

Audiometric Test Procedures 101

This information is meant to help you better understand the various test procedures as well as some of the terms you might see on an audiometric report.

In the previous issue of *Hearing Loss Magazine*, I provided an overview concerning hearing threshold results as recorded on the audiogram and an explanation of the pure-tone audiogram. In this article, I will describe various test procedures that are typically administered in an audiometric evaluation and what information the tests provide.

Audiometric Test Procedures

Pure-tone Audiometry: Tones of different frequencies are presented; the goal is to find the softest sound level which one can hear (threshold) the different tones. This test is typically administered in one of two ways: air-conduction audiometry—involving the use of head/ear phones; and, bone-conduction audiometry—involving the placement of a vibrating device on a person's skull.

By comparing the results from both procedures, one can determine if there is a conductive component present (some form of barrier interfering with the transmission of sound from the outer/middle ear to the inner ear). In addition to any inner ear hearing loss that might be present, the presence of a conductive component would result in air-conduction thresholds over and above the bone-conduction thresholds.

Speech Reception Threshold

(SRT): Compound words (words comprised of two smaller words, such as cow-boy) are presented, the goal being to find the softest sound level at which one can hear and repeat approximately one-half of the compound words correctly. The SRT decibel level typically obtained approximates the average of 500, 1000 and 2000 Hz tonal thresholds for individuals with

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Anyone who has ever had their hearing tested should know how to read the audiogram, but that's easier said than done. Hopefully, after reading this article you will have a greater understanding of the principles discussed and use your knowledge going forward—be it in reviewing hearing test results you already have or when discussing your results at your next hearing test.

relatively flat hearing losses, and the average of 500 and 1000 Hz for those with significantly sloping hearing losses (i.e., the individual's hearing thresholds drop sharply with increasing frequency).

Speech Reception Thresholds often serve as a reference for the audiologist in determining presentation levels for other speech tests and as a reliability check concerning the congruency of pure-tone test results and the SRT; that is, if the SRT and pure-tone averages are within 10 decibels of each other, audiologists can state with certainty that the results agree with each other.

An SRT is considered to be normal if it falls in the range of -10 to 25dB HL (Hearing Level). Even though an individual might obtain a value within this normal range, this does not always mean that he has completely normal hearing acuity. For example, it is possible that the individual's thresholds in one ear are 15dB, 25dB, and 35dB HL at 500, 1000 Hz, and 2000 Hz respectively. The average of these thresholds is 25dB HL (normal range), yet the individual presents with a mild degree of hearing loss at 2000 Hz. It is also possible that an

individual could, in fact, exhibit normal hearing acuity across these three frequencies, yet, exhibit a significant hearing loss in the higher frequencies (3000-8000 Hz). Thus, it is important to examine the SRT in the context of the other audiometric test findings.

Speech Awareness Threshold

(SAT): Compound words are presented, the goal being to determine the softest level one can detect the presence of words. This test is often used when an individual's hearing loss is so great that the person is unable to recognize/repeat the words, yet is aware that words have been presented. Similar to the SRT, a person could present with an SAT value within the normal range, yet exhibit significant hearing difficulty.

For example, an individual might have a hearing threshold of 15dB HL at 250 Hz and reveal an SAT of 15dB HL, but for frequencies 500 to 8000 Hz exhibit a significant hearing loss.

Word Recognition Score (WRS):

Single syllable words are presented at one or more listening levels: everyday conversational level (approximately 50 dB HL); and, comfortable listening (MCL) level. For most individuals with a hearing loss the MCL is louder than the everyday conversational level

Determinations of word recognition scores typically entail the presentation of 25 or 50 words to each ear separately and calculating the percent of words correctly repeated. This test can be administered either in quiet (without any competing noise) or in the presence of noise. Speech testing in noise can consist of different types of noise, such as a shower noise or the noise of multiple people talking in the background. The noise can

also be presented at different levels relative to the level of the speech stimulus being presented to the listener. The scores that are obtained can provide the audiologist with key information, including how well the individual:

- (1) can hear in quiet at an everyday conversational level or if an individual has a relatively significant hearing loss at his or her most comfortable listening level; and,
- (2) can hear in the presence of background noise.

For many individuals with hearing loss, the audiologist might administer this test at both everyday conversational level and MCL. This allows for a comparison of performance at both levels and provides an indication as to whether hearing aids are likely to be beneficial (i.e., if the individual does significantly better at the louder, MCL level).

Loudness Discomfort Level (LDL):

The LDL is the loudest level one can tolerate various sounds without the sound being uncomfortably loud. If

one purchases hearing aids, results from this test are used to set the hearing aids' maximum loudness levels so that loud sounds are not amplified by the hearing aids to a degree that they are intolerable.

Outer/Middle Ear Tests

Otoscopy: This entails the use of an instrument consisting of a magnifying lens and a light for examining the external canal and tympanic membrane (eardrum). This visualization allows the audiologist to determine if ear wax is blocking the ear canal or other foreign material is present, and, if so, its extent; and if there is a possibility of some form of outer/middle ear pathology.

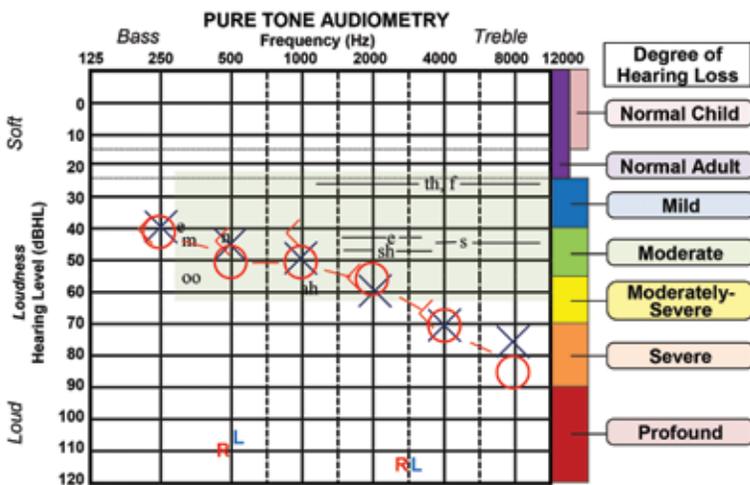
Tympanometry: The audiologist places a device with a rubber tip into the person's ear canal which creates a gradual change in the ear's air pressure. The results indicate how well the tympanic membrane (eardrum) moves relative to normative values, and in

turn, provides information regarding the condition of the middle ear (such as the possibility of middle ear fluid being present, perforation of the eardrum, etc.).

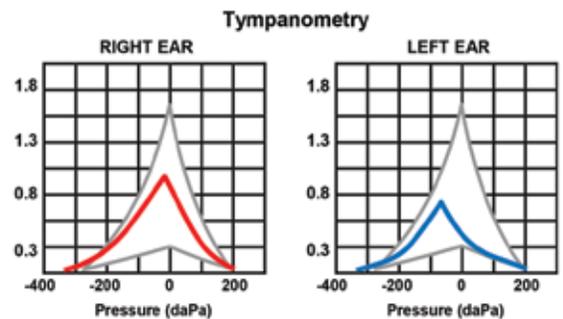
Ear Canal Volume (ECV): This refers essentially to the volume of the ear canal in front of the tympanic membrane and is derived through the use of tympanometry. ECV varies in size, being approximately double in size for adults as compared to young children. Ear canal volume can be affected by a number of conditions. For example, if there is a TM perforation, ECV will be very large since it will also include the middle ear space behind the TM. On the other hand, if there is much wax, then the ECV will likely be reduced in size.

Acoustic Reflex Testing: This test might be done subsequent to tympanometry with the rubber tip still in the ear canal. When loud sounds are pre-

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Otoscopy
R: Clear L: Clear



Speech Audiometry (dBHL)

	Right	Left	Right	Left
Speech Awareness Threshold				
Speech Reception Threshold	50	55		
Most Comfortable Level	80	80		
Loudness Discomfort Level				
Word Recognition Score %	80	84		
Presentation Level	80	80		

Acoustic Reflex Thresholds

Ear	Right			Left		
	.5k	1k	2k	.5k	1k	2k
Contra	105	105	115	105	110	115
Ipsi	105	105	110	105	105	110

Audiometric *cont. from page 17*

sented a small muscle in the middle ear usually contracts. This muscle contraction is called the acoustic reflex (or the middle ear muscle reflex). The purpose is to provide the audiologist with valuable information regarding the health of the middle and inner ears, as well as other structures like the auditory nerve and parts of the brainstem.

Case Example

To help you integrate the information that I have presented here, I have crafted audiometric findings for an imaginary case; the findings are displayed in the graphic on page 17. The first results I will review are those shown in the pure-tone audiogram. The X (left ear) and O (right ear) indicate the softest levels that an individual can hear (thresholds) via air-conduction audiometry using either headphones or earphones, while the < indicate the thresholds obtained via bone-conduction audiometry.

The fact that the results do not reveal a significant (less than a 10dB) difference between air- and bone-conduction thresholds, we do not suspect a conductive hearing loss. That is, a conductive hearing loss would indicate that something is preventing sound from being conducted through the outer and middle ear systems causing better thresholds to be obtained by bone conduction than via air conduction.

Because air and bone-conduction thresholds are essentially the same for all test frequencies we can assume that there is no blockage/pathology involving the outer/middle ears. Since we know there is a hearing loss, but have ruled out conductive involvement, we can deduce that the cause of the hearing loss lies within the sensory system, and therefore, we identify a sensorineural hearing loss.

The overall results indicate a bilateral mild sloping gradually to a severe sensorineural hearing loss.

In looking at the audiogram, the reader will also note the symbols

R (right) and L (left) at both 500 and 3,000 Hz. These represent the tonal Loudness Discomfort Level (LDL) values at these frequencies. For this individual, the LDL values occur at levels that an audiologist would typically expect for this degree/type of hearing loss.

Overall, the range between thresholds and LDL, though somewhat reduced when compared to those with normal hearing (more so at 3000 Hz), is sufficient enough for a hearing aid's circuitry/accompanying algorithms to amplify most speech sounds without significant difficulty, at least in the range extending from 250 to 4000 Hz.

Speech Audiometry Results

This individual's hearing sensitivity was sufficient for hearing and recognizing spondees (obtaining speech reception thresholds) at a level of 50 dB HL in the right ear and 55 dB HL in the left ear. The normal range for SRT is from -10 dB to 25 dB HL, therefore, this individual's SRTs are both beyond the normal range. These SRT values approximate everyday conversation level (50 dB HL), which is also typical of the most comfortable listening level for most normal hearing individuals.

Yet, this person was just barely able to hear and repeat these words at this level in the right ear and unable to hear the words in the left ear. In examining the hearing loss configuration of both ears, they appear to be relatively flat (the thresholds drop gradually). Because we average the thresholds at 250, 500, and 1000 Hz for flat/relatively flat hearing losses, this audiogram reveals pure-tone averages (PTA) of 47dB hearing loss and 45dB HL for the right and left ears, respectively. Since each of these PTA values is within 10dB of the SRT obtained for each ear, we can state with good certainty that the SRT and PTA findings agree with each other, and therefore appear to be reliable.

The next step involved examining this individual's ability to repeat

single syllable words at his or her most comfortable listening level (MCL) since everyday conversation level (50dB HL) would be too soft or inaudible. In this case, the listener's reported MCL in both ears was 80dB HL. Interestingly, this intensity level is similar to what a normal hearing individual would experience if a person yelled at a distance of six inches.

Upon obtaining an individual's MCLs, 25 or 50 single-syllable word lists are presented. In this case, the client was presented with 50 words to each ear, one ear at a time and was able to obtain scores of 80 percent and 84 percent in the right and left ears, respectively. Another way of stating this is that the listener was able to repeat 40 out of 50 words correctly in the right ear and 42 out of 50 words correctly in the left ear.

These scores do not mean that this individual has 80 percent hearing in the right ear and 84 percent in the left ear; the percentages just reflect his or her particular test performance in this specific listening condition.

Outer/Middle Ear Test Results

The information displayed on the right side of the graphic on page 17 reveals key findings relative to the outer/middle ears. Note that these procedures are usually administered before pure-tone and speech audiometry, with otoscopy always being performed first. This individual's otoscopic results revealed both ear canals to be clear, with no earwax present in either ear. The ear canal volumes (measured in cubic centimeters—cm³) as determined from tympanometry were 1.5 and 1.7 cm³ for the right and left ears, both within norms for adults.

As mentioned earlier, the primary goal of tympanometry is to assess how well the eardrum moves. By examining where the peak of the tympanometric tracings occur, one can determine the individual's middle ear pressure in each ear and accompanying tympanic membrane (TM) mobility. Middle ear pressure indicates the

extent to which the middle ear cavity (the space behind the TM) is being aerated properly by the Eustachian tube (a structure that connects the nasal cavity to the middle ear space).

Tympanic membrane mobility refers to how effectively the TM and the adjoining middle ear ossicles are transmitting sounds from the outer to inner ear. The X-axis displays middle ear pressure from +200 decaPascals (daPa) to -400 daPa (normal range being from +50 to -150 daPa). The Y-axis indicates TM mobility in millimhos (mmho), with typical adult values ranging from 0.3 to 1.5 mmho. In this individual's case, tympanometry revealed tracings that fall within the white shaded regions (within the normal range), thus, revealing bilateral, normal TM mobility.

Acoustic reflex testing revealed reflexes in both ears in response to stimuli presented at levels consistent with the degree of sensorineural hearing loss present (based on published values derived from empirical research). The presence of normal tympanograms as well as acoustic reflex findings that are consistent with the degree of hearing loss present are both congruent with the presence of a sensorineural hearing loss, and, in turn, provides greater confidence in the other findings.

Hearing Assessment Results Summary

The client revealed a bilateral mild sloping gradually to a severe sensorineural hearing loss. Otoloscopic examination revealed both ears canals to be clear, while tympanometric findings revealed normal middle ear pressure and mobility in both ears. Word recognition scores in quiet are consistent with the degree of hearing loss present. In the case example I provided, the client did not appear to have any issues involving the outer/middle ear, or the balance organ and/or auditory nerve.

However, it is sometimes the case that the medical history and test results suggest a disorder to be

present. In these instances, the audiologist might administer additional tests and/or refer the client to a physician for further evaluation and possible treatment.

If no medical issues appear to be present, then based on the degree of hearing loss and the extent of listening difficulties being experienced, an audiologist might recommend to the client: communication strategies; hearing aids or cochlear implant; hearing assistive technology, such as an amplified phone or TV listener; and/or involvement in an aural rehabilitation program.

Final Thoughts

Based on the information obtained, an audiologist can ascertain if a hearing loss is present in either or both ears, and, if so, its type and severity. In addition, an audiologist is able to glean information relative to the listener's ability to understand speech in quiet or noise. I focused primarily on assessment procedures that are typically administered by an audiologist. There are many other assessments that can be conducted, depending on the presenting case and the audiologist's/client's goals for the assessment. I hope that I have demystified somewhat the terms, graphs and numbers displayed on the audiometric report and, in turn, empowered recipients of audiological services to engage in a more meaningful dialog with your audiologist.

If you have any questions or comments, please feel free to contact me at larry.medwetsky@gallaudet.edu.

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Some Additional Terms

Bilateral/Unilateral: In this context, bilateral refers to occurring in both ears, while unilateral refers to occurring in one ear. For example, a bilateral hearing loss refers to a hearing loss of both the right and left ears, while a unilateral hearing loss means the hearing loss is only in one of the ears.

Symmetrical/Asymmetrical: Symmetrical refers to the similarity in hearing sensitivity from one ear to the other; that is, symmetrical hearing reveals the same type and degree of hearing loss (or normal hearing) in both ears. Asymmetrical hearing refers to hearing sensitivity that is significantly different between the two ears; this difference could be at all frequencies or just some of them. **HLM**