Using Speech Perception Testing to Maximize Auditory Performance

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The Goal of Audiology Practice:

The goal of audiology practice is to assist patients with hearing loss in maximizing auditory performance to enable them to participate fully in every aspect of daily life. To accomplish this goal, they need to hear well in normal and soft conversational levels, in quiet and in the presence of background noise.

How do we know if we've reached the goal? We can only know by assessing the ability of our patients to hear in these listening conditions. Speech perception testing can be used to confirm tonal thresholds, to assess the ability to perceive and discriminate speech information, to assess the benefits of technology, to identify perception problems that develop over time, and to plan and monitor habilitation needs. Additionally, for children, speech perception testing can also be used to assist in selecting the appropriate educational environment.

It is standard clinical practice to measure speech perception under earphones as part of basic hearing evaluations. However, hearing aids are frequently fit using real ear targets and measures without external verification. As clinicians, we need to ask ourselves why it would be more important to test speech perception with earphones than with fitted technology? People with hearing loss spend most of their day listening through their technology (hearing aids or cochlear implants) and therefore, that's the condition that needs to be tested and monitored.

When should speech perception be monitored?

Speech perception should be monitored when hearing loss is first identified, at each re-evaluation, when selecting technology, and when changing technology or technology settings. If we do not assess speech perception we cannot know if we've met our goals. Without testing, we cannot know what the person hears. More importantly, without testing, we cannot know what the person does not hear, whether there's been a change in perception or if there's something we can do to improve auditory functioning.

The Audiology Fruit:

We're all familiar with the speech banana. While speech information is found throughout the area of the speech banana, it's important to remember… If a person hears at the top of the speech banana she'll hear 90% of what is said but if she hears at the bottom of the speech banana she'll only hear 10% of what's said. Hearing "within the

speech banana" is not sufficient. Our patients must hear at the top of the speech banana if they're going to receive sufficient auditory access to use hearing to learn language and to understand everything around them.

Selecting Test Materials:

Speech materials need to be linguistically appropriate for the person being tested. We don't want to test a mainstreamed 9 year old in a 3rd grade class with a test standardized on pre-school children. It will not provide us with enough information about whether the child will hear what he needs to hear to succeed in his classroom.

We also need to select tests with the appropriate level of complexity. Sentence tests are generally easy because a person can hear part of the sentence and "fill in the blanks." If we want to fully understand how a person is hearing in everyday listening situations, we will need to use test materials that provide fewer clues. Monosyllabic words are a more accurate measure of auditory perception (than sentences) because there are fewer clues. Nonsense syllables provide the most information about perception because there are no clues. Phoneme scoring provides even more information regarding exactly what the person hears, which phonemes are being confused (e.g. *bed* for *bet*), and enables the audiologist to use an error analysis to change the technology settings with the goal of improving perception.

Selecting Levels to Test with Technology:

If we want to measure maximal standardized performance, it would be best to test people wearing their technology at comfortably loud levels (65 dBHL). If we want to see how people manage in everyday listening situations, we need to test in those situations. Normal conversation occurs at 50 dBHL and should be the "basic" test level. However, people also need to hear soft speech and to hear when the talker is 6 feet or farther away, so it's important to also test at soft levels (35 dBHL).

Unfortunately, the world is not quiet. Most people spend their lives living in noisy conditions. To understand how they're hearing in real-world daily living situations it's important to test in competing noise. Therefore, speech-in-noise testing should be accomplished at normal conversational levels. For example, speech should be presented at 50 dBHL with noise at 45 dBHL, representing a +5 dB signal-to-noise ratio (SNR). This test protocol (above) represents a reasonable real-world approximation of how the child hears in a regular classroom setting and these results can easily justify the need for an FM system to the school, and for the child.

Suggested Speech Perception Test Protocol:

Table 1 suggests conditions that should be tested. Testing needs to be conducted monaurally and binaurally. Testing devices one-at-a-time (and in-tandem) allows the audiologist to identify problems in performance related to each device. In the binaural condition, it is useful to test normal and soft speech in quiet and in competing noise. If a

child uses an FM system, testing should also be repeated with the FM system. Testing in all conditions is the only way to determine what a person is and is not hearing and what modifications need to be made to maximize performance.

Figure 1 suggests a protocol for determining which speech perception test to use. Testing begins at 50 dBHL with the person wearing his technology. If the person does well (scores between 50-75%) than this speech perception test is appropriate. Testing can then proceed to test at soft speech levels (35 dBHL) and to speech-in-noise (50 dBHL speech signal with 45 dBHL noise, yielding a +5 dB SNR).

However, if the score is less than 50% the test is too difficult and an easier speech perception test should be considered. For example, if the original results were acquired using PBK words (kindergarten vocabulary), testing should be repeated using the NU-CHIPs (vocabulary level 3-5 years). If the speech perception test score is greater than 75%, the speech perception test is too easy, thus, a more difficult test is desirable, such as the NU-6. If, when you get to the more difficult test (i.e. NU-6) the scores are poor, move back to the easier test for speech perception testing using soft speech and speech in noise. By carefully selecting the tests, one can get a complete picture of auditory performance.

Stimulus presentation:

When testing children, many audiologists prefer to test using monitored live voice (MLV) rather than recorded testing. MLV is useful with very young children who need more flexibility during testing, but MLV is affected by rate and quality of presentation and may not provide sufficient test-retest reliability. Recorded speech perception tests have greater test-retest reliability and are frequently more difficult than monitored live voice. Recorded tests often provide poorer test results than MLV. Due to the importance of reliability and repeatability, recorded stimuli should be used as soon as possible.

Open versus Closed-set testing:

Closed-set tests have a limited set of response possibilities. Nonetheless, closed-set tests are useful for very young children with limited vocabulary and they're also useful for patients with poor articulation, which makes it difficult for the audiologist to understand the child's response. Because close-set choices are limited, "chance scores" are possible, and indeed, obtained scores may be inflated by lucky guesses. However, closed-set testing should only be used when it is not possible to use open-set testing. For example, a 10 year old in a regular school setting should not be tested using a closed-set test with a vocabulary of a 3 year old as the results will not be a good measure of the child's performance in the classroom.

Open-set measures are more challenging as the response possibilities are somewhat unlimited and are arguably more representative of how a child might be expected to perform in everyday situations.

Case Studies:

Case 1:

Figure 2 describes test results for a child who uses hearing aids. Aided test results indicate he is receiving good gain from the hearing aids and should be able to hear soft speech. He does fairly well (84%) at a normal conversational level in quiet. If that were the only level tested we would expect this child to do very well. However, when we test soft speech and speech-in-noise we see he is having significant problems. We can increase the gain for low frequencies to improve perception for soft speech. Testing can also easily demonstrate the need for classroom assistance. By testing with FM, we can justify the purchase of an FM system to the school, and justify the need to use FM to the classroom teacher and the child.

Case 2:

Figure 3 describes test results for a child with a severe sensorineural hearing loss (SNHL). Speech perception testing of each ear individually indicates the left ear is performing much more poorly than the right ear. Noise band thresholds indicate the hearing aid is providing sufficient gain. However, it is possible the hearing aid is not performing optimally. It may have internal distortion or feedback, or may be inappropriately set. If the problem is not with the hearing aid, the child might benefit from auditory therapy to attempt to improve listening skills in that ear. Improving individual ear speech perception can be expected to improve binaural speech perception.

Case 3:

Figure 4 describes test results for a child with a profound SNHL. Narrowband noise thresholds demonstrate she is not hearing at soft levels while wearing her hearing aids. Word recognition testing with monosyllabic words confirms she is not hearing well enough. While speech perception is better in the right ear than the left at normal conversation, testing at soft levels and in competing noise indicates how much difficulty she is likely to experience in daily listening. Sentence testing is much better then monosyllabic word testing, but (as noted above) is not as good an indicator of everyday performance. If it is not possible to improve her speech perception with adjustment or replacement of her hearing aids, she would be considered a cochlear implant candidate. Note - this child did receive a cochlear implant in her left ear. Test results with her cochlear implant demonstrate significantly improved performance.

Conclusion:

Speech perception testing can provide a great deal of information about auditory performance. By testing at multiple loudness levels and in multiple test conditions (quiet and noise) it is possible to fully evaluate performance and to make changes in technology to maximize speech perception. Additionally, comprehensive speech testing allows one to make recommendations about auditory therapy and to add insight into educational

placements. By expanding our horizons, we expand opportunities for the children we work with.

References

Madell, J.R. (2008) Evaluating Speech Perception in Madell, JR, and Flexer, C,: *Pediatric Audiology: Diagnosis, Technology, and Management;* Thieme, NY

Table 1: Test protocol for assessing auditory performance.
Empty boxes indicate recommended testing. Shaded boxes indicate information that need not be obtained.

Test:	Right Technology	Left Technology	Binaural technology	Binaural + FM
50 dB HL				
35 dBHL				
50 dB HL +5 SNR				

Figure 1: Protocol for selecting a speech perception test that is appropriately difficult.

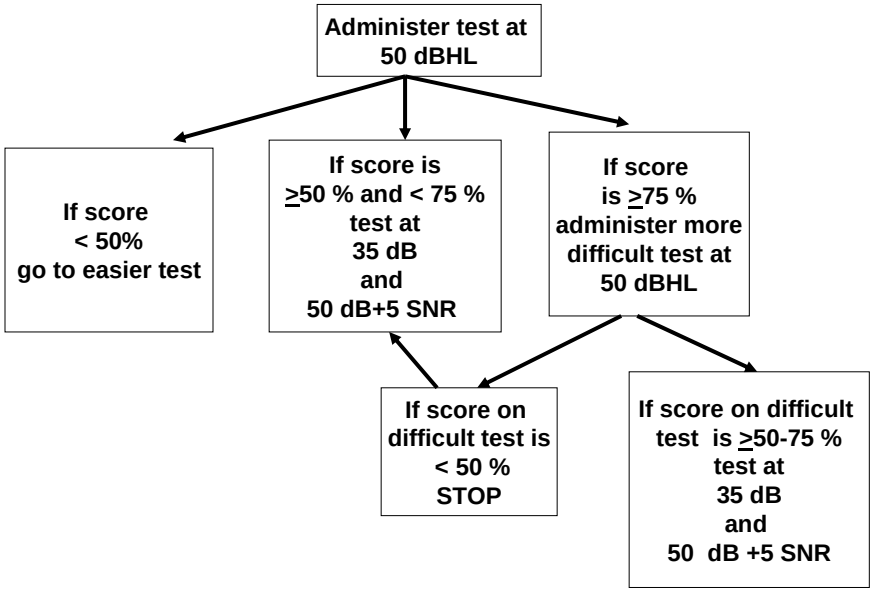
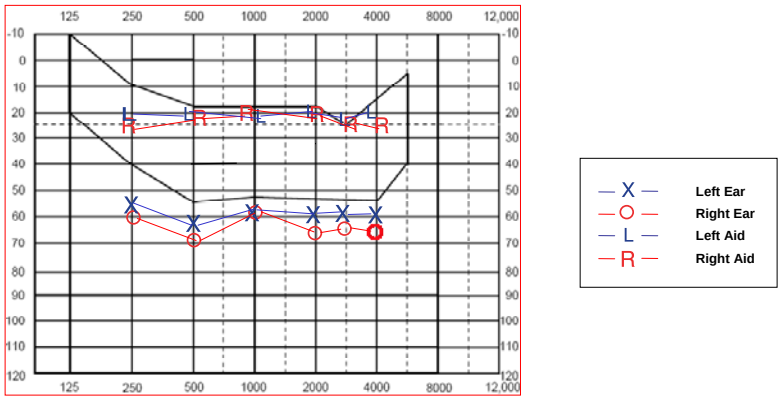
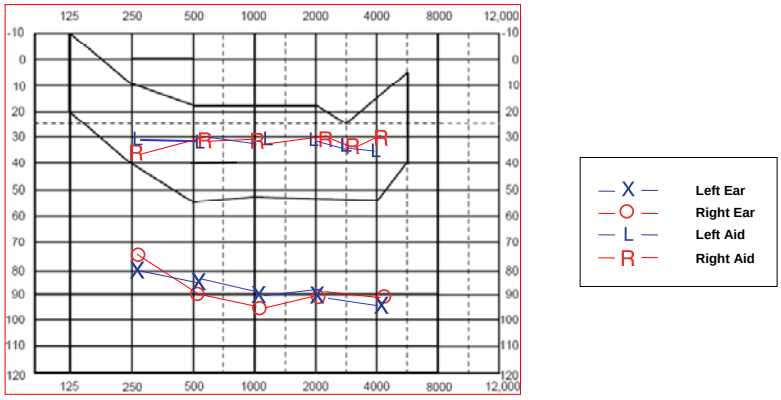


Figure 2: Speech perception performance for a 9 year old child with a moderately severe hearing loss



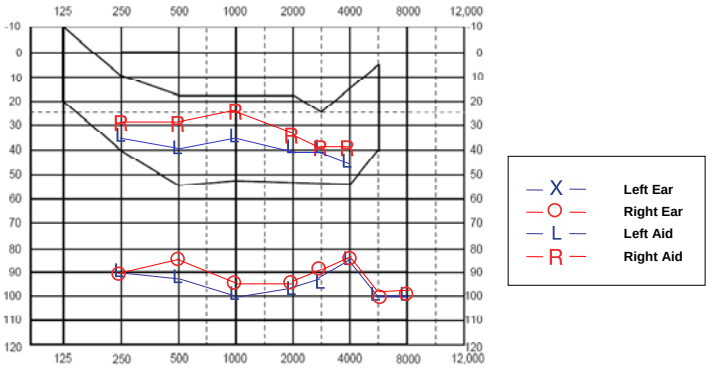
Test: NU 6	Right Technology	Left Technology	Binaural technology	Binaural + FM
50 dB HL	84%	88%	88%	96%
35 dBHL			56%	92%
50 dB HL +5 SNR			48%	88%

Figure 3: Speech perception results for an 8 year old child with a severe-profound hearing loss.



Test: PBK	Right Technology	Left Technology	Binaural technology	Binaural + FM
50 dB HL	96%	64%	100%	100%
35 dBHL			72%	92%
50 dB HL +5 SNR			80%	92%

Figure 4: Test results for a child with a severe to profound hearing loss and poor speech perception.



	R HA	L HA	Bin	FM	CI
PBK					
50 dB	**56%**	**28%**	**52%**	**68%**	**70%**
35 dB			**28%**		**56%**
50 dB + 5			**0%**	**20%**	**44%**
Hint C			**82%**	**82%**	**94%**