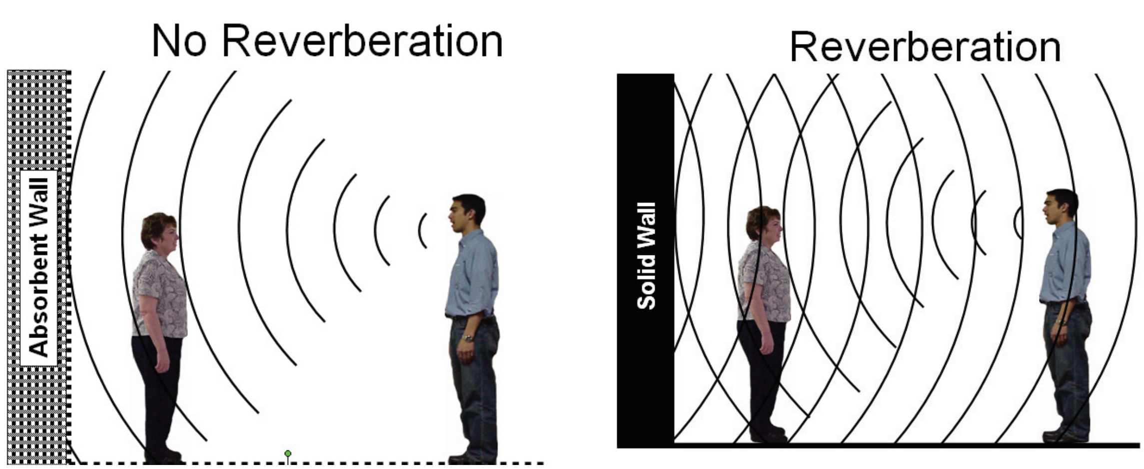

Figure 1. Visual representation of reverberation.

Assistive Listening Devices

Sydney's story continues:

Because of Irina's openness with her faculty about her hearing loss, I thought she might also be willing to try an assistive listening device which she had never used. I gave Irina the receiver and neckloop [an alternative to headphones for some hearing aid users] and I turned my back to her and spoke into the microphone. When Irina didn't respond, I thought her hearing loss might be too severe to benefit from the device. When I looked up, though, I saw Irina was fighting to control her emotions. She shared with me the following: "You don't know how long it's been since I've understood someone's voice without seeing their face. I'm thrilled with the possibilities that this technology can provide me, and really, really angry that no one ever told me about this before. I have struggled so much. Even my family gets frustrated with me not being able to hear them. I've often thought that if the people who love me most are challenged by my hearing loss, why would any employer ever take the trouble with me? A lifetime of choices are flashing before my eyes and I am thinking 'What would I have done differently if I'd only known?'"

Assistive listening devices (ALDs) consist of a microphone, a transmitter and receiver system, and a coupling device, such as headphones. The speaker talks into the microphone, which should be placed within 6 inches of his or her mouth. The microphone is attached to a transmitter which sends the signal across a limited distance to the hard of hearing user's receiver. The only sounds being transmitted are those coming through the microphone. The user's receiver picks up the signal and sends it to the coupling

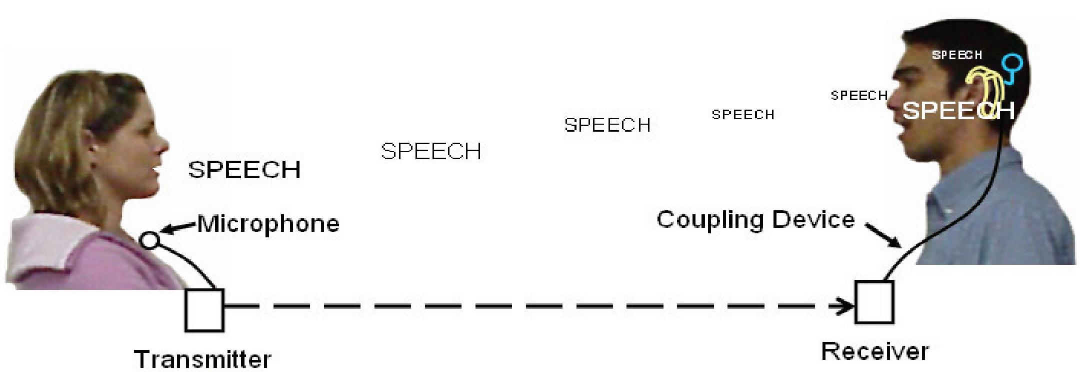

Figure 2. Assistive listening devices transmit sound without losing intensity.

device. There is a volume control on the receiver so that the user can turn it up or down as needed. ALDs help minimize background noise and maximize the desired target sounds. Because the speaker is using a microphone, the user can turn up the volume of the speaker's voice without turning up the background noise. Thus, ALDs improve the signal-to-noise ratio. In this way, speech can travel across the distance without losing clarity (see Figures 2 and 3).

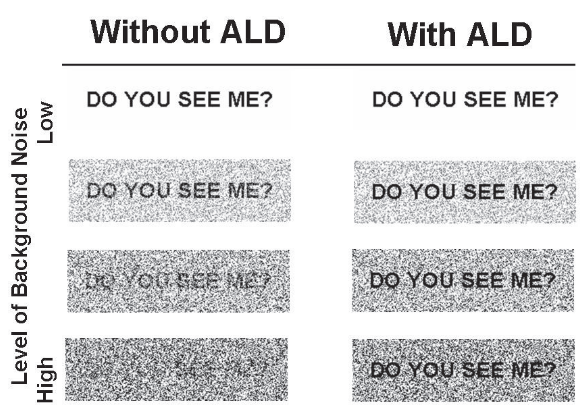

Figure 3. Visual representation of the impact of background noise with and without ALDs.

The user benefit depends on the severity of his or her hearing loss. ALDs aid in speechreading in more severe hearing losses and help reduce dependence on speechreading for milder hearing losses. For more severe hearing losses, ALDs may only help the individual pick up voice inflections, such as word endings indicating tense, mood, or number. However, this does help the individual interpret meaning. Individuals with and without hearing aids, and individuals with cochlear implants may benefit from ALDs (those with cochlear implants would need to use the appropriate coupling devices such as patch cords—audio cables with a plug on both ends—to be able to take advantage of them with the implant, or they may use the ALD with the aided ear). ALDs also help reduce eye strain and fatigue for those who depend on speechreading.

Assistive Listening Device Systems[7]

There are three major transmission systems related to assistive listening technology. Each system has advantages and disadvantages. There are large and small area personal versions available for each transmission system. Range varies with each system from under 100 feet to more than 500 feet. The receivers are generally powered by batteries, though not all transmitters are. With the appropriate coupling device, each system can be used with or without hearing aids.

FM (Frequency Modulation). The personal FM transmitter is about the size of a pager and has an on-off switch and a jack for a microphone. The speaker plugs in the microphone and clips it close to his or her mouth (within 6 inches), turns the transmitter on, and begins speaking. The FM receiver looks very similar and, like other receivers, includes an on-off switch, volume control, and a jack for headphones or coupling device. The hard of hearing user wears the receiver to intercept the signals and plugs in headphones or another coupling device to relay the sound from the receiver to the ear (see Figure 4). FM uses radio waves to transmit the signal across the distance, like a radio station broadcasting its programs. In fact, you can leave the room and still pick up the signal. Individuals wearing the transmitter should be aware that, unless they turn off their microphone, they, too, can leave the room and still be transmitting the signal. The receiver and transmitter must be tuned to the same frequency to function correctly.

FM systems are susceptible to interference from other devices using FM radio waves within the same frequency range, such as walkie talkies or emergency/dispatch radios. Similarly, in order to be used by two different users in two rooms side-by-side, there must be at least one free frequency between the two transmission channels or else both signals may be picked up simultaneously. If rooms are far enough apart, though, they may remain on the same frequency without the fear of this occurring. If signals are picked up from other devices, the user may ask the manufacturer to recalibrate his

[7] Some hearing aids have built-in or attachable assistive listening transmitters (such as FM), with a separate handheld microphone for speakers. A switch on the hearing aid will activate the system. The equipment that is personally prescribed (such as a hearing aid) would not be provided by an institution of higher education (IHE) or employer and thus is not discussed here. IHEs or employers would, however, provide assistive listening systems to individuals who are deemed eligible for services that do not require a prescription (such as those described below). The equipment would then belong to the IHE or employer, not to the individual. See **Part I** for more information on ALDs that are built into hearing aids or cochlear implants.

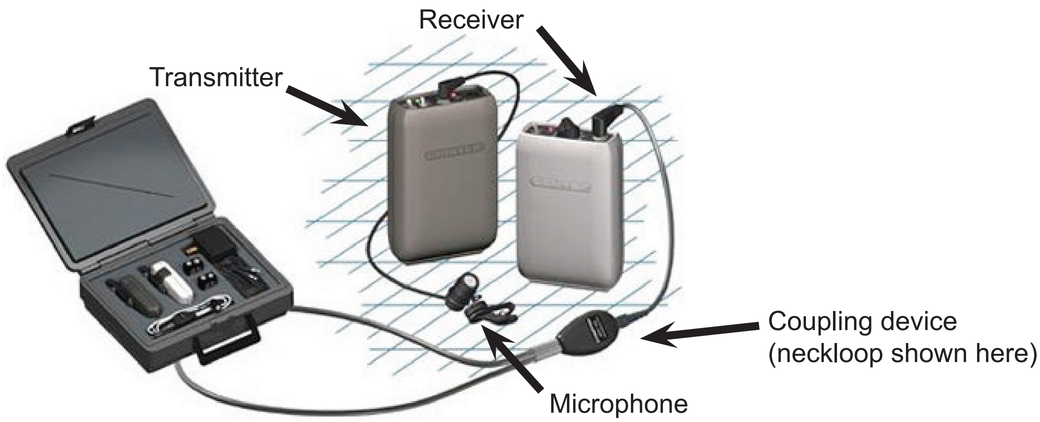

Figure 4. Comtek AT-216 Personal FM System.

or her equipment or the devices causing the interference to a different frequency. If the equipment is employed in a high use area, the user is advised to purchase narrow band equipment. These transmit on a different set of frequencies and are much less vulnerable to interference from other devices transmitting on similar frequencies.

Infrared. Infrared (IR) systems use infrared light to transmit the signals, like remote controls for televisions. While a direct line of sight between the remote control and the electronic device must be maintained, IR systems have a wider area of coverage than remote controls. Some older systems will require a more direct line of sight than the newer systems. Light does reflect off surfaces, so the signal can often be picked up from a variety of directions. There are a number of styles of IR emitters; some look like panels and some look like pyramids. They are all identifiable, though, by the rows of light diodes covering them. IR transmitters must be plugged into a power source. Most of them collect sound from an existing public announcement system, although there are home versions that are used with television sets.

There are also several different versions of IR receivers. All will have a light-intercepting diode terminal on them. This diode must not be covered or the signal will be blocked. So, unlike with FM receivers, the user would not be able to put the IR receiver in his or her pocket. Some are worn like headphones and have the diode on top; others are worn like a stethoscope and the diode hangs under the chin. Still others look similar to the receivers described above for personal FM systems and can hang around the neck or be placed on the desk. This last type is the most versatile because individuals who wear hearing aids often have problems wearing headphones or the stethoscope-type headsets (see Figure 5). Many users find they must remove their hearing aids to wear these two styles, losing the benefits of their hearing aid prescriptions. When purchasing receivers, one should be sure they include a jack so that other coupling devices (such as neckloops or headphones) can be plugged into them. Some IR receivers come with the audio jack, others do not.

Figure 5. Directear 810 Infrared TV System with stethoscope type receiver.

Because infrared light is used to transmit the signal, this system is considered secure since light does not pass through walls. Anyone passing by with IR receivers could not ‘tune in’ and pick up the signal as they might with FM. IR may be open to interference from high frequency lights or direct sunlight, but indirect sunlight does not usually cause problems. One should check with the manufacturer about systems that work with high-intensity lighting. IR has the best sound reproduction across the broadest range of frequencies, and is therefore the system of choice in theaters and concert halls. Infared systems are ideal for multiplex movie theaters because the signals do not pass through walls.

Electromagnetic Induction Loop. This is the only system that is properly referred to as a “loop.” The system consists of a loop of wire powered by an amplifier and a microphone (see Figure 6). The amplifier must be plugged into a power source. The wire loop transmits electromagnetic waves that carry the signal. An area as small as a table or as large as a room can be looped. Large listening areas should be set up by professionals to prevent dead spots (areas where no sound is picked up).

Figure 6. Oval Window Microloop.

If the consumer's hearing aid has a built-in telecoil (see **Part I**), no external receiver is needed. The user would enter the looped area and change his or her hearing aid setting to telecoil mode to pick up sound signals. Unfortunately, many hearing aids sold do not contain telecoils, and only recently have they been built into cochlear implants. In order for those without hearing aids (or those without telecoils) to use the system, an induction receiver must be used. These receivers (actually a telecoil in a box) look like the FM receivers described above and headphones can be plugged into them to transmit the sound to the ear.

There are a number of other induction options becoming available. *Oval Window* sells a small, lunchbox-sized portable induction device. It has a built-in microphone and an option for a plug-in microphone. It could be used easily at a service window like those found in banks or doctors' offices (see Figure 7). If the device were on the counter, the microphone would pick up the bankteller's voice. The customer would need to put his or her hearing aid in telecoil mode to pick up the signal. There are smaller versions of this made for the classroom. There are also mat versions that can go beneath a carpet to make an entire area accessible. The *Univox* (see Figure 7) is one such device. It would be placed under the seat cushion or under the chair for ease of television listening.

Everything that is powered by electricity gives off some electromagnetic energy, and telecoils may pick this up as interference such as static or humming. Some sources of interference are noticeable while others are not. Thus, this is not the system of choice for use in areas near bundled electrical equipment. With some sources of interference (such as light fixtures or ballasts) simply changing seats helps. This is not to say that induction loops are ineffective. In fact, at least one community (Holland-Zeeland, Michigan) is out to make the entire city hearing accessible via loops. (To read about this movement, go to *www.hearingloop.org*.)

Figure 7. Oval Window (left) and Univox (right) induction listening systems.

Coupling Devices

Acoustic Methods. Headphones and earbuds are the most commonly used devices to transmit sound from the receiver to the ear. If the individual does not have hearing aids or if the hearing aids do not have telecoils, the user is limited to headphones or earbuds. Earbuds are single-ear versions of headphones. Some clip on, while others fit into, or are held up to the ear. Some users remove their hearing aids to use headphones. This may be because of discomfort or because of a problem with feedback when covering the hearing aid microphone, and means the consumer loses the benefit of his or her hearing instrument. The benefits include not only specific amplification, but also compression circuitry. *Compression prevents sound from being amplified to a dangerous or painful level for the hearing aid user. This is an important benefit to individuals who need to preserve any residual hearing they may have.*

Induction Methods. If the hearing aids or cochlear implants have telecoils, there are two other listening options (see Figure 8). One is the neckloop which is a loop of wire that plugs into the receiver in the headphone jack and is worn around the neck. The neckloop gives off a signal (a magnetic field) that is picked up by the telecoil when the two are in close enough proximity. The neckloop can even be worn under clothing and still provide an adequate signal for the telecoil, depending on the strength of the telecoil, the thickness of the neckloops, and the severity of the hearing loss. As with the induction loop system, using the neckloop requires that the hearing aid be set to the telecoil mode.

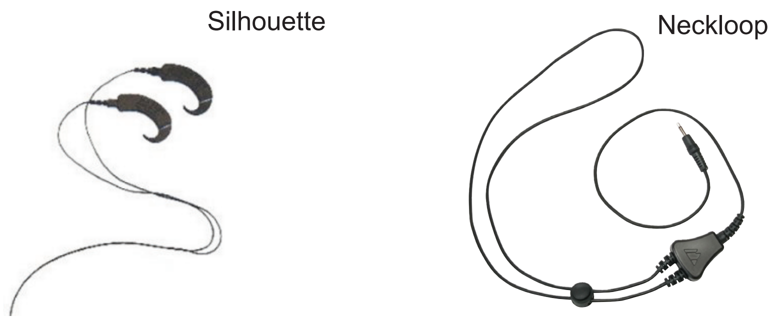

Figure 8. Silhouette and neckloop coupling devices.

Some people may find themselves holding the neckloop closer to the hearing aid to improve the signal transmission. In these cases, silhouettes may be the answer. Silhouettes look like flattened behind-the-ear (BTE) hearing aids and they hook behind the ear just like them. They will work with either BTE or in-the-ear hearing aids that are fitted with telecoils. Because they are closer to the hearing aid than a neckloop, they provide a stronger signal for more severe losses. Using the telecoil further reduces room noise because the hearing aid microphone can be turned off when its telecoil is activated. Then the only sound being picked up would be what was coming across the system's microphone. With the hearing aid microphone off, it cannot receive room noise or anything that is not picked up by the ALD microphone.

Even though the same electromagnetic induction method of transmitting the signal takes place, the neckloop and silhouette are coupling devices, not methods of transmission. They can be plugged into IR or FM receivers. As with the induction loop system, though, telecoils may still detect electromagnetic interference. Just as computer labs might cause problems using induction loops, they would cause similar problems if the user was coupling via neckloops whether the transmission system was FM or IR. In both cases, the telecoil is being used to pick up an induction field and is susceptible to interference.

Silhouettes, neckloops, and headphones can be used to deliver sound to both ears instead of just one. Research tells us that the brain is better able to comprehend when we can hear with both ears. Receiving sound through both ears provides better hearing in noisy environments and improved understanding of speech (Ross, 2006a). Especially in situations where viewing the face for speechreading may be interrupted or not possible, one should choose a coupling option that will deliver sound to both ears.

Direct Audio Input. Direct audio input (DAI) is an option on some models of BTE hearing aids that allows an external audio source to be plugged directly into the aid (see Figure 9). It also allows external microphones and assistive listening devices to be coupled to both BTE cochlear implants and older models with body worn processors. DAI is beneficial because no telecoil is needed, eliminating one source of interference. Its disadvantage is needing extra cords or adaptors as jacks on different equipment may not all be the same size. Some hearing aids can be retrofitted with telecoils or DAI in order to take advantage of assistive listening systems.

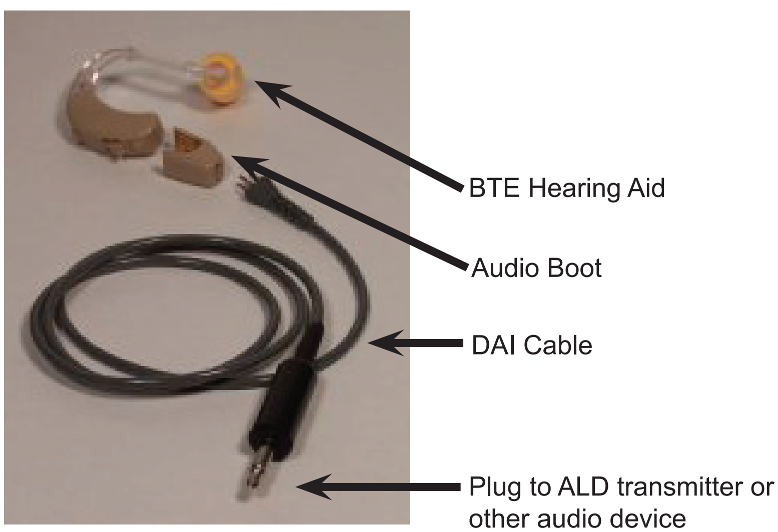

Figure 9. Direct audio input components.

Other Assistive Listening Devices

There are a number of other options for assistive listening that can help in a variety of situations. One simple device is the *personal amplifier***.** These can be purchased for around $50 to $150 from Radio Shack or (other electronics stores), or from hearing assistance technology dealers. The Williams Sound *PockeTalker* is shown in Figure 10, but there are also a number of other brands available. It is a single-unit device with a jack for a microphone and a jack for a coupling device (as shown here with an earbud). The user simply holds the earbud to his or her ear and points the microphone at the speaker. It works well for close range situations, such as riding in a car, eating in a noisy restaurant, or having small group or one-on-one meetings. Different microphones can be purchased for the unit, depending on the individual's needs.

Figure 10. Williams Sound PockeTalker.

The *Link it* (see Figure 11) is a wireless assistive listening device that clips on behind the ear like a silhouette. It can only be used with hearing aids equipped with telecoils. A series of microphones are located along the barrel of the device. The *Link it* is especially effective in noisy, reverberant areas where speech is difficult to hear.

Figure 11. Link It induction assistive listening device.

Many people depend on speechreading in addition to amplification. It is rare, though, to constantly see a speaker's face, even in one-on-one meetings. The *AudiSee* by *AudiSoft* was developed with the speechreader in mind. It is often used in classroom settings. The instructor wears a headset with a camera that is focused on his or her face. The student has a small receiver with a screen on it projecting the instructor's face. No matter where the instructor moves, the camera is always capturing his or her face. The unit includes an FM option. (For more information, go to *www.audisoft.net/en/index.htm*.)

Practical Applications

These systems are relatively simple in concept. Application to real-life situations, however, may require some troubleshooting. When only one person is speaking, the system is easy to set up, because only one person needs a microphone. If questions come from the audience, though, the hard of hearing user would not be able to hear them if they are not spoken into the microphone. The speaker should repeat audience questions into the microphone, or pass the microphone to the audience member for long comments. Panel discussions can also cause problems. If the speakers are taking turns, they would need to pass the microphone among themselves. If the structure of the panel is more of a discussion, there should be a separate microphone for each speaker or pair of speakers. *People do not reliably pass a microphone when discussions are fast-paced or heated.* Side comments become lost, causing the hard of hearing user to miss out on the flavor of the interaction. One should check with the campus audio-visual technology program to help with setting up multiple microphones and plugging the transmitter into public address systems. Otherwise, manufacturers can provide information about other options. (A few companies selling assistive technology can be found in the **Resources** section at the end of this chapter.)

If a video is shown, a patch cord may be used to plug the transmitter into the auxiliary component jack on the TV, VCR or other audio component for the best quality sound. If this is not possible, the microphone should be placed next to the television speaker. If the video is being watched alone, the transmitter could be plugged into the headphone jack. However, this will cut the sound off for anyone not wearing the receiver and headphones. Finally, the use of off-screen narrators makes speechreading impossible. Videos should be closed captioned if they do not have openly viewable subtitles.[8]

Some hearing aids can be on either microphone or telecoil, but not both at the same time. When the hearing aid microphone is turned off, the only sound being amplified for the user is what is said into the speaker's microphone. This means the user may

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[8]When it is not possible to present a captioned video, a transcript is sometimes provided as an accommodation. For example, in an educational setting the student should be allowed to watch the video outside of class. A guide might be needed to assist the student in knowing how far the video has proceeded in terms of the transcript. The student should be allowed to pause the video and read the transcript, as it is not possible to do both at the same time. This is especially true if the purpose of the video is the demonstration of a concept or technique or specific visual images that the student is responsible for learning.

not be able to hear his or her own voice or comments from a neighbor while using the telecoil. In that case, an ALD receiver that has two jacks (one for the coupler, like the neckloop, and one for an additional "environmental" microphone) answers this problem. The receiver fitted like this looks much like the *PockeTalker* shown in Figure 10, and functions like it as well. The receiver picks up the signal from the transmitter's microphone. The additional environmental microphone on the receiver will pick up the individual's own voice, comments from neighbors, and small group discussions. One should comparison shop for these items. There can be a $150 difference or more in catalog prices on this item, which ranges from $450 to $650.

Evaluating complaints of interference is always a challenge for people who do not wear hearing aids. As a first step, plug a headset or earbud into the receiver to test for problems. This will enable you to test if the transmission system itself is working. If this works, the location of the problem has been narrowed down, and the neckloop or the telecoil of the hearing aid would then need to be examined. For example, some automatic room controls (such as those for heating and lighting) can cause hearing aids to hum and deplete the batteries. (See Cederbaum [1996] for more information.)

If a loop transmission system is being used, an induction receiver will be required to test the equipment. This is the same induction receiver mentioned earlier that is used with induction loop systems when consumers do not have hearing aids with telecoils. Simply listen through headphones plugged into the induction receiver to hear what is being broadcasted from the induction loop. Neckloops and silhouettes can be tested in a similar manner. For example, suppose a student is using a neckloop to listen through an FM system. You have tested the FM transmitter and receiver and you know they are working. Now you need to determine if the neckloop is working. First, plug headphones into the induction receiver and hold the neckloop plugged into the FM receiver next to the induction receiver. Have someone speak into the microphone on the FM transmitter. What is heard through the headphones is the same signal that would be picked up by telecoils.

Rooms can be tested for noise or static to help telecoil users regardless of the transmission system they use (i.e., FM, IR, or induction loop). Using the induction receiver and headphones, walk around the room and listen for static. This is noise that would be picked up by telecoils. Note the areas of the room that are static free–those that are away from the light fixtures for example. Let the hard of hearing individual know where the good listening areas are located. In some cases, changing rooms, transmission systems, or coupling devices may be required. (For more detailed information see Ross [1994].) Finally, assembly areas with fixed seating (such as classrooms and auditoriums) require permanently installed ALD systems. (Guidelines from the Access Board and an informative guide concerning ALDs and the performing arts are listed in the **Resources** section at the end of this handbook.)

Speech-To-Text Accommodations

It is not unusual for students who succeeded academically in high school using hearing aids alone to find themselves needing more support in college. There are a number of reasons for this: lecture style formats, higher expectations, new vocabulary, limited feedback from instructor regarding progress (e.g., their entire grade may be based on the midterm and final exam with no other graded assignments), and total responsibility for understanding placed on the student's shoulders. Notice that the degree of hearing loss was not mentioned. Even individuals with milder hearing losses may be unable to understand someone with an accent, to function in a room with poor acoustics, or become lost in fast-paced group discussions. Combinations of these factors may cause someone who has never previously requested accommodations to seek help. In academic settings, speech-to-text options are now being employed more often. On the job, speech-to-text options may be needed less frequently, but are still vital when needed. These are especially important for meetings and training sessions.

The Difference between Notetaking and Speech-to-Text

When amplification alone is not enough, there are a number of options to convert speech to a visual text format to provide communication access. Understand that notetaking alone is not equivalent to communication access. *Communication access means that the hard of hearing individual can understand what is being said in real time, so that he or she can participate in the discussion as it is taking place.* Notetaking does not provide this kind of access. Notetaking provides information about what has happened, not what is happening. Instructors generally speak about 170-220 words per minute. Notetaking (at 20-30 wpm) is adequate to record the facts, but little else. Even though the information is written down more quickly with computerized notetaking, it does not provide the information needed for real time interaction. Notes typically do not include who is speaking, comments or asides that are made, or questions from other students. (See Stuckless, 1999 for a discussion of different notetaking options and content.) This does not mean that notetaking is not useful. As with students who are watching an interpreter, students who are reading the lecture as it is happening generally cannot take notes while they are "listening." When they look away to write, they will miss what has been typed and the opportunity to speech read.

Speech-to-Text Options

The main options for converting spoken language to text in real time include communication access realtime translation or CART (provided by stenographers), summary transcription or text interpreting (e.g., C-Print and TypeWell), automatic speech recognition (ASR) (e.g., Dragon Dictate, Liberated Learning Initiative, i-Communicator, Caption Mic), ASR supported CART or text interpreting, and remote CART or text interpreting. Each of these will be discussed in some detail to clarify the pros and cons of each option.

Communication Access Realtime Translation (CART). We have traditionally seen stenographers providing realtime speech-to-text services. They have been trained in a rigorous court reporting program to use a stenographer's machine. Realtime writers or stenographers strive to record, word-for-word, what transpires in court or in class. Their keystrokes are based on phonetics (in fact, their keys do not represent letters of the alphabet, but phonetic sounds). They must build their own dictionaries. If a word is not entered in their dictionary, no matter how perfectly they type it, the correct word will not appear on the screen. Thus, speed comes from being able to convert what they are hearing into the correct phonetic combination while striking the keys quickly and having a large dictionary. Figure 12 displays CART being provided to a group or individual.

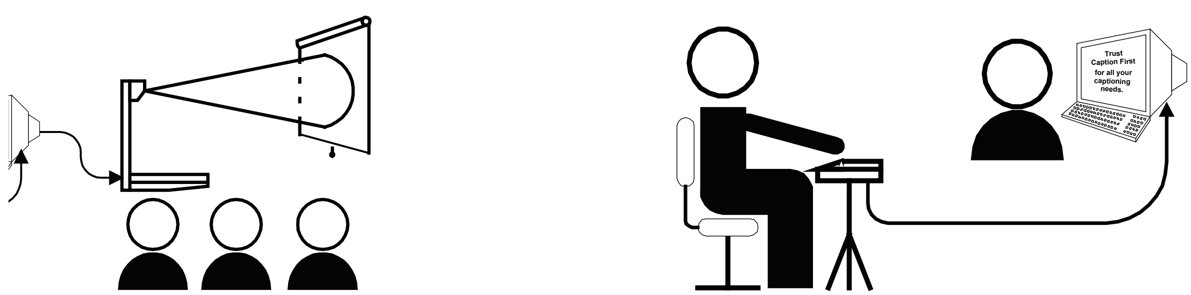

Figure 12: Examples of CART being projected for a group (on the left) and for an individual (on the right).

If stenographic service providers are not available locally, remote services may be an option, but a computer internet protocol (IP) or phone line is required. All spoken communication in the setting must be stated into a microphone so that the off-site transcriber will be able to hear it; thus, special care must be taken to ensure that group discussions are audible to the transcriber. Figure 13 diagrams an example of how remote CART might be used to make a conference call accessible. (The **Resource** section of this book lists several informative websites that provide more detail about how these services work and ideas for locating service providers such as, *www.ncraonline.org or www.cartwheel.cc* "The Leading Network of Realtime Providers for the Deaf and Hard of Hearing." Also, see Robson [2000] for realtime careers in alternative settings such as classrooms.)

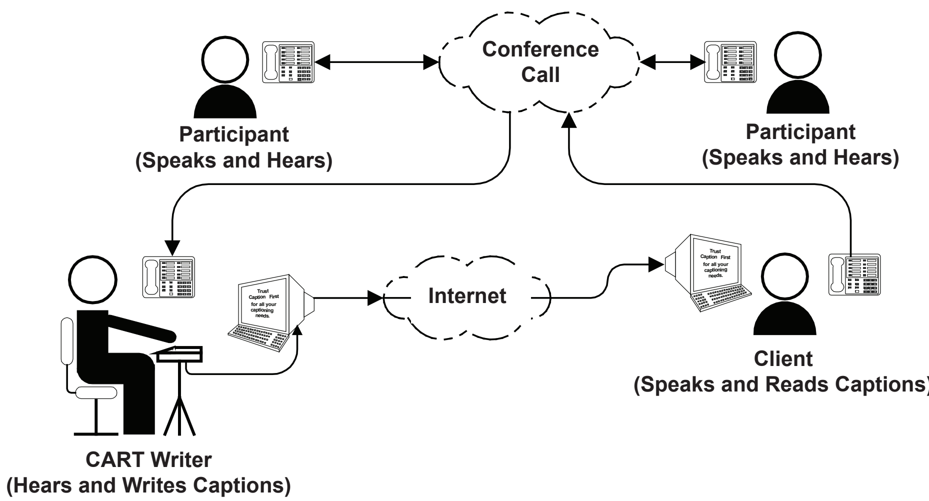

Figure 13: Internet-based remote CART.

CART providers are difficult to locate. Their training programs require at least two years, and less than half of the participants successfully complete the program. In addition, current Federal Communications Commission (FCC) regulations requiring television captioning have attracted the few stenographers not working in courtrooms into that field. Postsecondary institutions have been desperate to find service providers to work in their specialized academic settings. Enter text interpreting.

Text Interpreting. The two currently available text interpreting options are *C-Print* and *TypeWell*. *C-Print* is a system that incorporates phonetics and summarization to reduce keystrokes and increase the typist's speed. *TypeWell* is a similar idea, but uses spelling abbreviations (e.g., in some longer words, vowels are left out) and summarizing to achieve the same end result. Because of the "meaning for meaning" instead of "word for word" transcription, these services are sometimes referred to as "summary transcription services." With both systems, the transcriber uses a laptop computer, not a stenographic machine. The student views the output on a second laptop or on a monitor. The computer program automatically expands the abbreviations of the transcriber for the student to read. Depending on the speed of the text interpreter and the rate of the speaker, these transcripts may resemble the output of CART transcripts, although text interpreters tend to reduce speech dysfluencies (such as "um," "you know," stutters, and false starts) and write out complete thoughts, making the output easier to follow without sound. Text interpreters indicate changes in speakers and include environmental information such as "applause," "laughter," or "cell phone ringing" – just as stenographers do. Text interpreting is also available via remote options. The display options for output of CART and text interpreting are the same.

Training for either system can be done online and requires only a few months of practice before one can become an *entry level* service provider. These systems are helping to fill the gap of needed services left by the dearth of CART providers. Text interpreters are paid similar rates as sign language interpreters. Court reporter trained stenographers charge anywhere from $50 to $200 per hour.

Automatic Speech Recognition (ASR). As accuracy has improved, automatic speech recognition is increasingly being explored as an access tool (Davis, 2001). ASR programs were originally developed for dictation. The computer program must be trained to recognize the individual speaker's voice. Multiple dictionaries (i.e., different voice files for different speakers) are possible, but cannot be in use at the same time. Thus, it is not currently possible to change speakers and expect accuracy in the transcription. Punctuation is included only if it is spoken, and errors must be corrected along the way or the dictionaries will become corrupted. This is not usually possible in a lecture situation. However, assuming the individual has taken the time to train the program to his or her voice, ASR programs (such as *Dragon Dictate* and *Via Voice*) could be very useful in one-on-one meetings or tutoring sessions where the pace can be much more controlled and where the speaker can monitor the screen output for accuracy. Research is now being conducted on using ASR as an access tool with programs such as the Liberated Learning Initiative (*www.liberatedlearning.com*), and the I-Communicator (*www.myicommunicator.com*).

ASR with the spoken word provided by a secondary service provider rather than the original speaker is being implemented extensively. Some court reporters use a stenographer's mask to muffle the sound of their voices as they repeat what is being said into a microphone in the mask, speaking the punctuation. Their accuracy rates are not as high as stenographers, but are still very high. Similarly, the National Technical Institute for the Deaf is evaluating this "shadowing" technique combining ASR with *C-Print* (Stinson, Eisenberg, Horn, Larson, Levitt, and Stuckless, 1999). The advantage to these options in classroom access situations is that the service provider can monitor the output for accuracy and add punctuation while it is being presented and make corrections as necessary. ASR via a service provider, whether stenography or text interpreting, is being utilized extensively in remote CART services. It is also being used by Captioned Telephone (CapTel) in place of typing to increase the speed of the text display for hard of hearing phone users (Coco, 2000).

There is an interesting difference between the output of the various speech-to-text options. With ASR and text interpreting, the computer will present the closest sounding word on the screen even if it is not what was said. Thus, actual words are always presented. With stenography, the output can be gibberish (although not always) if the word is not programmed into the service provider's dictionary. This is an interesting difference in the two services as it is easy to identify the gibberish as an error, while errors may not be so obvious to the reader when they imitate actual words. (If the reader is interested in the development of Automatic Speech Recognition, Stuckless [1997] provides a wealth of information, most of it accessible to the lay reader.)

Special Transcription Settings

Transcription can be adaptable in many areas, but there are still some special considerations, especially where symbols, foreign languages or non-English alphabets are required. The following are a few resources for these settings.

Math, Science, and Foreign Language Transcription. Creativity and skill is required to provide transcription in courses that require formulas and equations, no matter which speech-to-text service is provided. Providing transcription in languages other than English is a challenge if the alphabet is the same, and probably impossible with other alphabets. Smith-Pethybridge (2006) suggested activities as simple as changing the font to Arial Unicode (because there are more symbol options), operating a webcam to take pictures of the equations to insert into the notes later, or manipulating the equation editor. The issue around foreign language transcription relates to having the appropriate dictionary so that the program will expand abbreviations correctly. While there has been some discussion of developing a transcription product in a specific language (e.g., Spanish), the author is aware of no products presently available. Malley (n.d.) described how she developed a French dictionary by deleting much of the English dictionary in C-Print in order to transcribe a French college course. (It is strongly recommended that the reader interested in these topics connect with others who are currently providing this service. The Speech-to-Text Services Network [*www.stsn.org*] and the National Court Reporters Association CART Providers section [*http://cart.ncraonline.org*] are excellent starting points.)

Transcription of Video and Web-Based Video. Undoubtedly, some readers will want to take advantage of the cost savings created by preparing a transcript of a video that needs to be captioned. In addition, the quality and ease of creating video for websites means their use has increased exponentially, and yet they need to be made accessible. This is a great use of transcribers' time while they are not on assignment in the classroom. While this chapter will not go into any detail on this topic, there are several good resources listed in the **Resource** section of this book.

Camp and Stark (2006) presented many tips about captioning video. One item in particular included the *Amazing Slow Downer* software (*www.ronimusic.com/slowdown.htm*) available for under $50. This software decreases the playback speed of digital audio files without distorting the sound, making it easier for the transcriber to work without stopping to rewind the recording. *MAGpie* is a free downloadable program developed by the National Center for Accessible Media (*http://ncam.wgbh.org/webaccess/magpie*) that can be used to caption digital video. There is a manual developed by the High Tech Center Training Unit available at *www.htctu.net/trainings/manuals/web/Digital_Caption_MAGpie2.pdf*. *WebAIM* has much information available concerning Web accessibility, including a manual on how to add captioning for QuickTime movies at *www.webaim.org/techniques/captions/quicktime/web.php*. The *Web Accessibility for All: Failure is Not an Option Project* at the University of Wisconsin-Madison just published a Campus Capacity Building Toolkit. Their website (*www.cew.wisc.edu/accessibility)* contains an amazing amount of information and examples to assist administrators, campus services providers, and faculty in understanding features that make websites (including video) accessible.

Choosing the Right Speech-to-Text Option

Students should consider the advantages and disadvantages of each option. Summary transcription services provide fewer pages, with the information written in complete sentences. Realtime transcriptionists strive to provide exactly what was spoken in the class, resulting in approximately three times the printed output of summary transcription services. Depending on the speaker's skill, the resulting output may be difficult to read without auditory cues or facial expressions to help interpret meaning. *Obviously, students must be comfortable with written English to use these accommodations.* Additionally, some highly technical programs (such as law school courses) will require word-for-word transcription in order for the student to remain competitive with classmates.

Evaluating Services. No matter which service option is chosen, the Student Access Center personnel should build in some type of evaluation component to ensure that the student receives a quality service. The student can identify whether or not the provider shows up on time, is prepared for the class, or is acting in a professional manner. However, asking the student if the provider is doing a good job may not provide accurate information as the student may not be aware of information that is being missed or presented incorrectly.

There are additional methods of assessing the accuracy of output from these services. One way is to ask the instructor to periodically review a transcript to ascertain its completeness of key points. One advantage of this approach is that it gives the instructor a better idea of how well instructional information is coming across to the students. A drawback, though, is that–because of their prior knowledge–instructors are sometimes unable to recognize gaps in information. Another way is to ask students to review several transcripts. Moreover, a person can visit the class to compare the speech-to-text output with what is spoken to ascertain that it is accurate and complete. This might be a useful task for interpreters or notetakers when cancellations occur.

The criteria of accuracy is vital for the Student Access Center office to explore in considering whether or not a service is truly making the classroom accessible. How accurate does the transcription need to be in order to be read and understood in real time? According to Gallaudet University's Technology Access Program (Technology Access Program, 2002), the required accuracy for certified court reporters is 96% at 180 words per minute (*http://tap.gallaudet.edu*). If speech were presented at 150 words per minute, there would be about six errors per minute. This is a difficult level to reach. But consider that if the accuracy falls to 90%, the number of incorrect words would be 15 per minute, or 750 in a 50-minute class. The readability of the transcription would depend on the type of errors made.

The Provision of Notes. There is some discussion as to what are the best practices regarding the provision of notes in addition to speech-to-text services. Some programs provide a transcript and require that the students take their own notes from it. Other programs provide a notetaker (or notes are obtained from other students in the class) but no transcript is provided of the speech-to-text service. There are pros and cons to each of these options. Notetaking is a valuable skill and an opportunity to practice informal writing. Students who never take their own notes miss out on developing these skills.

On the other hand, transcripts of the spoken word are very different from well developed written text. Without auditory cues, transcripts may be difficult to interpret. Also, many stenographers charge extra for cleaned-up transcripts. This should be negotiated when the stenographer is hired as transcription is one of the services they provide and they typically expect to be paid for that service. Some people feel that getting a transcript of the class is providing the student with more than equal access because the speech-to-text service provides in-class access and a notetaker provides students with information after the class. Some professors do not want students to have a transcript of their classes as they consider this to be intellectual property. Some programs accept this complaint and provide students with notes. Others consider this an accessibility issue (making this argument inappropriate) and have students sign agreements that they will not share the transcripts with others. Still others simply post the transcripts for all students to access. One should evaluate these issues carefully and discuss the matter with faculty and staff on your campus when developing policies. (The Speech-to-Text Services Network [*www.stsn.org*] is a wonderful resource that compares the differences in services, provides information on how to set up services, includes sample policies and procedures, and presents information for consumers, administrators, and service providers.)

Is This an Appropriate Service? Another campus services provider, Jack, relayed the following scenario concerning accommodations for a student with a cochlear implant.

> Marshall received a cochlear implant one year ago. He requested Communication Access Realtime Translation (CART) for all of his classes.

> Interestingly, his parents are against this. They want him to take advantage of any listening opportunities to improve his speech communication skills with his CI. With the stakes being so high in university programs, I did not agree with his parents' advice. I did not believe that the live classroom was the appropriate place to conduct his auditory rehabilitation. Because his brain's ability to interpret the sound it was hearing was still sketchy, I approved his CART request, and suggested that he use ALDs to improve his hearing in the classroom.

How does a service provider determine if a speech-to-text accommodation is appropriate? This cannot be judged by the severity of hearing loss or by how clearly a person speaks. Many individuals rely on a combination of amplification and speechreading. If either means is not there, comprehension is greatly impaired. Many conditions within the classroom affect a student's need for speech-to-text services. Is the course in a large room with many students? The student may not be able to sit close enough to speechread. Does the instructor have an accent or facial hair? These both make it difficult to speechread. Does the class require the instructor to provide demonstrations and look down, or is the instructor's speaking style such that she or he does not face the class much of the time? Does the instructor speak rapidly? Does the class make heavy use of unique vocabulary, such as biology? Unfamiliar vocabulary is difficult to speechread. Is there a lot of interaction or class discussion? The student cannot rely on sound to locate the speaker, and therefore will not be able to follow the discussion. Thus, speech-to-text services may be appropriate for someone with much less of a hearing loss than imagined by the service provider.

The question about the necessity or appropriateness of using ALDs with a notetaker or speech-to-text service often arises. The Americans with Disabilities Act (ADA) requires that each case be examined individually regarding appropriate accommodations. Notetaking is almost always appropriate, because it is difficult for the student to simultaneously speechread and take notes. Notetaking alone, though, may not be enough for adequate communication access. Notes do not provide the information needed to participate in discussions or to ask questions for clarification. Remember, too, that without inflection or tone, text transcripts may be very difficult to interpret. Hearing the speaker's voice will add meaning to what is being said. *Thus, the request to use ALDs in combination with a speech-to-text service is reasonable.*

Alerting Devices

Alerting devices are often not thought of in the classroom, but they have definite implications in the home (or dorm) and on the job. Being able to get up on time, and knowing that the phone is ringing or that someone is at the door can have a serious impact on well-being and the individual's timely availability for work and school. Because listening (especially for lengthy time spans) is stressful and tiring, many people take their hearing aids off at home. And, of course, hearing aids and cochlear implants are not worn in bed or in the shower.

Alerting devices enhance the ability to hear environmental sounds which we should not downplay the importance of in our daily lives. For some people, hearing aids or cochlear implants only provide access to environmental sounds, not speech. Nonetheless, when asked if their implant or hearing aid is worth it, these individuals almost always respond, "Yes!" Not understanding environmental sounds is disorienting and often results in feelings of reduced safety and increased stress especially for people with a progressive hearing loss or with a later onset of hearing loss. Nadia's story is not uncommon:

> I was a single mother with two young children. I worried that they would get out of bed at night without my knowing it. Every night, I would put my mattress on the floor in front of their door so that they literally could not get past me without me knowing it. I lost a lot of sleep, but at least it wasn't because I was worried about my children's safety.

There are generally three ways to make an auditory stimulus understandable to someone with hearing loss: make it louder, convert it to a visual signal, or convert it to a tactile prompt. It is also important to pay attention to the placement these alerting devices. If the device causes lights to flash, the lights must be bright enough and must be in a location where the individual is likely to see them. Location is also important with loudness. A smoke detector may use a 95 dB horn to alert individuals to danger. However, the sound is only 95 dB when the individual is nearby. If the individual is in a different room or down the hall, a single alerting device may not be audible. Alerting devices can be purchased for singular or multiple purposes. For example, an amplified telephone ringer, vibrating alarm clock, and flashing light door announcer can be purchased separately or assembled together in a multi-purpose device.

Telephone Alerts

Phone ringers are a common example of a single purpose device. An individual may not be able to hear the phone ring, may only be able to hear it when nearby, or only when it is in a particular frequency range (e.g., low frequency). In a noisy environment, it may be difficult to detect the ring of the phone from other sounds. One option is to alter the ring so that it is much louder. Some devices plug into the phone or wall jack (RJ-11 jacks) and ring at up to 95 db. Many of these devices also have a tone control so that the pitch of the ring can be adjusted to high, medium, or low, depending on the individual's hearing loss. They may also include a flashing ringer light. Some devices require batteries or an AC electrical outlet while others are powered by the phone line. These devices (e.g., Ringmax, Super Phone-ringer, Clarity Ring Signaler) cost between $35 and $50.

In order to have both the phone and the loud ringer plugged into the same phone jack, a "y" connector or a "split jack" can be used. These plug into the phone jack to allow more than one phone cord to be plugged into them. They can be found at electronics, home improvement, or even grocery stores for a few dollars apiece. When evaluating appropriate equipment, one should think about the environment and the individual's needs. Availability of outlets, desk space, and the charge of the batteries are issues to consider before making a purchase.

There are also devices that connect the phone to a lamp so that when the phone rings, the lamp light flashes. These cost about $50. This device may be perfect for a small office where the flashing light would be visible anywhere, or in situations where a loud ringer would be undesirable (e.g., dorm room, office, households with napping children). Some devices have an option so that the lamp can be used for its light as well as signaling (i.e., it can flash off-on or on-off); others can only be used for signaling.

Remote Alerts

In a home where the individual may not be in the same room as the phone, a remote device would be appropriate. Multipurpose remote devices are available and convenient. Transmitters, usually working off of FM signals, can alert the consumer to a variety of household sounds (such as the door bell, the phone, a baby crying, a kitchen timer, or an alarm clock). Receivers can be placed in different rooms with lights that flash in different patterns for each of these sounds or for other purposes. Some include a bed shaker, a device placed under the mattress or pillow that vibrates when one of the alerts is triggered (see Figure 14), in addition to the lamp outlet that would alert the individual in bed. Alternatively, a separate vibrating receiver can be worn on the belt like a pager, with lighted symbols to indicate each alert. A tactile version is also available. When the receiver vibrates, each signal option is selected by the user until the device vibrates again, indicating the source of the alert. These systems can range in price between $100 and $300, depending on how many different transmitters and receivers are needed.

Figure 14. Alert Master AM 6000.

Other Alerting Devices

One simple device that should not be overlooked is the mirror. When someone sits with his or her back to the office door, a mirror can be a simple, unobtrusive way to let him or her know someone is at the door.

No discussion of alerting devices would be complete without mentioning hearing dogs. These specially trained dogs are identifiable by their orange-colored service vests. As with guide dogs for the blind, they must be allowed in public places. At home, hearing dogs are trained to alert their owners to specific sounds. They get their owner's attention and lead them to the noise (e.g., doorbell, phone, timer, crib). Outside the home, hearing dogs can alert their owners when someone calls the owner's name, can respond to certain noises and even guide their owners out of harm's way. (A list of websites on hearing dogs is provided in the **Resource** section.)

Solving some situations requires creativity and a general knowledge of the equipment available for individuals with other disabilities. For example, one institution had a problem with a deaf student with a cognitive disability who forgot to turn the water off and could not hear it running. On several occasions, the student had caused damage to the housing. There are devices that produce an auditory signal when water touches them (e.g., one that lets an individual who is blind know the tub has filled). This device, used in combination with a baby cry signaler (which is alerted to any loud noise), provided a visual alert to let the student know that something had happened. Employers looking for job modifications are encouraged to contact the Job Accommodations Network at *www.jan.wvu.edu* to brainstorm options for any problematic situations.

Who Pays?

If the devices are needed for a dorm room, they may be purchased by the institution. When the student leaves, the item would remain with the institution. In other cases, it may be more appropriate for the state Vocational Rehabilitation agency to purchase the item for the individual. In these cases, the individual keeps the item no matter where he or she lives. There may also be programs that provide some of these items through a state agency. This is most often true for telecommunications devices, but some states may also offer a phone alerting device.

Emergency Alerts

Fire safety is important in homes, dorms, or places of employment. Smoke alarms save lives. Some devices may be a part of the multipurpose remote system discussed above, while others are stand-alone smoke alarms (see Figure 15). There are a variety of options to gain one's attention including bright flashing lights, 95 dB horns, and bed shakers. While individual units can be purchased and plugged in, it is safer to have the system wired into the home. That way, if any smoke detector in the house is triggered, all alarms will be triggered. *Individual units that are not wired into the home will only be triggered by nearby smoke and may not be heard if the individual is not in the same room*. There are similar items for detecting carbon monoxide. Tests have shown that units that have an intermittently vibrating bed shaker—in contrast to lights, loud horns, or continuous vibrations—are the most reliable to wake someone with a hearing loss.

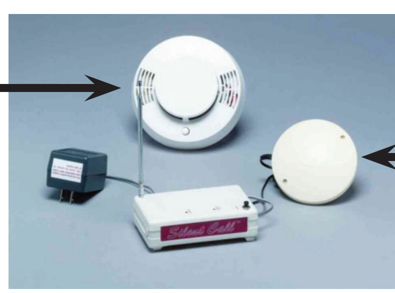

Figure 15. SD1008 smoke detector transmitter with RV5000 receiver and bed shaker.

If the individual is living in public housing, alerting devices and visual smoke detectors should be provided by the landlord (Sievers, n.d.). The 1988 Fair Housing Act Amendments (PL 100-430) amended Title VIII of the Civil Rights Act of 1968, adding prohibitions against discrimination in housing on the basis of a disability. FHAA requires housing owners to make reasonable exceptions in their policies and operations in order to afford equal housing opportunities to people with disabilities. Thus, housing units with a “no pets” policy must allow service animals for individuals with disabilities. While the FHAA requires landlords to allow modifications to housing units providing access for individuals with disabilities, these modifications may be the financial responsibility of the tenant. In order to request an accommodation, one needs a letter from a physician stating the diagnosis of the disability and that the requested accommodation is necessary because of the individual’s functional limitations. (For more information, contact the Fair Housing Enforcement Center. Contact information should be available in the blue-edged government pages in the phone book).

In addition, the federal Housing and Urban Development (HUD) program has developed specific regulations for smoke detectors for those who are hard of hearing and deaf. These regulations apply to any rental dwelling unit assisted or insured by HUD, and to public and Indian dwelling units. Smoke detectors are the responsibility of the landlord. Stand-alone and portable devices are not allowable under the regulations; equipment must be permanently installed (Sievers, n.d.).

The National Weather Service (NWS) warnings notify the public of imminent dangers such as hurricanes, tornados, and earthquakes. These television and radio voice broadcasts are not accessible to and fail to get the attention of individuals with hearing loss. Special radio receivers are available that provide visual and tactile alerting when receiving warning broadcasts for national and local weather and non-weather emergencies (i.e., All-Hazards life-threatening events [see *www.weather.gov/nwr/special_need.htm*]). There are also services available that will send a variety of alerts electronically to cell phones, e-mail addresses or pagers. One example of this is the Emergency Email and Wireless Network. (Information can be found at *www.emergencyemailnetwork.com* [Hamlin, 2006]). The Federal Communication Commission (FCC) has also recently imposed fines against television stations for broadcasting emergency information (such as evacuation instructions) without providing live captioning of these broadcasts (Sivertson, 2005).

Telecommunications

Telephones provide vital connections in today's world, so much so that many states provide free telecommunications equipment to those residents with disabilities who need special technology to access phone services. Lauren relays her frustration and positive advocacy with her state's public utilities commission.

> Our state has a telecommunications device distribution program. With documentation that you have a severe or profound loss, you are loaned a free amplified telephone or TTY while a resident of the state. Ironically, the amplified phones they offered did not provide enough amplification for individuals with severe or profound losses. They also hired people who were deaf and who signed to provide training for the equipment. This was a great service to one portion of the population, but severely limited the services to the hard of hearing consumers who did not sign. Fortunately, this state was open to the feedback they were getting from hard of hearing consumers, and now have hard of hearing people involved in the testing of equipment and in training consumers.

The inability to communicate effectively over the telephone is one of the leading reasons hard of hearing individuals list for leaving a job, whether by choosing to quit, taking early retirement, or being fired (Scherich, 1996). Hearing employers and consumers alike often do not know what telephone access options are available. If phone use is an essential job function, lack of knowledge of accommodation options may lead employers to believe that a person is not "otherwise qualified."

Telephone use may be thought of in terms of employment only, but it is also important for students, especially when they are entering into internship settings and must set up appointments or interviews on their own. Issues that come up around telephone use include the difficulty of listening with one ear, sound quality, background noise, hearing aid compatibility, the lack of visual cues (e.g., speechreading), and–of course–menu systems.

Analog vs. Digital

Before delving into the various options, it is important to recognize that there is a distinction between analog and digital phone lines which is relevant for cell phones, too. While this is not the place for a technical description of analog and digital, what the reader needs to understand is that analog landline phones and assistive devices are not compatible with digital phone lines. Most home phone lines are analog. There may be digital services offered, but the way the signal comes into a home is typically through an analog phone line. Businesses, on the other hand, often have digital phone lines. Audix and PBX systems are examples of digital phone services. This is an important distinction when shopping for phones with accessibility features. Many of these phones are analog only and are incompatible with digital phone lines. If access is needed in the office, it is best to check with the unit responsible for maintaining the phone lines in your organization to get the phone or handset that is most compatible with your system. A separate analog phone line may be an appropriate accommodation.

Standard Telephone Service[9]

Many people with hearing loss are able to use the phone effectively with or without their hearing aids by using independent amplification. There are a number of independent amplification options. A battery-powered amplifier held over the earpiece with an elastic strap, which can be removed in order to hang up the phone, is especially useful for travelers or those who may not know what type of phone accessibility devices will be available to them. This is the one truly portable telephone amplifier.

Amplified handsets with volume control are available for some phones and can be adjusted by each user. These handsets replace the regular handset but only work with modular phones that have a detachable handset and a dialing mechanism in the base. In-line amplifiers are attached between the handset and the base (see Figure 16). They usually include both volume and tone controls which are especially useful to people with high-frequency hearing losses. There are also phones developed specifically for individuals with hearing loss which have built in several of the features described above. One important additional feature is an audio jack. Headphones or neckloops can be plugged into the audio jack which allows listening with both ears. Cochlear implant users can use a patch cord to provide a direct connection to their speech processors.

All landline phones sold in the nation must be hearing aid compatible (HAC). Originally, this did not mean that the phone included a volume control option. It meant that the telephone speaker gave off at least a minimal amount of an electromagnetic field that the hearing aid telecoil could pick up. As of January 2000, there must also be a volume control. Individuals with a greater degree of hearing loss who need a strong signal transfer between the hearing aid speaker and their telecoil may need to test several or different

[9] Information on amplified phone ringers is included in the section on alerting devices.

phones until they find one that generates a field strong enough for his or her hearing aid telecoil. Many digital hearing aids now have auditory feedback reduction circuits, but for those without this feature, feedback may occur if the ear is covered and the sound is forced to bounce back into the microphone, as might happen when the phone is tightly held over the ear in an effort to get better sound. A donut-shaped piece of foam over the earpiece may help prevent this (one commercially available brand is *Squeal Stop*). If feedback is a frequent problem, the telecoil should be used rather than depending upon the hearing aid microphone. Telecoils pick up electromagnetic fields, not acoustic sound waves. When the “volume” is increased, it is not loudness, but signal strength that is increased. Telecoil advantages include reduction or elimination of background noise, elimination of feedback, and decreased likelihood that others will overhear what the caller is saying because the sound is not amplified.

Figure 16. In-line phone amplifier (HA 40).

Cell Phones

Having a cell phone seems to be a rite of passage for today’s youth, and many adults are lost without the flexibility cell phones provide. In general, in order for cell phones to be fully useful to hard of hearing individuals, they should have the following features: (1) hearing aid compatibility, (2) amplification, (3) no hearing aid interference on either digital cell phones or cordless phones, (4) an audio jack for neckloop or headphones to allow binaural listening, and (5) a vibrating ringer. With all these features the consumer would not need to purchase additional accessories.

Previous cell phones were analog and most were hearing aid compatible. Because digital cell phones offer many more services and business advantages, manufacturers are now phasing out analog versions. Historically, few digital cell phones have been made accessible to hearing aid users. TDMA and GSM[10] digital transmission networks cause the cell phone to draw current in a pulsing manner, which is transmitted as interference that can be picked up by either the telecoil or by the hearing aid microphone. CDMA digital networks do not cause as much interference as TDMA and GSM networks. Verizon and Sprint are CDMA networks. This interference problem has left hearing aid users squeezed out of the cell phone market, unable to purchase the many desirable digital options, such as text messaging, voice mail, and web browsing capabilities.

Interference. Interference on digital cell phones arises from several sources, regardless of whether the individual is using a hearing aid telecoil or the microphone. These sources of interference include the display, keyboard, battery, and circuit board. In order to reduce interference from the cell phone, look for ones where the battery is farther away from the ear (found on "clam shell" type flip phones), the antenna is farther away from the ear (found on styles where the antenna points down or out rather than straight up next to the ear when in use), and where the backlighting can be turned off manually (Kozma-Spytek, 2003). As of September 2006, new compatibility rules are being enforced (described below) that open up cell phone options for hearing aid users.

Individuals with hearing loss might try several tricks to improve their ability to operate digital cell phones. Some will be able to use a cell phone without a hearing aid by holding the phone up to the ear like anyone without a hearing loss. Several cell phones are now available with a speaker phone function. A speaker phone is really like an amplified phone in the level of acoustic output, so people wanting louder cell phones should explore that option. Other people use a hearing aid with a cell phone but do not use a telecoil. The microphone on the hearing aid picks up the sound from the phone. While interference due to GSM networks is a problem for some people, it can be reduced if the phone is loud enough and is held away from the hearing aid by

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[10] TDMA, GSM, and CDMA are cell phone technologies related to how the signal is transmitted across the cell phone network. CDMA stands for code-division multiple access, TDMA for time-division multiple access, and GSM for global system for mobile communication. TDMA service providers in the US and Canada have switched to GSM. To find out what type of digital technology your cell phone service provider uses, go to *www.wirelessadvisor.com*. Enter your zip code to find out the various services available in a particular area and the type of technology each provider uses.

a few inches. Finally, check with providers to find out if analog service is still available, or if they provide phones that can be manually switched to analog on a call-by-call basis. Some CDMA networks provide this service because, when roaming, analog phones may have service where digital phones do not. This option is generally not available with GSM services.

Accessories. While the goal is to have cell phones that are functional without having to purchase and set up additional accessories, individuals who are hard of hearing and cochlear implant users may benefit from a variety of cell phone accessories. Some phones have an audio jack that allows the use of a neckloop or patch cord for hearing (but the user would still need to speak into the phone mouthpiece). There are more convenient options. Nokia and Motorola both make their own version of a loopset which is an induction neckloop with a built-in microphone. Nokia products are proprietary and work only with certain Nokia phones. One should be aware that batteries are needed to power the amplifiers in loopsets, thus providing a stronger magnetic field signal, and that they can be used only with hearing aids or cochlear implants with telecoils. Hearing aid telephone interconnect systems (HATIS) is similar to a loopset, but instead of a neckloop a silhouette is used (more information can be found at *www.hatis.com).*

Hands-free kits (e.g., ear buds with microphones) that come with phones can be altered to provide direct audio input. Send the hands-free kit to your hearing aid manufacturer so that the firm can remove the earbud and replace it with the appropriate direct audio input jack. The cost for this modification is about $25. (To find contact information for hearing aid companies, go to *www.hearingresearch.org*.) For hearing aids with a telecoil the *Telemax* magnetic coupler for portable and cellular phones (which can be found at *www.hearmore.com*) is a useful portable amplification device. In addition, *Chaamp* by Audex reduces interference for specific Nokia phones and provides an amplified speaker and ringer volume (more information can be found at *www.audex.com*).

For individuals who do not have hearing aids or who prefer using a cell phone without their hearing aid, there are also a variety of options. The Ameriphone website shows a cellphone amplifier (CPA) which utilizes an earbud and connects directly to the cell phone. This provides up to 25 dB amplification. There are also JABRA telecoil compatible headsets and custom earmolds for earbuds of which Westone Laboratories, Inc. is one manufacturer.

Finally, Bluetooth options are becoming available for hearing aids. Bluetooth is a wireless technology that allows for communication between Bluetooth-enabled devices. The Phonak *Smartlink* and *Ear-Level Instrument* (ELI) (see Figure 17) are two examples of Bluetooth boots that can be plugged into some hearing aids via a direct audio input connection. These instruments allow the consumer to connect via Bluetooth to their Bluetooth-enabled cell phone, head set, and other Bluetooth enabled devices. There are even Bluetooth devices which attach to neckloops for individuals who have telecoils in their hearing aids but no way to add a Bluetooth boot. These will make hearing aids much more flexible to connect to a variety of Bluetooth enabled audio devices. (For an example, see *www.hearwireless.com/eli.html*.) People are excited about having a wireless way to get sound from, say, a cell phone or IPOD directly to the listener's hearing aid so that it will be amplified according to the user's prescription.

Figure 17. Starkey Ear-Level Instrument (ELI) Bluetooth boot.

Current FCC Accessibility Rules. In 2003, the FCC adopted rules to make digital wireless telephones compatible with hearing aids and the timetable was reaffirmed in June 2005. The guidelines (found at *www.fcc.gov/cgb/consumerfacts/hac.html*) include:

1. By September 16, 2006, nationwide *wireless carriers* (e.g., Sprint-Nextel, Verizon Wireless, Cingular, and T-Mobile) must make at least two hearing aid-compatible handset models available for each air interface.

2. Each *manufacturer* must offer to service providers at least two hearing aid compatible handset models available for each air interface.

3. By February 18, 2008, all wireless carriers and manufacturers must ensure that 50% of their handset models are hearing aid-compatible.

4. Hearing aid-compatible wireless phones must have prominent exterior labeling indicating the handset's technical rating, and must have more detailed compatibility

information included inside the package.

In addition, all carrier-owned and carrier-operated retail outlets must make live, in-store testing available to consumers, and wireless providers are encouraged to offer a 30-day trial period or flexible return policy. Hearing aid compatible cell phones will be clearly marked with M and T ratings. According to the Verizon website, “the higher the M-rating the handset has the lower the radio frequency emissions level and higher signal quality the handset will have” (Verizon Wireless, n.d.). To choose the best cell phone compatible with a hearing aid in the microphone mode, review the M ratings provided on the box. An M3-rating indicates the handset meets the American National Standards Institute (ANSI) standard, and an M4-rating indicates the handset has exceeded the ANSI standard. *If there is no M-rating, then the handset does not meet the ANSI standard.* To obtain the strongest signal using the hearing aid in telecoil mode, get a phone with the highest T-rating. The T-rating indicates the strength of the magnetic field provided. As with the M ratings, level 3 meets the standard and level 4 exceeds the standard.

Digital phone options are changing continuously. To find the most current information on cell phone use with hearing aids, check the Technology Access Program at *http://tap.gallaudet.edu*, or join an online users group or listserv and ask other consumers about their favorite phones and service providers. Once the desired features have been identified, go to *www.phonescoop.com* and click on “Phone Finder” to identify phones and services with those features.

Other Telecommunication Options

For those who cannot use amplification or telecoils to make telephone calls, teletypewriters (TTYs) also known as telecommunications devices for the deaf (TDDs) are available. TTYs are devices with keyboards that can transmit text over phone lines (see Figure 18). TTYs come with and without hard copy printers. Those with a printer are more convenient as it is difficult to record information like phone numbers or addresses while watching the light emitting diode (LED) screen. TTYs are not as popular among hard of hearing individuals as they have been with Deaf individuals because hard of hearing individuals, in general, would rather use their voices than type a message. TTYs are also analog devices. It is common for an analog phone line to be installed in an office where a TTY is needed. Another consideration for using TTYs is that both the caller and the receiver must have the devices which results in need for a method to relay a call from a

TTY user to a phone user. (The “Relay Options” section below describes this method.)

Figure 18. Ultratec Superprint 4425 TTY.

TTYs are now available that connect to digital cell phones and to cordless phones. Examples are the *TextLink 9100 Mobile TTY* (found at *www.hitec.com*) and the *Compact/C* and *Ezcom Pro/C TTYs* (found at *www.ultratec.com*). A very useful guide entitled “Wireless TTY Calling” is available from Ultratec. It includes information on using a TTY designed for cellular calling, using a direct-connect TTY with cell phones, and using acoustic TTYs with cordless phones. Recent updates to the guide are posted on their website.

Relay Options

When telephone relay was first invented, it was often run out of people’s homes and only connected TTY users with phone users. Thanks to the Americans with Disabilities Act and newer technologies, relay services are now mandated nationwide, are confidential, and free (although normal long-distance charges apply). There are a number of different technology and communication options.

What is involved in making a relay call? The caller calls the relay service and provides the number of the party he or she would like to call. The relay provider (referred to as a communication assistant or CA) reads to the hearing party what the TTY user types, and types to the TTY user what the hearing party says. Because turns must be taken, the phrase “go ahead” or “GA” is used to indicate when it is the next person’s turn. This traditional relay option is not used as much now as it was in the past. Many people have e-mail and text-enabled cell phones or text pagers. Nevertheless, relay still serves a purpose, especially in calling public entities or businesses. In the past, users called an 800 number to reach the relay service, and these numbers were different in each state and for each service. To reach a relay service anywhere in the US today, simply dial 7-1-1. Hard of hearing callers may still want to use one of the 800 numbers set up for some of the specific services described below for faster processing.

Online Relay. One of the newer additions to the relay family of services is online relay which is reached via the Internet instead of a TTY. The person with a hearing loss utilizes the service through an Internet website and a communication assistant provides the relay service in much the same way as the traditional telephone relay (see **Part III: Resources** for websites).

Instant Messaging (IM) Relay Service. AOL is offering IM relay services through either a computer or mobile devices with internet access. The user adds the appropriate designated AOL or AIM screen name of any relay vendor (e.g., MCI, Sorenson) to their Buddy List and would then call the relay service Buddy to reach a CA. Once the connection is made, the call would be carried out like a traditional relay call except by way of instant messaging.

Voice Carry Over. Even though most hard of hearing people do not use TTYs, there are still several options available through the relay service to assist them with phone calls. The first one is called voice carry over (VCO). With a TTY call, the CA must assist with communication in both directions. With VCO, the hard of hearing caller speaks directly to the person he or she is calling. The person being called speaks to the CA, who types what is said for the hard of hearing caller to read. The conversation progresses more quickly because the CA is only relaying one part of the conversation. The hard of hearing person would need either a phone that includes a screen for a text readout or a phone and TTY combination.

There are portable options for VCO as well, such as the *Pocket Speak-and-Read VCO*. To use this device, the individual calls the relay service and asks to place a VCO call. The device is then attached to the earpiece of the telephone with an elastic or Velcro strap. The TTY tones from the relay operator are picked up by the device, converted to text, and shown on a small screen on the face of the device. The individual reads what is being said and responds by speaking into the phone receiver. The Pocket VCO is portable, works on a variety of telephone handsets—including cell phones—and operates on battery power.

Two-Line Voice Carry Over. In some situations, an invisible relay service, where the communication assistant is not heard, is more desirable. For example, people who are not familiar with the relay service often think a telemarketer is calling and hang up on the caller. Using two-line VCO requires a bit of trial and error, but is worth it. There are several ways to set it up, but only one will be described here. The caller would need two telephone lines (i.e., two separate phone numbers, not just two phone jacks). One phone line would be connected to a TTY, and the other would be connected to a telephone that has conference calling and hold capabilities. The phone *service* on this line must also provide three-way conference calling. The hard of hearing user would use the phone to call the relay service. When the CA answers, the user would give the CA his or her other phone number. When the other phone rings, the user would answer the call and tell the CA that this is a two-line VCO call and put the CA on hold. The user would then place the call directly from his or her phone. When the person being called answers, the hard of hearing user would take the CA off hold and would now have a three-way conference call. The two people speak directly to each other and the CA types the information for the caller to read. The hard of hearing person could still use amplification on his or her phone in addition to having the backup text to read from the TTY. The caller is in control of the conversation. There is no turn-taking or use of the phrase “go ahead.” If the CA misses something, he or she simply types [unintelligible] or [...]. If this happens to be something that the caller missed as well, it is up to the user to ask the person speaking to repeat the statement. Michael expressed his positive experience with this accommodation:

> With two-line VCO, I have been able to keep my job. I work for a department store and answer the customer service phone, which often means responding to complaints. When people are already upset, they do not want to repeat themselves. With two-line VCO, I was able to stay in my job and the accommodation was only the cost of an extra phone line. My employer was happy not to lose a trained employee. Callers do not even know I’m using a relay service.

Video Relay Services. Video Relay Services (VRS) enable American Sign Language (ASL) users to converse in ASL rather than English. An inexpensive camera and a high-speed internet connection are required. With this service the caller connects to a video CA (who is a certified interpreter) through his or her computer. The CA and the person with a hearing loss can see each other with the hearing caller connected via the regular phone. The CA speaks what the individual is signing and signs the responses given by the hearing person to the ASL user (see Figure 19). The incorporation of body language and facial expressions makes for a much more natural flow to the conversation than text alone. Many states are establishing their own VRS component under their telecommunications relay service (TRS), which gives consumers the choice of a state-owned TTY or their own camera and the required software to access VRS. As high-speed internet connections become more available and affordable, the popularity of these services will likely increase. An additional benefit of internet relay and VRS is that there are no long-distance charges and either can be set up as VCO or two-line VCO calls.

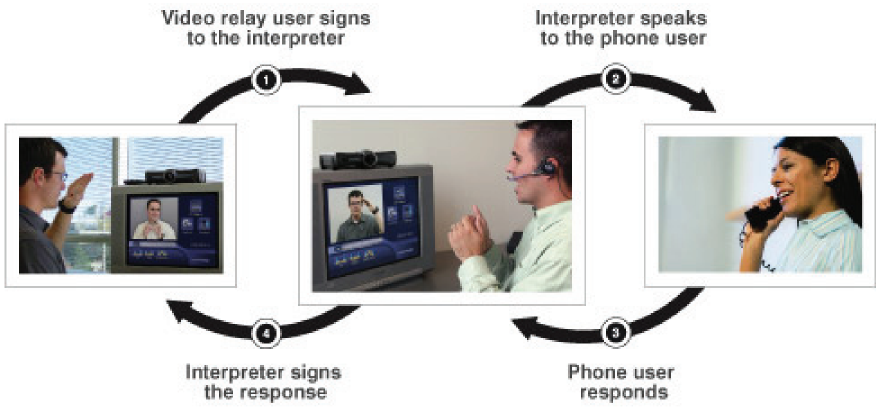

Figure 19. Example of Video Relay Service.

Videophones may be attractive to speechreaders regardless of whether or not they use relay services. With high speed internet technology, web cameras and videophones can make calling others with similar equipment much easier, as the user has access to sight and sound. *D-Link i2eye* is one such product which requires a TV and a high speed internet connection or a computer.

Other Relay Options. There are also other specialized relay service options, such as *hearing carry over* for people who can hear but cannot speak clearly, *telebraille* for deaf-blind individuals, and *foreign language relay services* such as Spanish-to-Spanish.

CapTel

The captioned telephone or CapTel is a service which offers seamless two-line VCO with a special CapTel phone (see Figure 20). When the caller picks up the phone, the CapTel relay service is automatically called. The caller simply dials the other person's number. The connection is made when the CA comes on the line. With the TRS described above, the CAs are typing what is said; with CapTel, the CAs employ a speech recognition program, and they repeat what the person being called says while the program displays the words on a small screen on the CapTel phone for the hard of hearing person to read.

Figure 20. Captioned Telephone or CapTel.

Initially, receiving calls was a bit more challenging because the hearing caller needed to call the CapTel service instead of calling the hard of hearing person directly. There is now a two-line version of CapTel which makes including the CA on direct incoming calls possible without hanging up and redialing the call. Initially, CapTel was not an option included in the federally funded TRS. Now it has been added as an option, although not all states are offering it.[11] As with any non-Internet-based service, long distance charges apply. In December 2006, the FCC approved adding an Internet-based version of CapTel to the reimbursable relay service options provided through the TRS Fund. Consumer trials will begin in early 2007.

Text Messaging

Pagers, especially those with alphanumeric displays, are common text messaging accommodations. Two-way pagers allow users to reply to text messages via e-mail and to use the device as a traditional numeric pager or voice phone. Cellular phones have been able to send and receive text messages for several years now. The cost and availability of text messaging and two-way text messaging vary by service provider and calling plan. These kinds of devices offer simple solutions to what at one time was an insurmountable telecommunications problem. With Internet access, users can utilize e-mail, instant messaging, and even online relay services. Wyndtell was an early provider,

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[11]As of this writing, CapTel is available in 44 states. But, it is available for all active or retired Federal personnel (civilian or military), veterans, and US Tribal members (of Federally recognized tribes) who are deaf, hard of hearing, deaf-blind, or have speech disabilities via the Federal Relay Services (FRS) in all 50 states and the US Territories. For more information, go to *www.federalrelay.us*. The advantage of FRS to federal personnel is that there are no long-distance charges. Besides CapTel, all other relay options (e.g., video, online, Spanish) are also available.

but there are many others on the market now, including Blackberry, T-Mobile Sidekick, Treo Smartphone, and Nokia. Milo explains his situation:

> Ironically, I work in telephone line repair. My office was frustrated that they could not call me on a cell phone to let me know of schedule changes or emergencies. This problem was easily solved with a two-way text pager. My office could send an e-mail or text message to my pager and it would vibrate when I had new messages. I could respond with a text message, call through a relay service, or instant message with them to have a live conversation.

E-mail and instant messaging programs from companies such as AOL, iChat, Yahoo, Google, ICQ, Trillian and MSN have become incredibly popular. E-mail allows the person with a hearing loss to take as much time as needed to read and understand the sender's message. Instant messaging programs are usually free and are much like a TTY conversation, except that they are on computers and (unlike TTYs) the font size can be changed so that it is easily readable. Most messaging programs also allow for small group discussions with multiple participants—similar to a conference call—and for file transfers (assuming this is allowed by the network). Both e-mail and instant messages can be saved and printed for review or reference at a later date and many have phone and internet options.

Many instant messaging programs also include options for video conferencing. With high speed connections, the video can be quite good and the cameras are less than $50. With modem connections the video is not as good for movement, but it does allow users to see the expressions and body language of the person with whom they are speaking, adding to their understanding of the conversation. In order to use video, the computer's current IP internet protocol address must be identified. This is the number that identifies a specific computer to its network, much like a phone number. It can be easily found by going to *www.whatismyip.com* from the computer whose IP you wish to identify.

Calling 9-1-1

Technology changes rapidly. No matter which option of telephone service is preferred, always check with both the telecommunications provider and the local non-emergency phone number for local emergency services to find out the most effective way to call for help. Cell phones do not transmit the address information to an emergency operator that is available in many areas if the call is made from a landline. Relay service call centers are not local to the emergency caller. If a relay service is used to call 9-1-1, there may be misunderstandings simply because the CA is not familiar with local city and street names. While some relay services are now advertising that they do transmit this address information to the 9-1-1 Call Center, it still takes more time than calling direct (Davis, 2003). Many people keep TTYs for these emergencies.

Closing Thoughts on Communication Technology

The following story was relayed in a statewide meeting of disability services providers:

> A disability services provider who was having difficulty locating a local CART provider came to me for suggestions. She researched remote CART services, got quotes, checked with her IT people, and performed the Herculean feat of getting the student's classroom changed to one with internet access. When she explained to the student that no one local was available but that she had (proudly) found a remote provider, the student responded, "I've heard that that doesn't work very well. I don't want that. I want you to find a local person." From that point on, the student blamed the service provider for not getting her the appropriate accommodation, and the service provider thought of the student as "difficult" and uncooperative. This is not effective self-advocacy.

There are a number of points consumers should keep in mind that are important to successful self-advocacy. The service provider must make rules and apply them equally to all students. The service provider also must work within the budget and restrictions set up by his or her administrators. Furthermore, service providers are most often responsible for providing accommodations for individuals across the range of disabilities, not specializing in a single disability group. They may have more information on accommodations for some disabilities than others.

Because not everyone will be well-versed in the needs of hard of hearing individuals, it is important that the individual consumer be aware of what works or what does not work for his or her particular loss and is able to communicate this information to the service provider. Remember Irina's story. It just so happened that the service provider had some ideas that she thought would be helpful to Irina. Irina could have left the office with the tape recorder. This is the major difference between the laws providing for K-12 settings versus postsecondary education. In college settings, the individual must self-disclose and request a specific accommodation, which documentation must support. The relationship between the above service provider and student would have been very different if the student had said, "Normally, remote CART would be great, but my understanding is that this instructor relies almost totally on group discussion. Because people would not be speaking into a microphone, I am concerned that the remote transcriber would not be able to follow the group discussion. I'm open to other ideas, but the only thing I know of to accommodate this situation would be a local speech-to-text service." This statement is assertive, educational, and helpful to the service provider.

Because we are talking about communication access, much more than the individual's audiogram must be considered to provide the appropriate accommodation. Indeed, the individual's needs will change from course to course and from year to year as the curriculum and instruction changes. People with cochlear implants fear that others will think that their CI makes them "hearing" and that they no longer need assistance. Likewise, other students are reluctant to admit that in some classes they do not need CART and that for that specific situation ALDs work well, because they are afraid that the service provider will remove CART from other classes where it is vital. Trust is an important component to this relationship.

Encouraging the Use of Assistive Technology

Many times, students who are unfamiliar with ALDs will be reluctant to use them. Encourage students to try out the equipment in safe environments outside of class or work (for example, with friends or watching television). They might request the equipment when attending movies or experiment with equipment in the comfort of their homes to see how the technology best combines with their hearing aids or cochlear implant. In fact, it may require a few extra visits to the audiologist to get the best programming or mapping of the technology for the kinds of specific listening situations the individual encounters.

Once individuals with hearing loss understand how helpful accommodations can be, they are often more willing to accept them. Explore their fears. Provide coping skills needed to gain confidence so that it will be easier to handle any problematic situations that may arise. Support groups are great places to learn more about how to live with hearing loss from others in the same situation. The Hearing Loss Association of America (HLAA) (formerly Self Help for Hard of Hearing Persons [SHHH]) and the Association for Late Deafened Adults (ALDA) are two such groups. If there are no local HLAA or ALDA groups, if the individual is uncomfortable, or just too busy, e-mail lists may be the perfect contact option. Two excellent resources are *Beyond Hearing* and *Say What Club*. (See the **Resources** section for information on how to join.)

One of the best ways to see what technology is available is to request catalogs from companies that sell assistive technology. For example, LS&S Group sells technology for individuals with hearing loss and/or vision loss. It is very informative to browse through the catalog to learn more about what is available. The Beyond Hearing Aids website (found at *www.beyondhearingaids.com*) provides not only information on the specifics of the technology, but also functional information on how it can be used in day-to-day life. For on-the-job situations, see *www.onthejobwithhearingloss.com*. It is also useful to contact the company to learn if there are products available but not listed in the catalog. (More companies selling assistive technology can be found in the **Resources** section.)

If you are trying to accommodate a student in a career specialty field, be sure to check for online groups that may already deal with the topic, such as medical professionals with hearing loss at *www.amphl.org*, lawyers at *www.deaflawyers.org*, musicians at *www.aamhl.org*, government employees at *www.dhhig.org*, and nursing at *www.nond.org.*

It is very important to understand that technology does not resolve all communication access issues. Creating effective communication is not like building a wheelchair ramp. Because individuals are involved (both in sending the message and in receiving the message) care must be taken to create a successful communication environment. This involves not just the technology, but the attitudes, beliefs, skills, and knowledge of both the sender and receiver. Until users integrate assistive technology into their identities, it will not come naturally to them. An accessible, 'hard of hearing friendly' campus or place of business makes this process achievable. Successful communication is an intricate dance made all the more interesting by the many technology options available now and on the horizon. There are too many options available now not to provide communication access.

III. References and Resources

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RESOURCES

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PowerPoint presentations on assistive listening technology, alerting devices, telecommunications options, and speech-to-text options are available from the PEPNet Resource Center website *http://prc.csun.edu* and *www.wou.edu/~davisc*. The presentations can also be accessed through the following links:

- Demystifying Assistive Listening Devices: The devil is in the detail
  www.wou.edu/education/sped/wrocc/demyst_files/frame.htm
- You Don't Know What You've Been Missing: Alerting and signaling devices
  www.wou.edu/education/sped/wrocc/alert_files/frame.htm
- For Whom the Bell Flashes: Telecommunications options
  www.wou.edu/education/sped/wrocc/telecomm_files/frame.htm
- Defining Communication Access
  www.wou.edu/education/sped/wrocc/commaccess_files/frame.htm

Assistive Listening Devices/Hearing Aids/Auditory Implantable Devices

General Information

Aarts, N.L. (2004). T-Coils: Getting the Most Out of Your Hearing Aid. *www.healthyhearing.com/articles/pf_arc_disp.asp?id=250&catid=1054*

Acoustical Standards for the Classroom *www.acoustics.com/ra_education_standard.asp*

Audisoft Audisee *www.audisoft.net/en/index.htm*

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Direct Audio Input (DAI) *www.nchearingloss.org/dai.htm*

Hearing Aids *www.hearingaids101.com*

The Kennedy Center (2005). Assistive Listening Devices for People with Hearing Loss: A guide for performing arts settings *http://nadc.ucla.edu/AssistiveListeningDevicesGuidePerformingArtSettings.pdf*

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Starkey Laboratories. (2006). Lexis Wireless FM System. *www.hearwireless.com/lexis.html*

Technology Access Project *http://tap.Gallaudet.edu*

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Yetter, C. (2005) How to read an audiogram. *www.wou.edu/education/sped/wrocc/HT%20Read%20Audiogram%20web.pdf*

Yetter, C. (2005). What is a hearing aid evaluation? *www.wou.edu/education/sped/wrocc/Hearing%20Aid%20Eval%20-%20web%20.pdf*

Assistive Device Companies

- Beyond Hearing Aids *www.beyondhearingaids.com* This is a great site with very helpful functional information and articles about using ALDs.
- Cochlear Implant & Hearing Aid Interface Systems *www.cihais.com*
- DeVilbiss DeVelopment Co., LTD. *www.deafmall.net/devilbiss* Custom made neckloops, CI patch cords
- General Technologies *www.devices4less.com*
- HARC Mercantile *www.harcmercantile.com*
- Harris Communications, Inc. *www.harriscomm.com*
- Hear-More *www.hearmore.com*
- HITEC Group *www.hitec.com*
- LS&S Group *www.lssproducts.com* Specializing in products for the visually and hearing impaired.
- Starkey Laboratories. Lexis Wireless FM System. *www.hearwireless.com/lexis.html*
- Weitbrecht Communications *www.weitbrechtcom.com*

General Hearing Loss Information

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Software/Simulations

- Hearing Loss Demonstrator *www.phon.ucl.ac.uk/resource/hearloss*
- Phonak Hearing Systems – Hearing Loss Demos *www.phonak.com/consumer/hearing/hearinglossdemo.htm*

Alerting Devices

Emergency Alerts

Davis, C. (2003). When Seconds Count: Being 9-1-1 Savvy. *Hearing Loss.* 24(4), 29-31.

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Fair Housing Act Information *www.hud.gov/offices/fheo/FHLaws/yourrights.cfm*

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Spiers, E. (2006). Emergency preparedness and people with combined vision and hearing loss. *Hearing Loss Magazine,* 27(5), 18.

Hearing Dogs

- Assistance Dog Model State Law *www.adionline.org/model.html*
- Assistance Dogs of America, Inc. *http://adai.org*
- Assistance Dogs International *www.adionline.org/hearing.html*
- Canine Companions for Independence *www.caninecompanions.org*
- The Delta Society *www.deltasociety.org*
- Dogs for the Deaf *www.dogsforthedeaf.org*
- Fidos for Freedom *www.fidosforfreedom.org*
- Paws with a Cause *www.pawswithacause.org*

Speech-to-Text

General Information

Camp, C & Stark, B. (2006). More than Words on the Screen. *http://dss.jsu.edu/pp/wordsonscreen_files/frame.html*

Caption Central: Your definitive caption information source. *http://captioning.robson.org/index.html*

Caption Mic *www.ultech.com* speech recognition captioning

CARTWheel Communication Access Realtime Translation. (n.d.). The leading network of realtime providers for the deaf and hard of hearing. *www.cartwheel.cc*

Frank W. Lovejoy Symposium on Applications of Automatic Speech Recognition with Deaf and Hard of Hearing People *www.rit.edu/~ewcncp/Lovejoy.html*

i-Communicator *www.myicommunicator.com*

Liberated Learning *www.liberatedlearning.com*

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Automatic Speech Recognition

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Technology Access Program. (2002). Automatic Speech Recognition. *http://tap.gallaudet.edu/SpeechRecog.htm*

Captioning Videos

Captioned Media Program *www.cfv.org* Huge library of captioned films to choose from.

Captioning Web *www.captions.org/softlinks.cfm* Lists many different companies for captioning services and software.

G&G Video - CCmaker *www.CCmaker.com*

NCI (National Captioning Institute) *www.ncicap.org*

WGBH/National Center for Accessible Media *http://ncam.wgbh.org*

Digital Media and Web-based Video

Amazing Slow Downer: Slows digital audio without distortion to simplify the transcribing process. *www.ronimusic.com/slowdown.htm*

Camp, C & Stark, B. (2006). More than Words on the Screen. *http://dss.jsu.edu/pp/wordsonscreen_files/frame.html* How-to information on captioning video.

Communique Interactive Solutions www.text2u.com Provides remote realtime captioning through TextStreaming via the internet.

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Klatt, J., Gugerty, JJ., Castaneda, M., and Smith, A (2006). Campus Capacity Building Toolkit: Web Accessibility for All. Madison, WI: Center on Education and Work.

MAGpie: Free tool for captioning digital video *http://ncam.wgbh.org/webaccess/magpie*

MAGpie training kit *http://pec.nhmccd.edu/magpiekit.htm*

National Center for Accessible Media (CPB/WGBH) *www.wgbh.org/ncam*

National Court Reporters Foundation *www.ncraonline.org* Lists qualified CART providers.

Portable laptop stands *www.stenograph.com*, *www.instand.com*

RapidText *www.rapidtext.com* Services include captioning videos, producing transcripts of videos, and remote realtime captioning.

University of Wisconsin-Madison. (2006). Web Accessibility for All: Failure is not an Option. *www.cew.wisc.edu/accessibility*

WebAIM. (2006). Captioning for QuickTime. *www.webaim.org/techniques/captions/quicktime/web.php*. Online manual for captioning QuickTime videos to create hearing accessible web video.

Remote Services

Communication Access Information Center *www.cartinfo.org/remotecart.html*

Caption First CART and Captioning Services *www.captionfirst.com*

Captions Unlimited of Nevada, Inc. *www.captionsunlimited.com/pages/1/index.htm*

EduCaption *www.educaption.net*

Wisconsin: Panther project
*www.uwm.edu/Dept/DSAD/SAC/February2003SAC_NEWS.htm*l
Contact: Shannon Aylesworth *shannon.aylesworth@pepnet.org* Ginny Chiaverina *ginny.chiaverina@pepnet.org*; in Maine, Lisa Sorenson *act@maine.rr.com*

Telecommunications

General Information

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CapTel *www.ultratec.com*: Information on Captioned Telephones and Captioned Telephones with USB ports for individuals with low vision.

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Cellular Telecommunications & Internet Association www.ctia.org: Information on how wireless technology works in general, as well as information on hearing aid use with wireless technology.
See specifically *www.accesswireless.org/brochure/audiologist_brochure.htm*

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Federal Relay *www.federalrelay.us*

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HATIS. (n.d.). Hearing Aid Telephone Interconnect Systems *www.hatis.com*

How Stuff Works *www.howstuffworks.com*: Great site useful for many topics, but in particular provides info on cell phones and services.

Information on cell phones (including neckloops and other attachments, use with TTYs):
Cingular *www.cingular.com/about/hearing_aid_compatibility*
Verizon Wireless
www.verizonwireless.com/b2c/aboutUs/accessibility/digitalPhones.jsp
Nokia *www.nokiaaccessibility.com/hearing.html*

Jay Wyant's 2-line VCO demonstrations *www2.bitstream.net/~jwyant/2lvco.html*

Kozma-Spytek, L. (2005). Digital Cell Phones and Hearing Aids FAQ *www.hearingloss.org/learn/cellphonetech.asp*.

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Rehabilitation Engineering Research Center on Hearing Enhancement. (2006). Links: Hearing Aid Companies *www.hearingresearch.org/links.htm#Hearing%20Aid%20Companies*

Silverman, F. (1999). The Telecommunication Relay Service (TRS) Handbook. Newport, RI: Aegis.

Starkey Laboratories. (2006). ELI [Ear Level Instrument] Bluetooth Technology. *www.hearwireless.com/eli.html*.

Wireless Advisor *www.wirelessadvisor.com* Enter your zip code and find the wireless options available in your area

Wireless TTY Calling instructions *www.ultratec.com/support/ttycell.php*.

Yanz, J.L. (2005) A Wearable Bluetooth Device for Hard-of-Hearing People. *www.hearingreview*.com/Articles.ASP?articleid=H0505F04 An article on ELI (Ear Level Instrument), a Bluetooth boot for hearing aids.

Internet Relay Providers

- AT&T Relay Services *www.consumer.att.com/relay*
- CSD *www.c-s-d.org*
- Go America i711 *www.i711.com*
- Hamilton Relay *www.hiprelay.com*
- MCI *www.ip-relay.com*

Instant Messaging

- AOL Instant Messenger *www.aim.com*
- MSN Messenger *www.msnmessenger-download.com*
- Yahoo Messenger *http://messenger.yahoo.com*

Two-Way Pagers

- Audex *www.audex.com* Amplified cordless phones, cell phones, adapters.
- PalmOne (previously PalmPilot) *www.palmone.com* Handhelds and wireless phones.
- TMobile *www.t-mobile.com* Sidekicks, BlackBerrys and handhelds.

Videophones/Video Relay Services/Video Remote Interpreting

- AT&T How to make a video relay call *www.consumer.att.com/relay/video*
- AT&T *www.attvrs.com*
- Communication Access Center for Deaf and Hard of Hearing *www.cacdhh.org*
- CSDVRS *www.csdvrs.com*
- D-Link Corporation D-Link i2eye *www.dlink.com*
- Hamilton Telecommunications *www.hipvrs.com*
- Hamilton Relay *www.hamiltonrelay.com*

- Hands On Video Relay *www.hovrs.com*
- MCI *www.ip-relay.com/index.htm*
- Sorenson *www.sorensonvrs.com*
- Sprint *www.sprintvrs.com*

To find out your IP address (needed to make video calls or to have others call you) go to *www.whatismyip.com* . Use this URL from the computer you'll be using to place or receive video calls.

Currently, there are several national providers of video relay services (VRS). The FCC maintains a list of providers at *www.fcc.gov/cgb/dro/trs_providers.html*.

White Paper on VRS/VRI CSAVR Website
www.rehabnetwork.org/position_papers/whitepaper/white_paper.htm

Video Interpreting Committee: Registry of Interpreters for the Deaf
www.rid.org/VideoInterpretingTalkingPoints.pdf

Organizations

Hearing Loss Organizations

- Alexander Graham Bell Association *www.agbell.org*
- American Tinnitus Association *www.ata.org*
- Association of Medical Professionals with Hearing Losses *www.amphl.org*
- Association of Late-Deafened Adults *www.alda.org*
- Hearing Loss Association of America *www.hearingloss.org*
- League for the Hard of Hearing *www.lhh.org*

Professional Organizations

- Academy of Rehabilitative Audiology *www.audrehab.org*
- American Speech-Language-Hearing Association *www.asha.org*
- American Academy of Audiology *www.audiology.org*
- Educational Audiology Association *www.edaud.org*
- National Board Certification of Hearing Instrument Specialists *www.hearingnbc.org*
- Rehabilitation Engineering Research Center on Hearing Enhancement *www.hearingresearch.org*

Electronic Mailing Lists and Consumer Groups

- Association of Adult Musicians with Hearing Loss *www.aamhl.org*
- Association of Medical Professionals with Hearing Loss *www.amphl.org*
- Beyond Hearing *www.geocities.com/heartland/prairie/4727/bhframe.htm*
- Deaf and Hard of Hearing in Government *www.dhhig.org*
- Deaf Lawyers *www.deaflawyers.com*

- Exceptional Nurse *www.exceptionalnurse.com*
- Hard of Hearing Audiologists *HOHAudiologists@yahoogroups.com*
- Hearing Loss Web *www.hearinglossweb.com* (HOH-LD News)
- National Organization of Nurses with Disabilities *www.nond.org*
- Say What Club *www.saywhatclub.com*

Federal Law and ADA Training Materials

ADA Title I PowerPoints developed by John Evans include Definition of Disability, Americans with Disabilities Act Introduction, Essential Functions, Pre-Employment Inquiries, Medical Examinations & Inquiries, Qualified Individual with Disability, Reasonable Accommodations, Undue Hardship. Direct Threat, Rehabilitation Act Reauthorization and information on the 1998 Amendments to Section 504 of the Rehabilitation Act of 1973 (Workforce Investment Act). *www.wou.edu/wrocc* and click on "Training Materials"

Access Board ALD Bulletins for:
Consumers *www.access-board.gov/adaag/about/bulletins/als-a.htm*
Installers *www.access-board.gov/adaag/about/bulletins/als-b.htm*
Providers *www.access-board.gov/adaag/about/bulletins/als-c.htm*

Access Board information about ALDs and Assembly areas
www.access-board.gov/adaag/checklist/AssemblyAreas.html

Federal Communications Commission *www.fcc.gov/cgb/dro/section255.html*
Section 255 of the Telecommunications Act of 1996

Job Accommodations Network *www.jan.wvu.edu*

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