How to Describe and Characterize Your Hearing Loss

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In this article, we provide information to aid our readers in describing and characterizing their own hearing losses for others, as well as understand others' descriptions of their hearing losses. This article has been divided into several sections beginning with an anatomy and physiology overview of the auditory system and ending with interpretation of an audiogram.

Anatomy and Physiology Overview of the Auditory System

We begin here with an overview of the anatomy and physiology of the auditory system. Knowing a little about the auditory system may do much to help describe and explain the cause of hearing loss and how it may affect one's daily communication.

The auditory system can be divided into four major parts: outer ear, middle ear, inner ear, and auditory nervous system (peripheral and central). Figure 1 displays the anatomical organization of the auditory system.

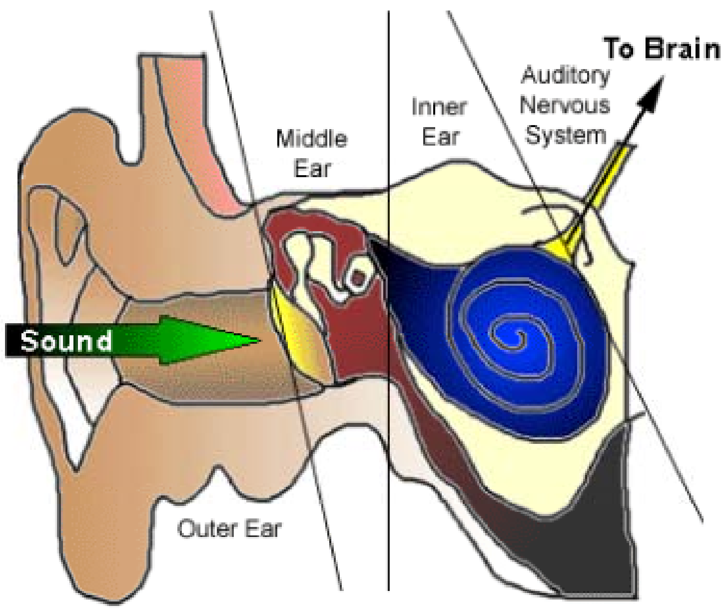

Figure 1. Anatomy of the Auditory System.

The outer ear is made up of the auricle (visible fleshy extension on the sides of the head) and the ear canal. The primary function of the outer ear is to trap and funnel sounds through the ear canal towards the eardrum. By virtue of design, the outer ear has the capacity to amplify sounds, particularly those sounds that occur in the human speech frequency range.

The middle ear is an air-filled pouch that contains the eardrum and ossicles. 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. Attached to the eardrum is a chain of three tiny bones called the ossicles. The chain includes the malleus, incus, and stapes, which transmit the movements of the eardrum to the oval window of the inner ear. Remarkably, the auditory system is sensitive to pressure changes (or movement) as low as 0.0000000001 of a meter, the width of a hydrogen atom.

The inner ear, i.e. the cochlea, is a fluid-filled organ containing approximately 3,500 inner hair cells and 12,500 outer hair cells. When sound strikes the eardrum, the vibrations set up on the eardrum travels through the middle ear by the movement of ossicles, which then sets up a pressure wave in the fluid of the cochlea. These fluid vibrations cause the inner hair cells to fire signals to the auditory nerve (VIIIth cranial nerve). The expansion and contraction of the outer hair cells in response to pressure waves in the cochlea allows for the amplification of softer sounds.

Most descriptions of the auditory system stop at the inner ear; however, our ability to hear does not. Healthy hearing also depends on working neural circuitry from the auditory nerves to the auditory centers in the brain, called the auditory nervous system. After inner hair cells fire, the auditory nerves send their signals to various cell groupings in the brainstem for minor processing before reaching the auditory centers of the temporal lobe. When sounds reach the temporal lobe, this is presumably when we are first aware of sound.

Conductive, Sensorineural, Retrocochlear, or Mixed?

Following a general understanding of the anatomy and physiology of the auditory system, we can begin to appreciate how problems in any one part of the auditory system can result in different types of hearing loss. These problems can occur in one or both ears in which case we may refer to them as unilateral or bilateral, respectively. In this section, conductive, sensorineural, retrocochlear, and mixed hearing losses are briefly described.

Conductive Hearing Loss

Conductive hearing losses are created when it is difficult for sounds to reach an otherwise normally functioning cochlea. This means that a problem exists somewhere between the outer and middle ears. Excessive earwax in the ear canal, fluid and/or infection in the middle ear (otitis media), damaged eardrums, and broken ossicular chains are examples of problems that can cause can conductive losses. Most (not all) hearing losses of a conductive nature can generally be repaired or medically treated. Losses of up to 60 dB can result from uncorrected conductive hearing losses. If an individual has congenital deformities such as atresia (small or absent auricle and closed ear canal) or microtia (small or absent auricle and tiny ear canal), the intensity of sounds can be severely reduced and obscured. Hereditary disorders such as otosclerosis can cause the ossicular chain to become more rigid, which prevents faithful representations of the vibrating eardrum from reaching the cochlea. Because the hearing loss is manifested in only the outer and middle ears, hearing aids or bone oscillators may overcome the conductive hurdle in order to deliver sounds to the otherwise normally functioning cochlea when medical treatment is not an option.

Sensorineural Hearing Loss

The word sensorineural is now a misnomer because audiologists, in years past, could not differentiate an inner ear disorder from a nervous system disorder. With advanced tools, however, it has become easier to separate the two, with the exception of individuals with auditory neuropathy, where the problem is either associated with the inner hair cell, auditory nerve, or both. Still widely used today, the term sensorineural hearing loss implies a disorder in the inner ear. Sensorineural hearing losses are the most common of the different types of hearing loss. The hair cells are susceptible to damage from ototoxicity, from aging, and from long-term exposure to loud sounds. Age-related hearing loss (presbycusis) may have genetic implications. Many syndromes that interrupt, arrest, attack, or breakdown the structure of the inner ear can cause an array of problems. Finally, as genetic research advances, genes are being found that influence the normal operation of the inner ear.

The inner and outer hair cells play different roles in hearing acuity. In the previous section, we mentioned that inner hair cells communicate directly with the auditory nerve, whereas the outer hair cells amplify soft sounds via changes in fluid pressure in the inner ear. It is entirely possible for the inner and outer hair cells to be affected independently of one another. For example, most people with hearing loss have outer hair cell damage and little to no inner hair cell damage. People with only outer hair cell damage make very good hearing aid candidates, because the hearing aid replaces the amplification role of the outer hair cells. However, the ability to understand speech degrades with increasing damage to the inner hair cells. Individuals with obsolete inner hair cell function generally are cochlear implant candidates, since the cochlear implant bypasses the normal function of the both the inner and outer hair cells.

Retrocochlear Hearing Loss

Retrocochlear hearing losses refer to hearing disorders associated with the auditory nerve to the auditory centers of the brain. Progressive neural disorders, such as multiple sclerosis (demyelination), can obscure sound information being sent by the cochlea. Tumors developing on the auditory nerve (e.g., vestibular schwannomas) can wipe out large frequency regions within the range of speech sounds, making it difficult understand speech.

Lesions of the brain whether traumatic, vascular, chemical, neoplastic, or developmental, can cause a variety of different auditory processing disorders. In the event that hearing loss is due to problems with the auditory nerve, an individual may elect to receive an auditory brainstem implant (ABI).

Mixed Hearing Loss

As the name implies, one can have one or more of the above hearing disorders.

Interpreting The Audiogram

When there is suspicion of hearing loss, a battery of tests is usually performed that may illuminate where the problem is in the auditory system and determine the degree (or severity) of the problem. Unfortunately, it is beyond the scope of this article to describe the various tests that can be performed. Instead, we will focus on how to interpret an audiogram, a task that requires several steps.

An audiogram is a graph used to plot hearing thresholds (figure 2). On the top of the audiogram, frequency (Hz) increases from 125 to 8000 Hz. The perceptual correlate of frequency is pitch. For example, the rumble of a train is low in pitch and the chirps of birds are high in pitch. The human frequency range for young, normally hearing individuals is 20 to 20,000 Hz; however, the most important frequencies for speech fall in the range of 250 to 8000 Hz (figure 3).

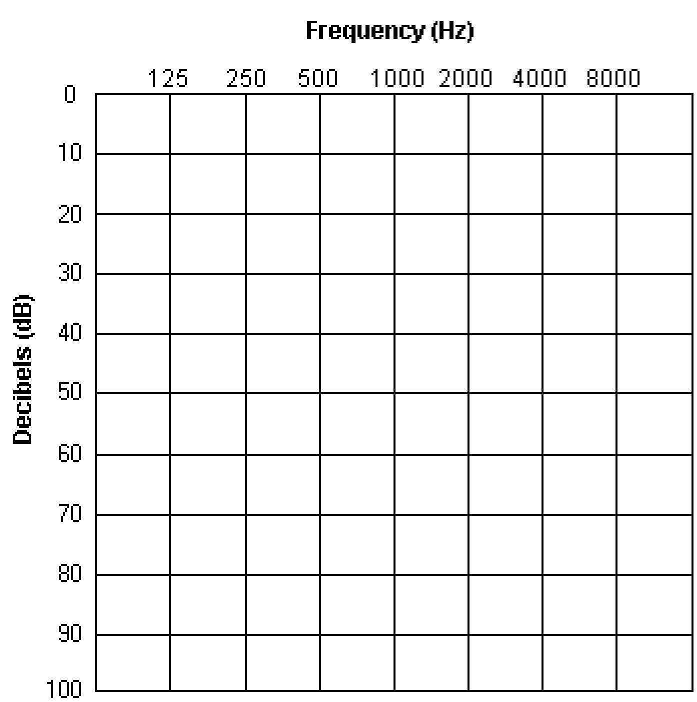

Figure 2. The Audiogram.

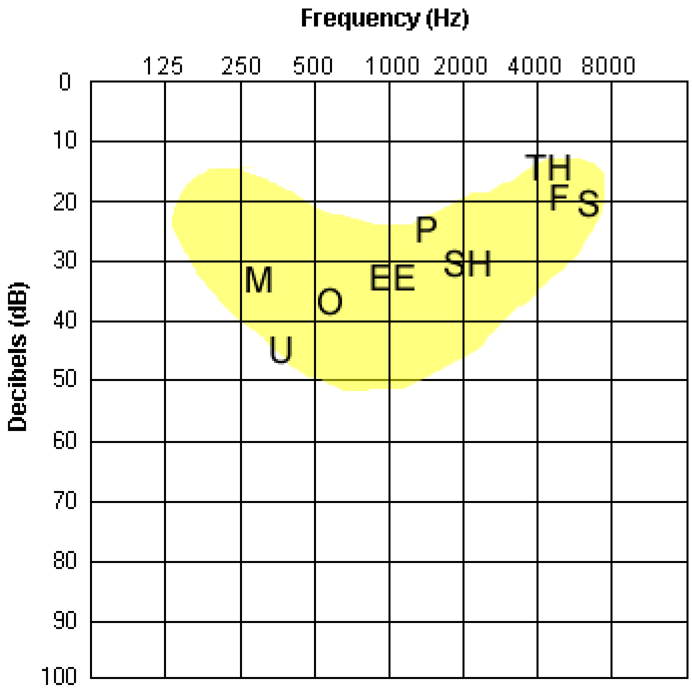

Figure 3. Speech Sounds in Reference to the Audiogram. The yellow shading represents the speech area.

On the left hand side of the audiogram, decibels (dB) increase from top to bottom. The perceptual correlate of decibels is loudness. We can use decibels to represent how loud something is (e.g., whisper vs. siren) or we can use it to describe how well an individual hears. The audiogram is a graph that portrays how well someone hears relative to loudness of sounds.

When hearing is tested, the goal of the audiologist is to determine what an individual's thresholds are at various frequencies in order to capture an idea of how well the individual hears within the human speech frequency range. Thresholds are defined as the softest sound an individual can hear at least 50% of the time. Someone with perfect hearing would be expected to have thresholds at 0 dB across the frequency range, specifically at 250 to 8000 Hz. It should be noted that 0 dB is often misunderstood as being the absence of hearing when it really means the average softest sound that a group of young, healthy individuals can hear. Lower thresholds mean better hearing.

Testing for thresholds usually does not exceed 110 dB, because sounds in excess of 100 dB can be damaging to the ear. As thresholds get higher, the ability to hear sound becomes poorer.

In the next couple of sections, we will describe two things needed to interpret an audiogram. One, it is important to know the pattern (or configuration) of thresholds plotted on an audiogram. Simply, an individual may actually hear better at certain frequencies relative to others. Two, using thresholds, even with different configurations, one can classify hearing loss by degree or severity. Finally, we will use a case example.

Configurations of Hearing Loss

By configuration of hearing loss, we are asking, "How are the thresholds plotted on your audiogram?" Do the thresholds appear to go straight across the board (flat)? Do the thresholds appear to be good in the low frequencies and poor in the high frequencies? Are thresholds worse in the middle frequency range? Figure 4 displays different configurations of hearing loss based on their pattern of thresholds across the frequency range, and their common names are displayed.

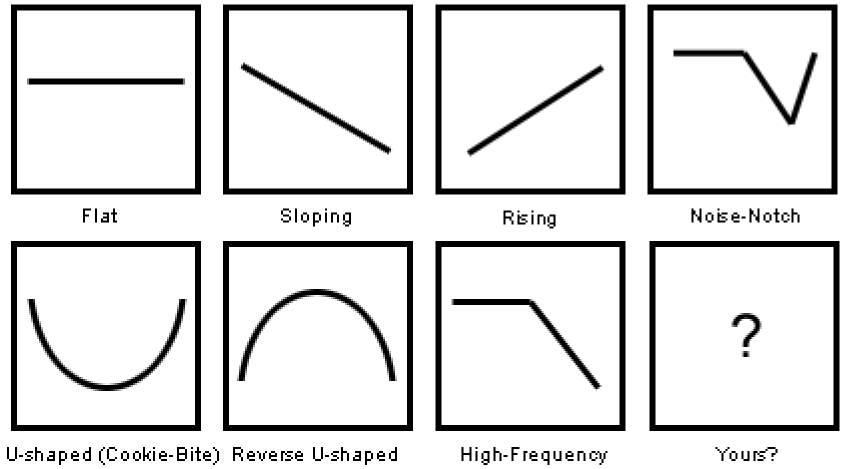

Figure 4. Example Configurations of Hearing Loss

Degree of Hearing Loss

Once the specific problem area(s) of the auditory system is identified, questions we might ask next are, “How severe?” or “What is the degree of hearing loss?” Hearing loss is quantified for legal, medical, and rehabilitative purposes. Generally, amount of hearing loss has been described in one of two conventions: decibels (dB) or percentages. Which convention one uses is a matter of personal, legal, and/or professional preference, and each has its own set of rules for how their values are derived. Furthermore, different conventions may be used in different parts of the world. Here, we describe both, each of which are quantifications of how well an individual hears.

Percents. The American Medical Association (AMA) and the American Academy of Otolaryngology (AAO) calculate hearing loss into percentages (http://www.ccohs.ca/oshanswers/phys_agents/noise_auditory.html). First, with 0 dB as the softest sound that most people can hear, the amount that thresholds that exceed 25 dB at 500, 1000, 2000, and 3000 Hz are summed and then averaged. That average is multiplied by a factor of 1.5 and then the product is turned into a percentage. Any average that exceeds 92 dB is considered 100% loss. Additional calculations are necessary, however, to calculate hearing disability with one or two ears. The problem with percentages is that there is poor correlation with speech recognition abilities (how well one understands words or speech in optimal or noisy listening conditions).

Decibels. The American Speech-Language-Hearing Association (ASHA) and American Academy of Audiology (AAA) calculate hearing loss using decibels. Simply, one takes thresholds at 500, 1000, and 2000 Hz and averages them to derive a pure tone average (PTA). The average obtained will fall into one of six categories: normal (< 25 dB HL), mild (25-40 dB HL), moderate (40-55 dB HL), moderately severe (55-70 dB HL), severe (70-90 dB HL), and profound (> 90 dB HL). Figure 5 displays these six categories. Although these averages tend to correlate better with speech recognition abilities, the cutoffs are quite arbitrary. Just because one’s hearing loss falls into the profound hearing range, does not imply that he/she cannot perform as well or better than someone in the moderately severe range.

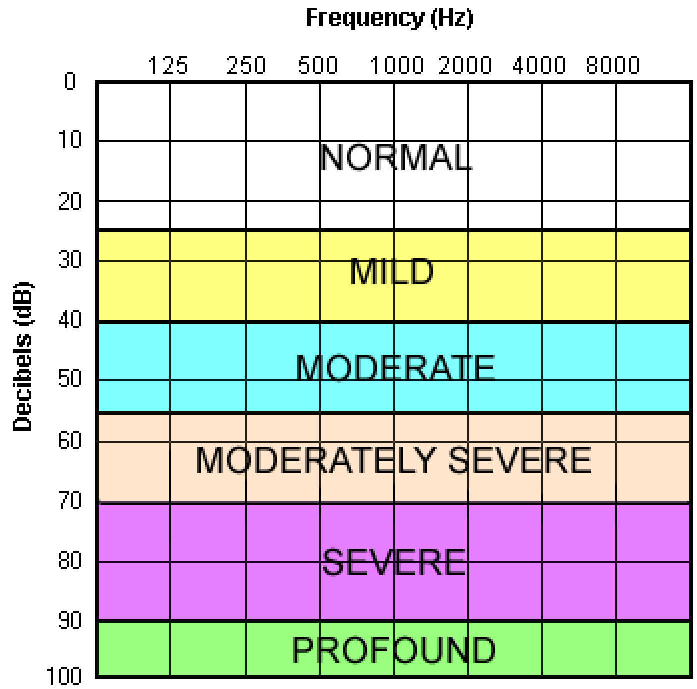

Figure 5. Degrees of Hearing Loss

For a comical look at the decibel vs. percentages debate, you may wish read Dr. Neil Bauman's commentary online (http://www.hearinglosshelp.com/decibelsvspercent.htm).

Case Example

The audiograms in figure 6 will be used to illustrate how an audiogram is interpreted and what it means. First, we will describe what each of the symbols means on the audiogram. Normally, the results of both ears are superimposed on the same audiogram; however, for simplicity's sake, we have put the right and left ear results on separate audiograms.

Red circles and blue X's represent air-conduction thresholds for the right ear and left ear, respectively. Air-conduction thresholds are obtained when testing an individual with sounds presented through headphones. In figure 6, the left ear is normal with thresholds at or better than 5 dB across all frequencies. However, for the right ear, there appears to be a hearing loss, particularly in the low frequency region.

Let us suppose that the audiologist had prior suspicions about a possible conductive hearing loss. Because of the suspicion, there is a chance for air-conduction testing to produce misleading thresholds. In situations such as this, thresholds would be obtained for the right ear using a bone oscillator that is placed behind the right ear on the skull in the region of the mastoid. These thresholds are called bone-conducted thresholds, and these are obtained following air-conduction test to assess how large the conductive component is. In the left ear, some masking noise is presented to keep the normal left ear from responding to the bone oscillator. Masked, bone-conduction thresholds were obtained for 250, 500, 1000, and 4000 Hz. The brackets ("[ ]") represent the masked, bone-conduction thresholds. The right ear masked, bone-conduction symbol is "[".

Notice how much better the bone-conduction scores are compared to the air-conduction scores for the right ear. This is typical for someone with a conductive hearing loss, where the inner is presumably normal, but there is something going on in either the outer or middle ear, or both.

The full interpretation of this audiogram is: Left ear is within normal limits (i.e., thresholds < 25 dB). A unilateral mild conductive hearing loss is present in the right ear. (Following the pure tone average decibel calculation.) More specifically, the right ear is characterized as a unilateral conductive hearing loss that is mild to moderate in the lower frequencies gradually rising to normal limits from 2000 to 8000 Hz.

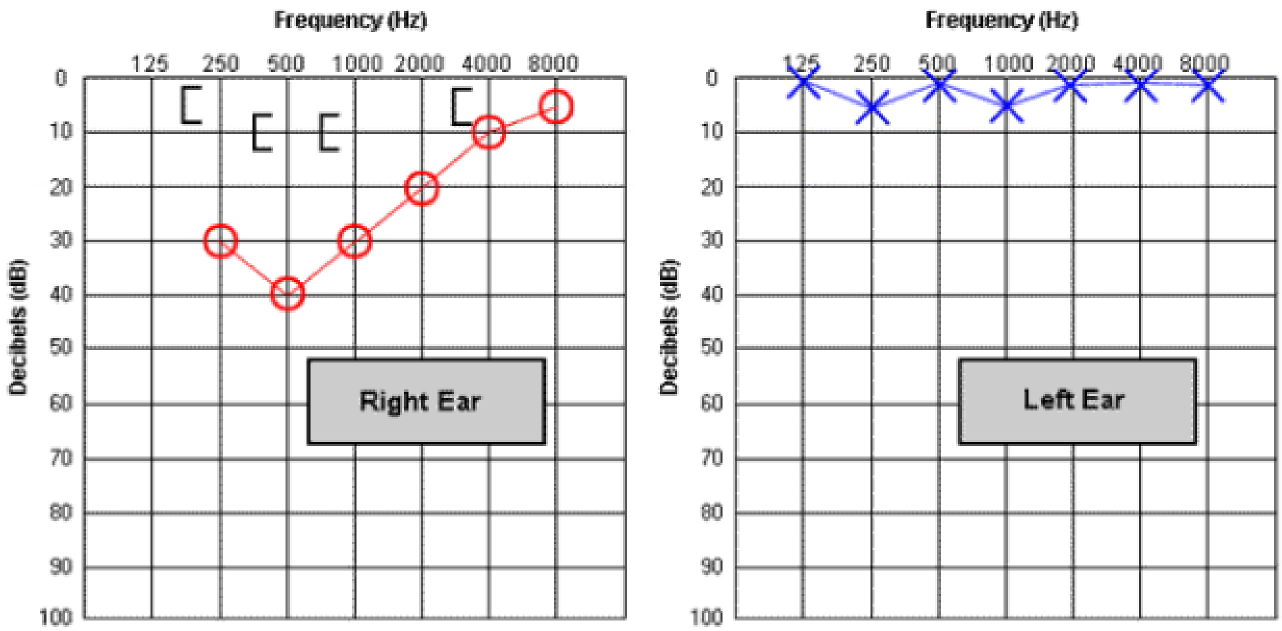

Figure 6. Case Example of an Audiogram. Red circles and blue X's represent air-conduction thresholds for the right ear and left ear, respectively. The brackets ("[ ]") represent masked, bone-conduction thresholds.

Conclusions

From this article, we hope that our readers will come away with tools to talk about their hearing losses, not only by classification, but also by attending to specific anatomical, physiological, and auditory processes that can make or break their ability to hear and to understand.

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