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Fasten your seat belts, folks, because we're about to do some time traveling—30 years backward! It's 1971, the Vietnam War is starting to wind down, Sonny and Cher have a new TV show, and two fuzzy-cheeked lads, James W. and H. Gustav, are audiology graduate students.

Routine audiometric testing was a lot different back then. First, we used these big bulky earphones called TDH-somethings that never did seem to fit on the head correctly; nothing like the small, comfortable, and more reliable insert earphones of today. Then, if you can believe this, we used to do SRTs on *everybody*. And, because 1971 wasn't that far removed from the '50s—promise not to laugh—we used to do our word-recognition testing) at *30 or 40 dB SL*. And, you know, those reel-to-reel tape decks were a little cumbersome, so on occasion we'd close the door, use live voice, and hope we never got caught. It would still be 5 years before Aaron Thornton and Mike Raffin presented their data on the binomial model, so we often wrote reports saying that a 12% difference between ears on word-recognition testing was significant. Immittance audiometry had just been introduced (we called it impedance back then), and there were times when we would devote several minutes to obtaining a good seal, conduct tympanometry, and then never even do acoustic reflex testing. Here's the real knee-slapper: There also were times when our immittance battery was normal, and we'd do bone-conduction testing anyway (guess we had a lot of time on our hands—or had a fetish for masking).

Things sure have changed, haven't they? *Haven't* they? That 1971 graduate student, **James W. Hall III**, PhD, takes us forward to 2001 and is here to fill us in on current thinking regarding our basic audiometric battery. Dr. Hall is the Clinical Professor of Audiology in the Department of Communicative Disorders, College of Health Professions, University of Florida Health Science Center. If you don't know Jay from his numerous workshops, book chapters, and journal articles, I'm sure you've noticed his three recent books: one on OAEs, and the two-volume *Audiologists' Desk Reference*.

Jay tells me that his inspiration for writing this Page Ten originated from casual chats about diagnostic audiology with his Florida AuD students, who, not surprisingly, wanted to know why we do things the way we do. Is it because these are the most efficient and effective methods, or simply because this is how we've been doing them for 30 years? I think after reading Jay's excellent article, you'll be able to separate the former from the latter.

Gus Mueller
Page Ten Editor

Audiology students ask the darnedest questions!

By James W. Hall III

1 As we begin our careers in the 21st century as Doctors of Audiology*, we face a time of diminishing revenue for hearing care services and increased emphasis on outcomes of these services. Should we rethink our strategies and protocols for basic audiologic assessment of children and adults?

Absolutely! It's timely and necessary. Fortunately, as changes in health care have limited the time we have available for each patient, advances in technology have permitted quicker and more sensitive auditory measurement of children and adults. Given the changes in health care and audiologic technology, it's not surprising that you students are questioning some of the traditional clinical concepts and approaches that served us quite well not so long ago.

2 We learn about so many procedures in our classes. Some tests have been around for over 50 years, whereas others are quite new. How do we know which procedures should be applied with a specific patient in the clinic?

That's a logical question that, unfortunately, isn't asked as often as it should be. There are a few straightforward guidelines for deciding which procedures to use with which patients. First of all, the procedure must add value to the description of the patient's auditory status. That is, the procedure provides information that is useful in managing the patient and is not available from other procedures. Or, it provides useful information more quickly than another procedure.

3 Could you give us some examples of how that kind of thinking applies to particular audiologic procedures?

Sure. For instance, let's take two venerable old workhorses in the audiologic test stable—bone-conduction pure-tone audiometry and the speech-reception threshold (SRT). Both procedures are probably viewed by many audiologists as routine, perhaps even mandatory, components of the basic test battery. However, in audiology today neither is really essential for each and every patient. Once again, to justify their inclusion in the test battery for a patient, test procedures, even bone-conduction pure-tone audiometry and SRTs, must make a useful contribution to the description of auditory function and, usually, management of that patient.

4 You mean bone-conduction pure-tone thresholds are optional? Then how do you verify conductive hearing loss?

Bone-conduction audiometry is, of course, still necessary for defining the degree of conductive hearing loss when middle ear dysfunction is known, or at least suspected. But there is no way to justify the time required for measurement of bone-conduction thresholds, with or without masking, when the likelihood of a conductive hearing loss is nil.

5 You can probably figure out my next question. When should we suspect middle ear dysfunction? Is it based on the history, or otologic inspection, or some audiologic finding?

The real question is, when can you confidently rule out the likelihood of middle ear dysfunction and, therefore, bypass bone-conduction measurement? The answer has been around for years, probably since you were just a twinkle in your parents' eyes!

Begin the audiologic assessment with a procedure that is highly sensitive to mid-

* Most of the questions in this article were posed by Julie Manche, a student in the University of Florida Doctor of Audiology program.

dle ear dysfunction. If the results of this procedure are entirely normal, then middle dysfunction is effectively ruled out, and bone-conduction audiometry will be useless.

6 I'll bet you're referring to immittance measurements?

That's certainly one option for either effectively ruling out or confirming middle ear dysfunction. In the early 1970s, aural immittance measurement, that is tympanometry and acoustic reflexes, were the technique of choice for this objective.[1] Nowadays, though, middle ear dysfunction can also be quickly and effectively ruled out with OAEs.[2]

OAE measurement is dependent on the propagation of stimulus energy to the cochlea via the middle ear system, and then propagation of the cochlear energy (from outer hair cell motility) back out to the ear canal via the middle ear system. The middle ear system must be working well for the OAEs to reach the ear canal with normal amplitudes. If OAEs are within normal limits, especially for stimulus frequencies within the region of 500 Hz to 2000 Hz, then middle ear function is, in all likelihood, normal.

Of course, with the same quick test you've also confirmed normal cochlear (outer hair cell) function. For those patients with normal OAEs, you don't need to be concerned about bone-conduction thresholds and masking. Spend the time instead on a more valuable procedure, or save a few precious minutes with that patient and spend it on another patient. Or, better yet, leave work at 5 pm for a change.

7 Well, it sounds as if bone-conduction audiometry is over-used, or at least performed with no clear rationale on some patients. That may also answer another question we were about to ask. We recall reading somewhere that there's no need to perform bone conduction with children when air-conduction thresholds are 20 dB HL or better. Is that true?

Yes, and that's another good reason to begin a pediatric hearing assessment with OAEs. For a child with pure-tone thresholds in the region of 15 db HL to 20 dB HL, one would expect abnormal OAE findings, whether there was a conductive component or a mild sensory hearing loss. If OAEs are abnormal, or not observed in this child, it's important to perform bone-conduction pure-tone audiometry to differentiate between these two possibilities, i.e., mild conductive and mild sensory hearing loss, even if tympanometry is normal.

Normal tympanograms do not always indicate normal middle ear function. Keep in mind that a normal-hearing child should have hearing thresholds very close to 0 dB HL. If thresholds are in the range of 15 dB HL to 20 dB HL, then statistically the child's hearing is outside the average normal (one standard deviation from audiometric zero is only 5 dB). Also, even a very mild (e.g., 20 dB HL) hearing deficit may cause serious communicative problems for a young child. If bone-conduction hearing thresholds are 0 dB or better, then the child with air-conduction thresholds of 20 dB HL may have a conductive loss of at least 20 dB, and maybe more, which might be treatable medically or surgically. So, performing bone-conduction audiometry is a wise decision with children who lack OAEs or absolutely normal immittance findings (including the presence of acoustic reflexes).

8 We see your point but, to save time, is it okay to measure bone-conduction thresholds from children without using masking?

Do you mean placing the bone vibrator first on one mastoid, and then the other, and plotting the results of unmasked bone-conduction audiometry for each ear separately?

9 Yes. We've seen audiologists use that technique quite often.

I'll give it to you straight. Trying to determine without masking which cochlea is actually producing the bone-conduction response can be a guessing game. And, plotting unmasked bone-conduction thresholds separately for each ear in pediatric hearing assessment—"best ear bone"—can be misleading.

Do you really want medical or surgical decisions for a child to hinge on your unmasked bone-conduction findings? Why not eliminate the uncertainty and assure ear-specific bone-conduction thresholds by routinely presenting narrow-band masking noise of 50 dB HL to 60 dB HL to the non-test ear via insert earphones?

On the other hand, unmasked bone conduction can be a handy approach for verifying the absence of an air-bone gap in adults with symmetric high-frequency sensorineural hearing loss.

10 You're not saying that we can dispense with those confusing formulas when performing masked bone conduction, are you?

Yes, that's exactly what I'm saying. This strategy is straightforward (no formulas or calculations are needed) and adequate for all mild-to-moderate hearing loss. The use of insert earphones minimizes the chance of over-masking and cross-over of the masker to the test ear.

The routine use of insert earphones offers a variety of clinical advantages in addition to increased interaural attenuation, such as aural hygiene in this era of universal precautions.[3] Sure, you'll be using more masking noise than needed in some cases, but what's the harm? For more serious bilateral conductive hearing losses, the underused SAL procedure is ideal. But that's a topic for another day.

11 A few minutes ago, you mentioned the speech-reception threshold? Shouldn't the SRT be part of the typical audiologic test battery?

Like any other audiologic procedure, the SRT takes time to administer. Therefore, it's reasonable with each patient to question the need for performing the procedure and to ask what value will be gained from the time spent doing the SRT.

For a cooperative patient with normal pure-tone thresholds within the speech-frequency region, the SRT is redundant and contributes no diagnostic value. Time spent on it would be better applied to assessing word recognition or, for a patient with normal hearing sensitivity, conducting some measure of auditory processing or a more sensitive measure of peripheral auditory status, such as OAEs.

However, there are plenty of good reasons for recording the SRT in selected patients, including poor reliability, sus-

picion of malingering, and the inability to complete pure-tone thresholds in young children. Again, ask this simple question: What will be gained from the findings of this procedure?

12 You've been stressing the importance of saving test time. Isn't monitored live-voice presentation a good way to cut down on test time in speech audiometry?

No, nay, never! Word recognition should routinely be conducted with recorded materials, even though many audiologists apparently rely on a monitored live-voice approach, presumably to save time. With a selection of speech materials in CD format, little time (if any) is saved by using monitored live voice. In fact, the efficient clinician can wrap up other simple tasks, e.g., completing paperwork, while performing recorded speech audiometry.

In addition, there are defensible and feasible strategies for conducting word recognition quickly and efficiently.

One strategy is to use commercially available CD recorded materials with the10 most difficult words presented first.[3] If the patient yields a score of 100% or 90% (9 or 10 correct), then the procedure is terminated. Or, you can go on to another intensity level. With some patients, there are advantages to measuring high-intensity maximum word recognition for diagnostic purposes, and then a word recognition score at a lower conversational-speech intensity level—about 40 dB HL—for patient counseling purposes.

13 While we're on the topic of speech audiometry, don't we need to include speech-discrimination testing in every basic hearing assessment?

Despite pervasive and popular use of the term "speech discrimination" or, simply, "discrim scores," that's not what we're evaluating with our word lists. The more acceptable and accurate term is speech or word recognition, as detailed in reviews of current speech materials and procedures (e.g., Strouse and Wilson[4]).

Actually, of more concern than nomenclature is the lack of consistency in, and rationale for, the speech audiometry practices that continue to be followed doggedly (or dogmatically) in clinics around the world. Back in 1980, Jim Jerger uttered the classic statement: "We are, at the moment, becalmed in a windless sea of monosyllables. We can sail further only on the fresh winds of imagination."[5]

Sadly, we're still adrift, apparently without a wisp of wind on the horizon to propel us toward a more effective and efficient measure of hearing with speech signals. Today's practices have changed little from those described in 1948 by Egan and his colleagues at the Psychoacoustic Laboratory.[6] Most audiologists go about speech audiometry just as their audiologic grandfathers and grandmothers did 50 years ago.

14 So, what do you recommend?

I already stressed the compelling evidence in support of relying on standardized (relatively) recorded materials rather than monitored live-voice presentation. Also, we should be assessing speech perception or understanding in noisy as well as quiet conditions, and at more than one signal intensity level. The value gained from using speech audiometry in assessing auditory processing disorder is particularly enhanced for patients with complaints of hearing problems, yet normal OAEs and hearing sensitivity.

15 So, are you saying that we should always evaluate speech recognition clinically?

Not necessarily speech recognition, but rather communication abilities with better and improved speech audiometry strategies. The time saved by not routinely performing (unless there is a good reason) bone-conduction pure-tone thresholds, the SRT, or just a simple measure of word recognition in quiet could instead be devoted to more sophisticated and sensitive speech measures. For most patients with less than a severe hearing loss and persons with normal audiograms yet complaints about their hearing, it might be advisable to go straight to a measure of auditory processing. And, as suggested by Jerger,[7] for evaluation of everyday communication status, in comparison to the diagnosis of hearing loss, we should rely more on soundfield than earphone signal presentation.

16 Gosh, now I'm beginning to question how to perform even such really basic procedures as pure-tone audiometry. Do you have any handy tips for an earnest student?

The answer to that question could easily be expanded into a practical audiology textbook. Here are a few suggestions to get you started in modifying and refining this traditional audiologic test with patients.

- Regularly assess hearing thresholds for inter-octave frequencies (e.g., 3000 Hz and 6000 Hz), even with patients who yield normal audiograms for octave frequency signals.
- Perform high-frequency audiometry (signals above 8000 Hz) for patients with normal findings for traditional frequencies and auditory complaints.
- Pursue complaints of hearing problems with measures of auditory processing whenever pure-tone audio-metry findings are normal.

17 Speaking of basic procedures, what tips do you have about tympanometry?

Perform high-frequency tympanometry (1000-Hz probe tone) in the aural immittance evaluation of infants. Otherwise, tympanometry with multiple probe-tone frequencies offers no clear advantage for most patients.

18 Tympanometry makes me think about acoustic reflexes. Could you clarify for me how I should report and record the results?

First of all, perform crossed, or contralateral, acoustic reflexes for selected pure-tone frequencies, such as 1000 Hz and 2000 Hz. Avoid the 4000-Hz frequency as a signal because acoustic reflexes can be absent even in a proportion of normal-hearing persons (a false-positive error). If crossed acoustic reflexes are elevated, or absent, then immediately go ahead (don't remove the probe from the ear canal) and measure uncrossed (ipsilateral) acoustic reflexes and analyze for any discrepancies. Poorer

thresholds for crossed acoustic reflexes are a sign of central (brainstem) auditory dysfunction.

Acoustic reflex findings for all four conditions (crossed and uncrossed for right and left ears) can be plotted (using the separate ear audiogram) or reported based on the stimulus ear. For uncrossed acoustic reflexes, the probe and signal ear are one and the same. Crossed reflexes should be reported for the signal ear, the ear stimulated, rather than the probe ear.[3]

Analysis of the pattern of findings for acoustic reflexes is a quick, objective, and extremely valuable strategy for differentiating among middle ear, eighth cranial nerve, brainstem, and facial nerve dysfunction.

19 Any other suggestions for the use of acoustic reflexes, like whether or not decay should be routinely assessed?

With children, there's evidence that a broad-band noise (BBN) signal can be useful in quickly estimating the likelihood of a sensory hearing impairment.[3] Children with normal hearing typically have acoustic reflex thresholds (for crossed or uncrossed) of 85 dB HL or better for the BBN signal, assuming middle ear function is normal. Elevated BBN acoustic reflex thresholds imply some degree of sensory hearing loss. Acoustic reflexes can be a valuable adjunct to OAEs for estimating cochlear hearing status, since they provide information on inner hair cell and eighth nerve function in addition to outer hair cell function.

As for acoustic reflex decay, it seems as if fewer audiologists are performing the procedure these days. There are probably two good reasons for this trend. First of all, other audiologic procedures, e.g., ABR, have relatively greater sensitivity in identifying retrocochlear auditory dysfunction, which is, of course, the main diagnostic objective for the acoustic reflex decay procedure. Also, in this age of litigation, audiologists are reluctant to run the risk of exposing patients to the potential risk of acoustic trauma without a clear rationale.

20 Do you have any parting words of wisdom for us audiology students?

Go ahead and revolutionize the audiologic test battery to meet today's clinical demands with today's technology. To quote Henry Wadsworth Longfellow, "Look not mournfully into the Past. It comes not back again. Wisely improve the Present. It is thine. Go forth to meet the shadowy Future, without fear, and with a manly [sic] heart." (Longfellow, *Hyperion*, 1939).

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