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Formal Versus Informal Hearing Tests: What Is Functional Hearing?

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Abstract: This article defines the difference between formal audiological hearing tests and functional, or informal, hearing tests and describes how information from these assessments can be shared to meet the needs of a child.

Key Words: programming, audiological test, functional hearing, auditory functioning, deaf, deafblind

The term functional hearing is being used more and more often these days. What does it mean? What is functional hearing and how is functional hearing determined?

Formal audiological tests stand in contrast to “functional” tests of hearing. This is a bit misleading and unfair to standard tests since they can give a great deal of information about the functioning of the auditory system. A better distinction might be formal versus informal. This informal process is a way of gathering information about how students use their hearing to gather information and how they make meaning out of this information in different environments across the day.

Formal Audiological Tests

There are 2 major categories of formal audiological testing: physiological tests and behavioral tests.

Physiological tests

Physiological tests include auditory brainstem response testing (ABR or BSER), oto-acoustic emission audiometry (OAE), and tympanometry. These tests are functional in the truest sense of the word: they describe the neurological or mechanical functioning of the auditory system. They do not involve active participation of the person being tested. Audiologists can hypothesize about how results on these tests will affect an individual’s use of auditory information but there is not an exact one-to-one correspondence between neurological or mechanical function and what an individual can and cannot do with his or her hearing.

Behavioral tests

Behavioral tests require the participation of the individual being tested. The most common behavioral tests involve pure tones. Pure tones are sounds generated by a machine. These sounds are very controlled for their pitch and loudness. Pure tones do not exist in nature. Even individual musical notes are not pure tones. All natural sounds, especially speech, contain a combination of different frequencies (pitch) of varying intensity (loudness). During pure tone testing, audiologists are trying to find an individual's threshold at various frequencies. Threshold is the intensity level where a sound can just be detected. There is not an exact one-to-one correspondence between auditory thresholds and what an individual can do with her or his hearing, but pure tone testing is important to use as a starting point for predictions and to use as the basis for hearing aid fitting. Procedures very similar to pure tone testing are also necessary for the fitting of cochlear implants, during the procedure known as mapping.

Pure tones can be delivered to the ear either through the air, by using headphones or speakers, or through bone conduction, which involves a special vibrator being placed on the head. Differences in air conduction and bone conduction thresholds give information to audiologists and doctors about what part of the auditory system might be having difficulty.

There is another type of behavioral testing that many students who are deafblind never have administered. Instead of using pure tones, speech is used. Using speech, an audiologist can determine:

- a speech detection threshold (how loud speech needs to be for a person to just detect it),
- a speech reception threshold (how loud a special type of 2-syllable word needs to be before an individual can correctly identify a specific proportion of them), and
- speech discrimination (what percentage of words at a fixed loudness an individual can correctly identify).

Unfortunately, the measure that is the most like "the real world", speech discrimination testing (especially when done in the presence of noise), is also the most difficult. This is because the individual who is being tested needs to be able to repeat words, write words, or point to pictures of words. Speech discrimination testing is very important to good hearing aid fitting and in the on-going adjustment of the speech processor component of a cochlear implant. Many children with significant multiple disabilities are not able to participate in speech discrimination testing.

Again, there is not an exact one-to-one correspondence between these formal audiological tests and everyday use of hearing. Then why do these tests?

Both physiological and behavioral tests were designed to give specific information about the auditory system. The conditions under which they are given and the type of input used is carefully controlled so that results of one person's tests can be compared to another person's tests. And so that performance on a test one day can be compared to performance on the same test on another day. This gives us the opportunity to talk about the integrity of the auditory system with as little regard to other factors, such as cognitive or physical ability, as possible.

The advantage of this is that we can identify where in the auditory system a problem might exist. This has very important medical implications and for this reason alone **formal audiological testing should never be replaced with informal testing.** The two kinds of testing are complementary.

Formal testing allows for the careful evaluation of hearing aids and the adjustment of cochlear implants. Finally, while pure tone testing done in an audiological test booth is a different listening situation than trying to carry on a conversation in a car, pure tone tests can give a ballpark prediction of the success of that conversation. Physiological and behavioral tests give us a very important starting point.

Listening in the Real World

What is it about “real world” listening situations that make predications from formal tests inexact? There are three factors to consider: the source of the sounds, the environment, and the listener.

Sound sources

Sound is not simple and speech, the sound we often are most interested in, is the most complex. Speech contains a mix of sound energy at different frequencies and this information changes very rapidly. This mix and these changes allow us to hear the difference between the various vowels and consonants. We then have to assign meaning to the speech sounds we hear. This takes cognitive ability. Finally, to create those sounds ourselves takes motor ability and then auditory ability again as we monitor our own speech.

It is important to understand that being able to detect a sound is a different skill than being able to discriminate a sound. I may be able to hear the presence of a sound because it contains energy in a range my auditory system can handle. But if my auditory system can’t give me the whole picture, if I can’t hear all the energy in that sound, I may not be able to hear how it is different from another sound. Talking over the telephone is an example of this. Telephones do not allow the full range of sound energy to go through. Some high frequency information is taken out so that the telephone can work more quickly. This is why the word “fin” can easily be confused with the word “sin”, or “thin”. You can “hear” (detect) the word but have trouble discriminating (understanding exactly what is heard).

A person with enough speech and language experience, often can “fill in” pieces of what was not heard. For example, someone may call to me from another room and all I can hear is, “Do you have the _og?” Now if I know the other person is trying to light a fire in the fireplace, I will fill in the blank and “hear” **log**. However, if I have just been petting my German Shepherd, I will probably “hear” **dog**. This effect of experience and context on hearing is just one reason why formal tests don’t predict use 100%. Experience also helps us interpret other sounds we hear. Before cell phones were common, how many of us knew what those sudden noises coming out of nowhere meant? Why would I pay attention to a doorbell if I grew up in a house that only had a doorknocker? I always think Harley Davidson motorcycles sound like they are broken. This is

because they normally sound like my car does when its muffler has fallen off. How many of us think rap music is noise but rock and roll is here to stay?

The environment

The environment in formal audiological testing is very controlled. Typically, there is little competing visual or tactual information and the room is treated to eliminated noise and echo. Now think of a child's typical listening environment where there are all kinds of competing sights, sounds, smells, and touches. Some children may get so neurologically "distracted" by what they see that they appear "deaf" in typical listening environments but appear to hear just fine in formal testing environments. On the other hand, it is not uncommon for a listener to use other senses to help support and confirm what was heard. For example, people with Usher syndrome often think their hearing is getting worse when really the hearing loss is stable and it is their visual skills that are declining. These individuals have been using visual information to support their hearing for so long they are unaware of doing so.

The listener

Finally, there is the listener. Part of the "art" of formal behavioral tests is discovering how to motivate a listener to participate in what is a fairly boring, uninteresting task. The formal testing situation may be so unfamiliar to the child being tested that it is scary. Formal testing may be associated with unpleasant experiences in a doctor's office. The amount of time allotted for the testing may be too short to allow the child to be comfortable or so long that the child's participation wanes. The time of day of the testing appointment may not be the time that the child is the most alert. Formal testing often treats the child as if he or she were only a pair of ears and ignores the rest of the child.

The Informal Hearing Assessment Process

The goal of informal hearing process is to:

- develop an idea of how the child uses his or her hearing in various environments across the course of the day; and
- try to discover what variables support the best use of hearing in order to continuously improve the use of hearing.

During the process, observation will be used to determine what, if any, sounds the child seems to react to and what, if any, meaning the child is getting from auditory information. Observation, of course, is also supported with information from formal hearing tests. Observation also includes setting up situations and seeing how the child responds.

Step 1: General functioning

The first step of informal hearing assessment is getting an idea of the general functioning of the child.

- Does the child show any awareness of any sensory information (visual, tactual, etc.)?
- How does the child show that awareness?
- What motor behaviors seem to indicate that the child was aware of and responding to sensory information?

Without this information, you can't tease out hearing from other factors.

Good questions to ask at this point are:

- What does the child do with sensory information?
- Has the child learned (or can she learn) to associate movement cues with a pleasurable activity?
- Does the child show anticipation of an event from seeing or touching an object?

Step 2: Responses to auditory information

Now you can ask:

- Does the child show anticipation or recognition through the use of hearing? That is, does the child anticipate an event when they only hear a sound associated with that event (before they see or touch something associated with the event)?
- What sounds does the child respond to?

Step 3: Looking for patterns

At this point, we are looking for patterns of responses. We are trying to find out which sounds under what conditions give the best (easiest to see, most consistent, meaningful to the child) responses.

1. Is there a difference in performance based on the types of sounds?
    - low pitch vs. high pitch
    - onset vs. cessation
    - simple vs. complex (for example, one instrument vs. orchestra)
    - rhythms
    - loud vs. soft
    - long vs. short (duration)

2. Are there any clear preferences?
    - people's voices (male/female, young/old, familiar/unfamiliar)
    - types of music
    - musical instruments
    - objects
3. Is there a difference in performance in different environments?
    - quiet vs. noisy
    - echo
    - competing (or supporting) information from other senses
4. Is there a difference in performance depending on where the sound comes from?
    - in front
    - behind
    - right
    - left
    - above
    - below
5. How long after the input does it take for a typical response to occur?
6. Do responses vary
    - across different environments? (indoors, outdoors, hallways, carpeted room, tiled rooms, etc.)
    - at different times of day?
    - before or after meal time?
    - before or after receiving medication?
    - with the physical position of the child?

Natural observation (doing nothing but watching the child) might not give you all the information you need at this point. Using information from formal hearing tests, you might want to set up some situations to help you observe patterns. For example, the results of formal hearing tests may indicate that the child should be able to hear loud low frequency sounds, like a drumbeat. You then might want to set up a simple turn taking game involving the beating of a drum to see if the child will listen while you beat a drum then take a turn and beat a drum after you stop. If the child can do this, then you might want to try similar games with other sounds that vary by pitch and loudness to see what sounds the child can use and which he or she can't. Of course, it may take several repetitions of the game, across several days or weeks, before the child learns their role.

Step 4: What does it mean to the child?

The next step is to ask, “How does the child use auditory information?”

- At a reflexive, awareness level? Does the child startle to sound but otherwise not pay much attention?
- At a regulating level? Does sound help the child enter and maintain a quiet and alert biobehavioral state? Are there sounds that send the child into a fussy, agitated state?
- At a motor level? Does the child turn towards or reach for an object or person making a sound, even if the child can’t see or touch the sound source?
- At a play level? Does the child enjoy making noise, either with his or her mouth, by activating switches, hitting two objects together, playing musical instruments, etc.
- At an associative level? Does the child associate a particular sound with a particular event?
- At a communication level? Does the child recognize any common words, especially his or her name? Does the child try to use any sounds consistently to communicate?

Step 5: Where do we go from here?

Gathering this information over time can help guide programming for the child. Information from steps 1-4 should give an emerging picture of what is meaningful to the child. This information should guide our next steps: that is, how do we help the child use a greater and greater variety of auditory information in more and more situations and with better precision and in more and more sophisticated ways. Informal information should be shared with audiologists to help them in the process of deciding how well a hearing aid or cochlear implant is meeting the needs of a particular child and if adjustments need to be made. Information from the informal hearing assessment process can also help guide the formal hearing assessment process by letting the audiologist know typical kinds of responses a particular child might make to various kinds of auditory input.

Resources

There is a book, *Every Move Counts*, by Jane Korsten (Therapy Skill Builders, 1993) that outlines a process that can be useful for gathering information. *Every Move Counts* deals with all the senses, not just hearing.

Another soon to be released product that helps look at how a child uses sensory information is the “Sensory Learning Kit”, (Millie Smith, primary author) from American Printing House for the Blind. This product should be available sometime in 2006.

Finally, is “A Process for Identifying Students Who May Be At-Risk for Deafblindness”. This is a collection of information and downloadable forms that can be used to support the gathering of information in an informal way.

Teachers for the deaf and hard of hearing typically have training to help look at auditory functioning in this informal way. They may be a valuable resource in this process.

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