Hearing Testing: A Guide for Parents and Teachers

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KEY TERMS

- audiogram
- thresholds
- frequencies
- hertz
- decibels
- dB HL
- external auditory meatus
- air conduction
- bone conduction
- cochlea
- within normal limits
- pure tone average
- degree
- conductive
- sensorineural
- mixed hearing loss
- cerumen
- eighth cranial nerve
- auditory/vestibular nerve
- speech audiometry

Whether you are a parent, relative, friend or teacher of a child or student who has a hearing loss, it is essential to be comfortable and knowledgeable about his or her hearing loss. The first step that will get you there is understanding hearing testing, the audiogram (the graph that represents the hearing testing results) and some of the other special tests that audiologists often complete.

You should certainly do your own research and talk to your child's audiologist for additional information. The purpose of this primer is to get you on solid ground with the important information, terms and many acronyms that you need to know if you want to have a productive and substantive conversation about hearing loss. In the online version of this article (see end for more

information), you will find a Glossary of Terms—a handy navigator for this "acronym soup" of terms and concepts. Also, check out the glossary of terms on the AG Bell Listening and Spoken Language Knowledge Center for an easy alphabetical search of terms, concepts and definitions related to hearing loss at www.agbell.org/Glossary.

The Audiogram

An **audiogram** is a graphic representation of a person's hearing or auditory responses, specifically **thresholds**, which are defined as the "softest" sound detected 50 percent of the time. Thresholds need to be repeatable, before they are recorded on the audiogram.

Across the horizontal plane (abscissa or x-axis) of the audiogram are **frequencies** in Hertz (Hz), formerly referred to as cycles per second. Frequency information reflects the physical stimuli of sound vibrations, with the psychological correlate of "pitch." A person with typical hearing can usually hear sounds between 20 and 20000 Hz. During hearing testing, however, only the octave frequencies are typically measured and are considered "frequency-specific" samples (i.e., 250, 500, 1000, 2000, 4000 and 8000 Hz). On the vertical plane (ordinate or y-axis) of the audiogram are labels of "loudness" measured in **decibels** (dB, the upper case B is a convention which honors Dr. Alexander Graham Bell). On the audiogram, the dB referent is to **dB HL** (Hearing Level; whereas the physical measure is dB Sound Pressure Level or dB SPL) (see Figure 1).

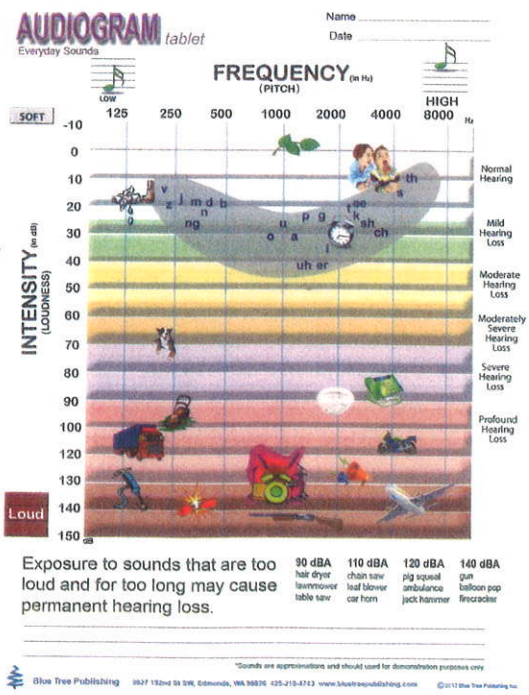

Figure 1. Sample audiogram. Also, check out the Speech Banana on the AG Bell Listening and Spoken Language Knowledge Center at www.agbell.org/SpeechBanana.
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The Hearing Testing Process

Now that you are oriented to the audiogram's basic form, let's begin talking about the typical hearing testing process. Most evaluations begin with the taking of a case history, including probes of the mother's health during pregnancy, the actual delivery, medical and family history, along with inquiries to learn more about the child's development (fine and gross motor skills, speech sound productions, receptive and expressive language, early literacy status, among other areas).

There are a host of electrophysiological tests of hearing such as otoacoustic emissions or OAEs, automated and diagnostic auditory brainstem response (ABR) testing, and auditory steady state response (ASSR), but these measures are beyond the scope of this article. However, if behavioral testing doesn't quickly lead to ear-specific data being determined (that is, right ear only and left ear only measurements) and/or if questions about the tests' reliability (repeatability) or validity (did the test accurately measure what it was supposed to measure) remain, a prompt referral and follow-up with a pediatric audiologist and a facility with significant experience completing auditory electrophysiological measures, such as the ones mentioned above, is in order.

The behavioral measures referred to above might include Behavioral Observation Audiometry (BOA), Visual Reinforcement Audiometry (VRA) or Conditioned Play Audiometry (CPA), depending on the age and developmental status of the child. The testing method(s) used should be coordinated and completed by experienced pediatric clinicians.

When testing is completed with ear inserts placed in the child's ear canal (**external auditory meatus**) or if headphones are used, the measurement is called **air conduction** (AC) testing. The complete pathway for air conduction includes the "whole system" (i.e., the outer, middle and inner ear, and beyond to the brain). The thresholds obtained with AC testing are placed on the audiogram as red circles for the right ear and blue "X"s or crosses for the left ear. In the actual behavioral testing, the audiologist will have selected a frequency (the first frequency often tested is 1000 Hz), and by using an up and down "bracketing" procedure of "louder" and "softer" pure tone or sine wave presentations, a 50 percent criterion of the "softest" sound level needs to be obtained. That level (in dB HL) is plotted on the vertical line (x-axis) on the audiogram, in this case under 1000 Hz, and at the intersection with the horizontal line (y-axis) point for the X dB HL number established. Testing is completed at other frequencies for each ear separately, and a complete AC audiogram is subsequently filled in.

Bone conduction (BC) testing makes use of a bone vibrator or oscillator that is placed on the "temple" bone area of a patient, behind and to the side of the ear. Testing via bone conduction essentially bypasses the outer and middle ear, and literally vibrates the bones of the skull and directly measures responses from the **cochlea**, which is the sense organ of hearing located within the inner ear. Thresholds from the bone conduction measures are similarly placed on the audiogram as red (<) or blue (>) brackets (these are placed directly to the left and right sides, respectively, of the vertical line reflecting the frequencies tested—typically only 250, 500, 1000, 2000 and 4000 Hz are measured by BC).

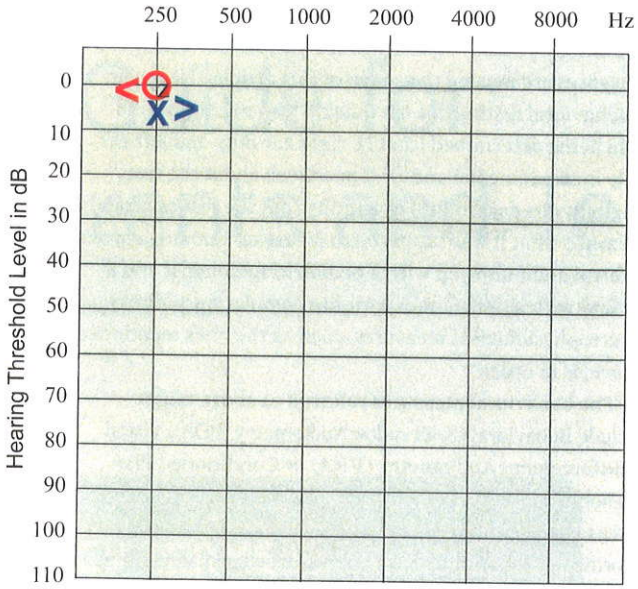

Figure 2. CREDIT: DONALD GOLDBERG

Using Figure 2 to clarify, for 250 Hz the AC threshold for the right ear is 0 dB HL, as noted by the red circle, and the AC threshold for the left ear is 5 dB HL for the left ear, as indicated by the blue cross. You will also see that for 250 Hz, the BC threshold for the right ear is at 0 dB HL (red <) and the BC threshold for the left ear is at 5 dB HL (blue >).

As the audiologist evaluates the threshold results, specific guidelines are used to interpret the "degree" or "level" of hearing or hearing loss. Threshold responses for a child that are at 15 dB HL or "better" (e.g., 10, 5, 0, or even -5 dB HL) are all considered to be **Within Normal Limits** (WNL). In other words, thresholds at the top of the audiogram reflect "good" hearing. As the thresholds need to be plotted further down the dB HL (higher or larger numbers), this indicates a more significant degree of hearing loss.

Some professionals characterize hearing loss based on each individual threshold; others rely on the number average for each ear at 500, 1000 and 2000 Hz called the **Pure Tone Average** (PTA); whereas still others methodically characterize the whole audiogram, taking into consideration that rarely are the thresholds completely "flat" across the audiogram, and are often more likely at "better" levels in the low frequencies (pitches) and sloping downward in the mid frequencies, with the "worst" threshold data often in the high frequencies (which helps explain why many individuals have the most difficult time hearing "weak" sounds with most of their acoustic energy in the high frequency regions such as the "f," "s," and "th" sounds).

Degrees and Types of Hearing Loss

The severity of a hearing loss is typically determined by evaluating the dB level and using various terms to decode the degree of the hearing loss. Depending upon the choice(s) noted above of describing individual thresholds, the PTA numbers or the severity details across the whole audiogram, most texts use the following characteristic terms to indicate **degree** of hearing loss: dB HL numbers of 26-30 as a "slight" hearing loss; 31-40 as "mild"; 41-55 as "moderate"; 56-70 as "moderately severe"; numbers between 71 and 90 suggesting a "severe" loss; and thresholds of 91 dB HL and above are indicative of a "profound" hearing loss. Most audiologists avoid language that uses terms suggesting a "percent hearing loss" for a variety of reasons. Notably, hearing is not a 0 percent or a 100 percent issue. In addition, because we use measures that can reach 120 or 130 dB—and the audiogram scale is logarithmic—the transfer of, for example, a 75 dB HL hearing loss cannot be interpreted as a 75 percent hearing loss.

It should also be noted that there are three primary **types** of hearing loss, which are based on the three classifications of **conductive, sensorineural (also referred to as sensory/neural or sensori-neural)**, and **mixed hearing loss.** By definition, a conductive hearing loss involves a problem(s) with the "conduction" of sound to the cochlea. In conductive hearing loss, the site of lesion (or the anatomical location of the problem) is in the outer and/or middle ear. An example might be a combination of wax or **cerumen** in the ear canal (part of the outer ear) at the same time a child is experiencing a build-up of middle ear fluid. Fortunately many conductive hearing losses can be managed medically and can be reversed, corrected or improved.

A sensorineural hearing loss involves the cochlea and/or the auditory nerve (the **eighth cranial nerve** or the **auditory/vestibular nerve).** Although many people, especially the older adult, are incorrectly told they have "nerve damage" or "nerve deafness," few hearing losses

actually involve the auditory nerve. This fact becomes especially important as we review patients for cochlear implant candidacy. If there was an absent nerve or a damaged nerve, a cochlear implant would be intuitively contraindicated. As most of our patients have damage to the cochlea, the cochlear implant actually "replaces" the function of the cochlea for these patients and they can become cochlear implant recipients. Sensorineural hearing losses, which are typically permanent and nonreversible, result from heredity, birth disorders, assorted diseases and disorders (e.g., meningitis), damage to the hair cells of the cochlea from medications (referred to as "ototoxic"), noise exposure, or the aging process. Finally, a mixed hearing hearing loss represents a combination of a conductive and sensorineural hearing loss.

In the July-September issue of *Volta Voices*, Part 2 of this article will discuss additional testing in the category of **speech audiometry.** In the meantime, please see AG Bell's Recommended Protocol for Audiological Assessment, Hearing Aid and Cochlear Implant Evaluation, and Follow-up at www.agbell.org/Protocol.Audiological.Assessment/, which provides a "gold standard" of testing for children and other patients.

See you in September!

To access this article online as well as other helpful resources, including a Glossary of Terms, visit **www.agbell.org/VoltaVoices/Apr-Jun2015/HearingTestingGuide**

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