Step #1—Before You Get Hearing Aids

Impaired hearing reduces background noise

Think Hearing, not Hearing Aids

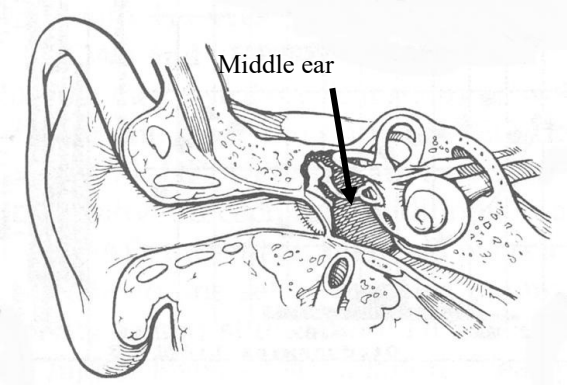
Step #1 is to get a thorough evaluation of your ears and hearing. Hearing is the most complex sense of the body. The outer ear collects sound that is traveling through the air, converts that sound to mechanical vibrations in the middle ear, converts that mechanical energy to hydraulic energy within the inner ear, and the inner ear amplifies and filters that hydraulic energy, converting it to electrical information that the brain can understand. One shouldn't assume that you don't hear well because you are elder or worked in noise. One shouldn't assume that all you need to do is find the best hearing aid and you will hear perfect. Hearing is complex…

- The ear is contained within the temporal bone, the densest bone of the body—if your spouse says you're hard-headed, say 'thank you'.
- Your ear contains the 3 smallest bones in the body. The smallest of these is the stapes.
- It also contains the smallest muscle in the body, the stapedius.
- It is the only organ to contain 2 senses, hearing and balance.
- The cochlea is the hearing part of the inner ear and contains roughly 18,000 sensory cells, about 3000 inner hair cells and 15,000 outer hair cells. The outer hair cells are the only sensory cell in the body that can move/vibrate using their own energy.
- These 18,000 sensory cells within one ear communicate with approximately 30,000 nerve fibers of the VIIIth cranial nerve.
- The hearing nerve is the only nerve that twists around on itself.
- The outer ear is somewhat like a collector and resonator. It collects sound, giving preference to sound coming from in front of you and, in adults, resonates (amplifies) it in the 2000-3000 Hz range. Guess what frequency range is most important for understanding

Solar panels are amazing because of their ability to convert solar energy, sunlight, into electrical energy. Consider, however, the ear. It converts acoustic energy into mechanical energy, then into hydraulic energy and then into chemo-electric energy.

speech?

- Sound in air does not easily transfer its energy to fluid. Since the cochlea is fluid filled, it needs the middle ear to amplify air conducted sound in a manner that will move the cochlear fluids. The middle ear is an impedance matching mechanism designed to do this.



- The middle ear is an air-filled cavity that ordinarily is closed off so that body sounds, including your voice, are not louder than outside sounds.

- The Eustachian tube of the middle ear opens when you swallow so that air pressure is equalized: the middle ear works best when its air pressure is the same as the outside air pressure. This is why you hear a little better when, as you are changing elevation, your ears "pop". That pop is the sound you get from the middle ear air pressure equalizing.

- The cochlea contains 3 fluids: endolymph which is high in potassium and low in sodium, perilymph which is high in sodium and low in potassium, and cortilymph which is similar to perilymph. These different sodium/potassium balances form an electrical battery that help the cochlea work.

- The cochlea has fine capillary beds, much like the kidney, because it uses a lot of oxygen and other nutrients. We are not sure why you do not ordinarily hear blood pulsing through your ear.

- The tympanic membrane, what most call the eardrum, has the look of plastic wrap (used in food storage) and the texture of wax paper.

When you have your hearing evaluated, the doctor will obtain a history regarding your past of noise exposure and ear disease, he/she will inspect your ears with an otoscope checking specifically for the condition of the skin of your ear canal, for the presence of excessive cerumen (earwax), and the appearance your tympanic membrane (eardrum). You may have a tympanogram which is a test that checks for fluid behind your tympanic membrane and the air pressure within the middle ear.

Otoacoustic emissions are sounds produced by the inner ear (this would be analogous to the eyes actually producing light). A microphone can be placed in the external canal and these emissions measured. This is that basis of one method for screening the hearing of newborns.

The middle ear is an air filled space that contains the 3 smallest bones in the body. It is the part of your ear that you may feel 'pop' when you change elevation.

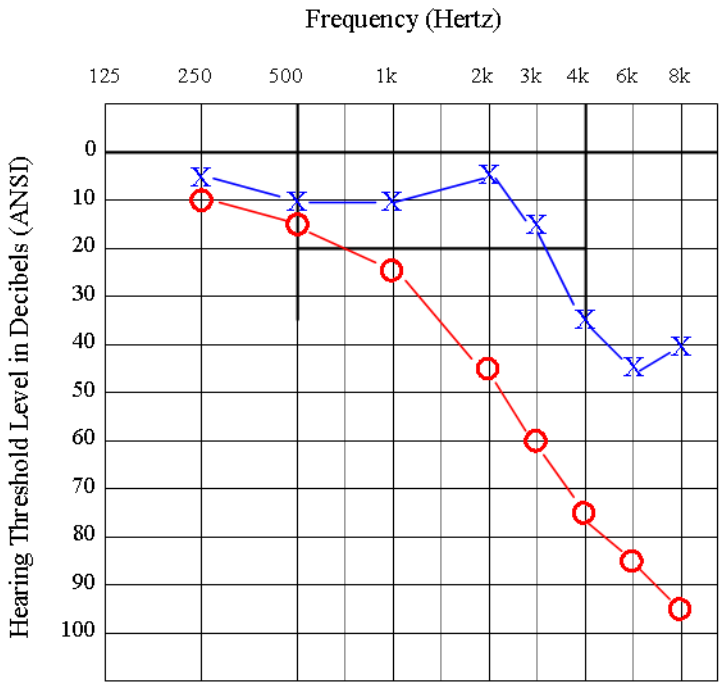
You will have air and bone conduction threshold testing to see how softly you can hear tones of various frequencies, and you will have a speech discrimination test that gives a rough estimate of how well your auditory system handles speech. Comparison of air conduction thresholds to bone conduction thresholds aids in the diagnosis of the part of your ear that is causing hearing loss.

Hz = Hertz, a measure of sound frequency. This used to be called cycles per second. You hear changes in frequency as changes in pitch.

dB = decibel, a measure of sound level (loudness level). There are various types of decibels. When talking about a hearing test (audiogram), the decibel references normal human hearing (0 dB).

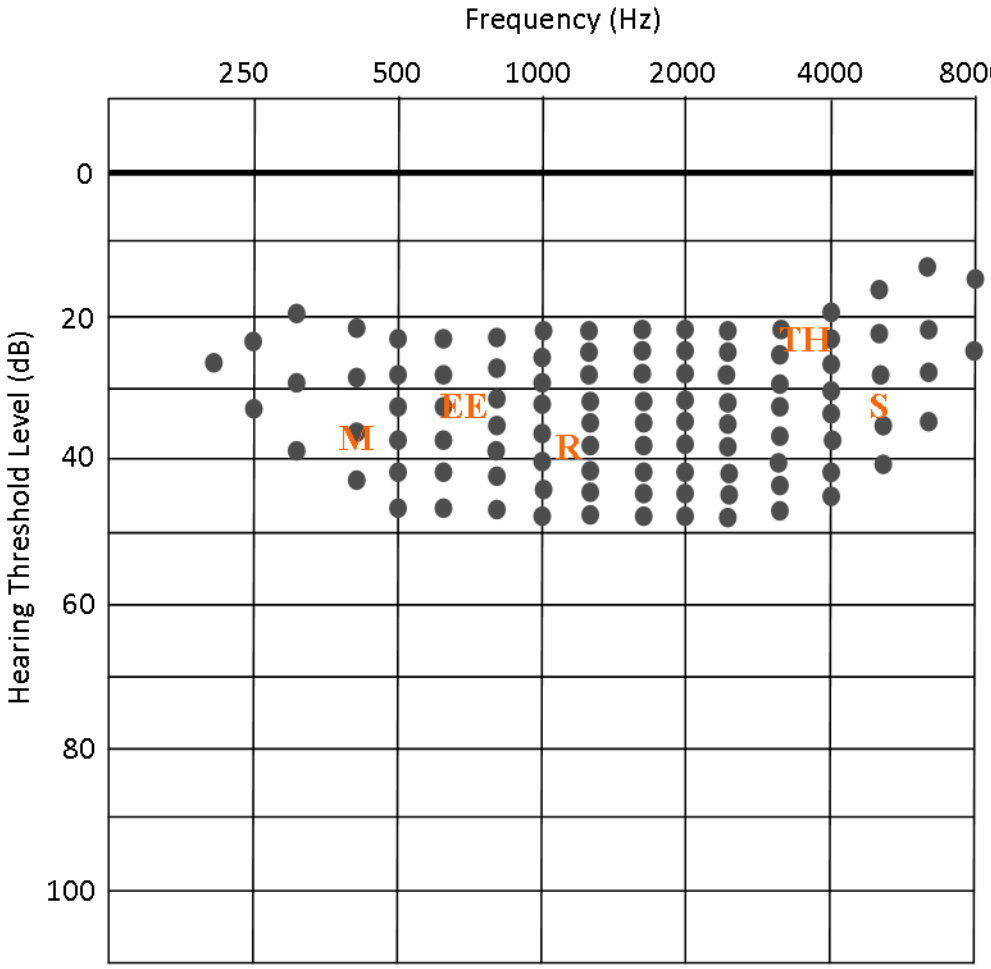
Air conduction refers to sound entering the ear through air and external ear, as it does in the real world. Bone conduction is sound that is transferred (conducted) to the inner ear via bone. This is usually done with a bone vibrator placed on the forehead or on the mastoid bone behind the outer ear.

The most common way of depicting these results is an audiogram as shown here. It shows air conduction thresholds for the right ear, depicted as circles, and for the left, depicted at X's.



Along the left hand side of the audiogram is the sound level, or loudness, of the tone. This is easy to understand; 0 dB (at the top) is extremely soft, 100 dB (near the bottom) is loud.

Along the top of the audiogram is represented frequency. Frequency is very important to how hearing aids work and often explains why some people say:



I Hear OK, I Just Don't Understand What is Said

You hear changes in frequency as changes in pitch. A low frequency sound, 125 Hz for example, is heard as a low pitch or bass tone (think tuba). A high frequency sound like 8000 Hz is heard as a high pitch or treble sound (think of a 'squeak').

Some speech sounds are predominantly low frequency, like the sound "M", while others are high frequency, like the sound "S".

Notice two things on the above figure. There are 100 dots representing where speech energy

falls on the audiogram. This is sometimes called the speech banana because of its shape. We put some speech sounds on the audiogram to give you an idea that different speech sounds have different frequencies.

I _an hea_ _ine.

With most hearing impairments, there are some frequencies that are not heard normally and, therefore, some speech sounds that are not heard normally. The above example (I can hear fine) might be what a hearing impaired person hears. They hear the person talking but may not understand what that person is saying. With a little thought, they might figure out what is said, even though there were "holes" in the words.

Speech is comprised of many frequencies and if you can hear all of those frequencies normally, you hear the entire speech spectrum. If you are hearing impaired, it is likely you are hearing only parts of the speech spectrum.

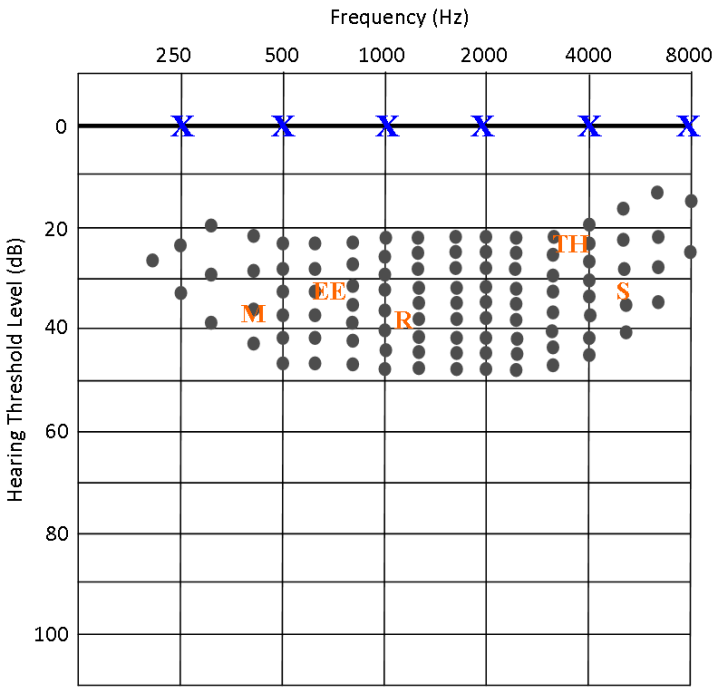
The audiogram shown is often called a pure tone audiogram because the tones used to test your hearing have only one frequency: a pure tone. 1000 Hz (Hertz) is a mid-frequency and in audiometry is one of the tones used test your hearing. In the real world, a given speech sound might be comprised of multiple frequencies of say 250 Hz, 500, and 1000 Hz in combination.

Once a diagnosis is made and it is determined that your hearing impairment is one for which the best solution for is a hearing aid:

Several factors go in to the decision to get hearing aids

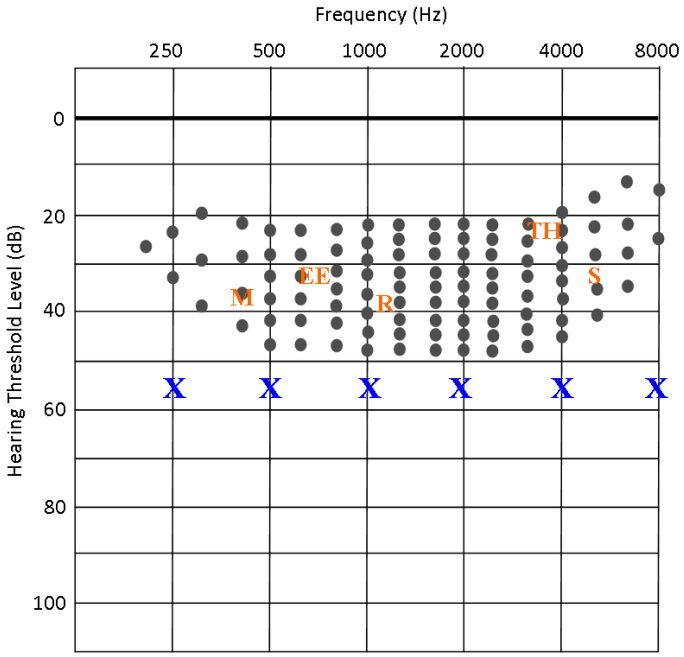
One. The degree of hearing loss as shown on the pure tone audiogram.

In the figure here we have shown a persons pure tone audiogram for the left ear. The blue X's fall on the 0 dB threshold line and all of the 100 dots that represent the speech spectrum exceed the person's threshold. This person would be said to have normal hearing sensitivity and would not, under normal circumstances, be a hearing aid candidate.



In the next figure, the person's thresholds are at 55 dB at all frequencies. None of conversational

speech exceed this person's threshold and so this person does not hear speech unless it is very close to his/her ear or louder than normal. Going by the pure tone audiogram alone, they would be a hearing aid candidate.



Many folks fall between these 2 examples. They hear many of the frequencies ok, but not all. There are methods for measuring how much of the speech spectrum is audible and how much is not. One method is called "count the dots" by Killion and Mueller (2010). The greater the number of dots that are inaudible to the person the higher the indication of hearing aid need. In the first example, the person had 100 dots above his/her thresholds. In the second example, with the person having 55 dB thresholds, they had 0 dots above threshold. There are other factors, however, for the potential hearing aid wearer to consider.

Two. Tinnitus

It can be pronounced either "ti-night'-us" or "tin'-i-tus". This is our three paragraph explanation of what is a textbook-length subject.

Most tinnitus is a phantom sound. The person with tinnitus hears a noise in their ears or head but the sound is nowhere in the environment and only the person with tinnitus hears it. There can actually be a type of tinnitus that can be heard by another person because the patient's body is making a sound, but that's another story.

You may have heard of phantom pain. An example of a phantom pain is where someone had his small finger cut off, but that small finger still hurts or has other sensations. Well, the finger isn't there so it can't hurt, but the nerve pathways associated with the finger are registering pain.

Many cases of tinnitus are similar to phantom pain. There is an initial insult, usually to the hair cells of the inner ear. Hair cells don't register pain, but they do register sound and an insult to them can cause them to produce a sound. The insulted hair cells may have recovered from the initial insult, or they may have died (remember, there are 18,000 of them and missing just a few of these hair cells may not be a problem other than tinnitus), or they have gone to a "status quo" of partial recovery. They are no longer producing that sound that the initial insult caused, but the nerve pathways associated with those hair cells are still registering sound.

We bring tinnitus up here because hearing aids often provide some relief to people who want relief from their tinnitus. So if someone has a hearing loss that might be considered "borderline" for hearing aids, tinnitus might help weight the decision toward getting hearing aids. It ties in with the last thing discussed in this section: how much will hearing aids help.

Roughly 25 million of American adults (about 10 percent) have reported having had tinnitus that occurred for five or more continuous minutes in the past year.

Hearing aids are not the only treatment for tinnitus, but can provide benefit, especially if the person with tinnitus also has enough hearing loss that they are not hearing all frequencies normally. Some hearing aids have tinnitus devices built into them. These devices can produce various types of sounds that many people find helpful.

And just as we encourage you to think first things first when it comes to hearing (Step #1 is a hearing evaluation), don't assume that your tinnitus is the most common type and that a hearing aids are what you need. With tinnitus, as with hearing, Step #1 is a hearing evaluation.

Three. Auditory Deprivation

This can be described as a "use it or lose it" phenomenon. Auditory deprivation refers to the fact that even though we hear with our ears, our central auditory system in the brain is where we perceive sound and its meaning. Just as our muscles can atrophy when not used over a long period of time, our central auditory system's ability to distinguish various sounds becomes less and less if it is not used.

The person that belongs to the previous audiogram, where their thresholds are 55 dB over all frequencies, is hearing very little speech. Without a hearing aid he or she is hearing only a smattering of sound and the hearing mechanism, including the central auditory nervous system, is being used little. This person is likely to suffer auditory deprivation. His or her ability to discriminate speech sounds next year may not be as well as she does this year. Since the part of the central auditory system that deals with speech is not being used, it is going to quit trying. The longer he or she goes not hearing, the longer it will take to get used to hearing again.

We have known clinically for many years that if a youngster is fit with a hearing aid on only the right ear, the left ear will become more and more resistant to being helped with amplification.

Auditory deprivation is probably not a factor in adults with mild hearing loss, but in adults with severe hearing loss it is. The harder it can be to get used to hearing all the sounds of life the

longer one waits to get hearing aids.

Four. Do you want to Hear Better. Is Hearing Impairment a Problem to you.

As you can perhaps tell from the sidebar comments here which point out the advantages of wearing hearing aids, we are pro-hearing aid. However, hearing impairment is personal and situational and you are the one who has to wear the hearing aids, not us.

> "Hearing aid use improves adults' health-related quality of life by reducing psychological, social and emotional effects of SNHL [sensorineural hearing loss], an insidious, potentially devastating chronic health condition if left unmanaged.
>
> *-Healthy People 2010, 2004*

The problem caused by hearing loss often depends on the situation. Those with mild hearing loss can sit and talk face-to-face with you all day and not miss a word. Put them in background noise and they may miss lots of words. A child with mild hearing loss may not hear all that is said from the back of the classroom, especially when the teacher has her back turned. But that mild hearing loss may not be so evident at home.

> "Workers with untreated hearing loss are twice as likely to be unemployed compared with those using hearing aids.
>
> *-MarkeTrak VIII— 2010*

A mildly hearing impaired salesperson who travels to Europe does not want to miss conversation nuances or the difference between 'million' and 'billion'. A retired person who rarely leaves the house may not be bothered, or consider a problem, that same amount of mild hearing loss.

> *37% of children with only minimal hearing loss fail at least one grade.*

Because the family of a hearing impaired person may have a different perspective on when mother's hearing impairment is a problem—because of missed phone calls, unheard doorbells, misheard doctors orders—well-meaning family members reasonably think that if only mother tried hearing aids she would see what she is missing.

Unfortunately, we've not found this to be the case. The hearing impaired person may like silence, they don't want to hear the phone from the other room or they don't want to be encumbered by a hearing aid. If they don't want the hearing aid, wearing one for a trial period usually doesn't change their mind.

There are more formal ways of assessing the amount of disability a hearing impairment is causing, or how much a hearing loss might be bothering someone. Two self-report questionnaires for doing this are the Abbreviated Profile of Hearing Aid Benefit (APHAB) and the Hearing Handicap Inventory for the Elderly (HHIE).

Tying in with this is a test call Acceptable Noise Level (ANL). ANL has to do with a listener's reaction to background noise while listening to speech. This is a test developed at the University of Tennessee by Anna Nabelek and others. It can be a formal test (the ANL test) that is part of your pre-assessment for a hearing aid. But in general terms, it relates a little to how much someone wants "silence", and how much someone wants "plugged-in" to all the sounds around us.

Five. An Expert Opinion

Sometimes the likelihood of your success with hearing aids is not clear. Sometimes a second opinion is warranted. In all instances, a second opinion should not be your neighbor who wears hearing aids in a dresser drawer. It needs to be from someone who know both hearing and hearing aids.

Fitting hearing aids is the most difficult thing that an audiologist does, partially because fitting a hearing aid relies on the other steps leading to fitting hearing aids, such as determining accurate hearing thresholds, diagnosing the site of lesion, determining threshold of discomfort, cleaning the ears and taking impressions of the ear.

It is reasonable for you to rely somewhat on an expert in deciding whether to get hearing aids or not. We are calling someone an expert in hearing aids who actually evaluates hearing and fits hearing aids as a profession. He or she understand both hearing and hearing aids and how to couple hearing aids to an impaired ear, has experience fitting hearing aids, and knows what succeeds and what fails.

Yes, they want to fit hearing aids, but they fail if you fail and they do not want to fail. They want you to succeed. You want someone with a permanent office, not someone who is selling hearing aids from a hotel room or from the internet.

Six. How Much Will Hearing Aids Help

Many people with impaired hearing would like us to describe their hearing impairment in one number; a percentage, as in, you have a 25% hearing loss. We don't measure hearing in this manner and when a hearing professional does give your hearing percentage, he/she is using a method that may be unique to them. Take your audiogram to a different person and he/she will likely give you a different percentage based on the same test.

Just as we do not have a single number way to accurately describe your hearing, we do not have a numeric way, or even a way with words, to completely describe the benefit you will get from hearing aids. And I'm not aware of a way to accurately demonstrate how much hearing aids will help you without first having the hearing aids made, adjusting (programming) the hearing aids for your residual hearing, and then having you actually wear them a while to get used to hearing in a new way.

Unlike glasses and the examination gear the Optometrist uses, our audiometric equipment or a loaner hearing aid cannot sound like the actual hearing aid made for your ear. How that hearing aid physically fits in your ear canal and the amount of air space between the speaker and your eardrum it has to drive, how much it is vented, its frequency response and compression characteristics all have an impact on the sound delivered to your eardrum.

This doesn't mean it may not be worthwhile putting a temporary hearing aid on you in the office, but even if we could duplicate the way your hearing aid would sound to you, you might not like it. It will take your central auditory system -your brain- a while to adjust to hearing in a different way. So we are resigned to trying to describe in numbers or words how much hearing aids will help you.

At the extremes, the answer to this question is easy to communicate. For someone with perfect hearing, hearing aids would not help; they would help "0". For someone with complete deafness (which is rare), standard hearing aids would not help; again "0". It's the people in-between for which we do not have a good way to communicate how much hearing aids will help.

The way that we am going to talk about it here is on an unscientific scale of 0 to 10. We often use a similar scale in other aspects of our practice. With tinnitus, for example, we might ask the person to rate the loudness of his/her tinnitus on a scale from 0 to 10 with 0 being no tinnitus whatsoever, and 10 being the loudest you could imagine. We might also use the same scheme to make sure we understand a person's description of a sound that is too loud. For example, if a person is being bothered by the organ music at church being too loud, is it a 10 (painfully loud), or an 8 (very loud, but ok). How loud is the organ without the hearing aids?

So with benefit from hearing aids we try to make an estimate of benefit for the person. One other test result considered in this unscientific method is the speech discrimination or speech recognition test result. The speech recognition test is usually given by having the patient repeat one-syllable words and then the percentage of correct words is the patient's speech recognition score. For example, if the person was given 25 words and they correctly repeated 24 words, their speech discrimination score would be 96%. If they missed 10 words out of 25, the speech discrimination score would be 60%.

The pure tone test previously discussed deals with the detection, or audibility, of sound. The speech recognition test deals with the recognition or correct identification of words.

So for someone where the entire speech spectrum is not heard, but with a speech recognition score of 84%, benefit from hearing aids should be great and I would tell them that without hearing aids they are hearing at about a '3', but with hearing aids they might hear at about an '8'.

If this persons speech recognition score were 12%, I might have revised my estimate to aided hearing of about '7' in quiet, but '4' in noise (still an improvement over unaided hearing, just not as big an improvement).

The take home lesson here is that we don't have a good way of demonstrating beforehand what hearing aids will sound like to you. Even if an expert tells you that hearing aids will help only a little, a little bit better hearing can mean a lot, perhaps the difference between hearing a "million" or a "billion"; or "no-way" and "maybe".

Even if your speech discrimination score is 0%, it doesn't mean that a hearing aid won't help you.

One reason is that the speech discrimination test is most often given by using single syllable words in isolation. That is useful, but how we listen everyday is to sentences in context. A two syllable word is easier to understand than a one syllable word and a sentence is easier to understand than a two syllable word.

If you don't hear the sentence (the sentence is not audible), you don't have a chance at hearing the sentence. But if the sentence is audible, you have a chance at understanding it even if it is mushy and difficult to understand.

Many years ago, David Pascoe put into perspective the importance of speech detection even in the absence of speech recognition: *Although it is true that the mere detection of a sound does not ensure its recognition, it is even more true that without detection the probabilities of correct identification are greatly diminished.*

There is also something to be said about being in touch with the world through hearing, hearing the melody of speech even if you don't discern the specific speech sounds. Hearing signals, hearing birds sing, etc. is important to many people. Not everyone likes silence.

A real-world example of this is some patients with perfect hearing in one ear, but terrible hearing in the other with a speech discrimination score in the bad ear of 0%, wear hearing aids in the bad ear. If they plug their good ear and try to understand what you are saying, they can't (unless they are watching you). However, they wear the hearing aid because it relieves the sense of "deadness" in the bad ear, it lets them know when someone is talking to them on the bad side, they can hear the intonation (melody) of speech and even recognize voices with the bad ear, and there is something to be said about the bad ear and good ear helping each other.

How can a hearing aid provide better than normal hearing, and does it really?

The shape of our outer ears make them directional. They deflect some of the sound coming from behind, while collecting sound coming from the front and side. Hearing aids can also be

directional.

In 2014 Siemens came out with a hearing aid that is “clinically proven to outperform normal hearing”. Other manufacturers will, no doubt, adapt this technology and by 2016 all manufacturers will offer some variation of it. How does it work?

We have had directional hearing aids for years. These are hearing aids that have 2 microphones and can discern whether sound is coming from the front or coming from the back. In the past, directional hearing aids have emphasized sound coming from the front, since what we are facing is usually the signal of interest, de-emphasizing the sound from the back.

In recent years significant improvements in hearing aid directionality have been made. Hearing aids have been developed that can follow the location of speech and emphasize sound from the back or front or even side. These newest hearing aids that “give better than normal hearing” now have the left and right hearing aids communicating with each other and sharing information about the direction of speech and the direction of noise. In this manner, the directionality of the microphones can be very narrowly focused on the person talking and in many situations give a significant improvement over normal to the ratio of speech sound to that of noise. Speech reception thresholds (SRT) can improve up to 2.9 dB for those with mild to moderate hearing loss wearing this technology compared to normal hearing. As the ad says: better than normal.

What’s the catch? Mrs. “Harris” with auditory neuropathy and 0% speech discrimination scores is never going to hear better than normal. She is still going to rely a lot on lip-reading. Consider also that if a person hears a given background noise without hearing aids, the hearing aids are not going to make that background noise softer (than it is heard without hearing aids).

That doesn’t mean this technology is not going to benefit many people. It just means that there are a lot of people for whom this technology cannot make them hear better than normal.

Auditory Neuropathy—Sometimes called Auditory Dysynchrony and even Central Auditory Deficit –*A disruption in the synchronous activity of the auditory nervous system. Results in greater real-world difficulty than would expect on the basis of the pure tone audiogram alone. Standard hearing aids are not able to ameliorate this.*