REPORT CARD 2024

# NEW PERSPECTIVES IN HEARING ASSESSMENT: PART 1.

## Application of Value-Added Tests in the Diagnosis of Hearing Loss

Milaine Dominici Sanfins, Piotr Henryk Skarzynski, and James W Hall III

Journal of Hearing Science®

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# New Perspectives in Hearing Assessment: Part 1.

## Application of Value-Added Tests in the Diagnosis of Hearing Loss

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**This is the first in a series of seven bulletins focusing on the importance of evidence-based hearing assessment for making an accurate audiological diagnosis. An accurate diagnosis of auditory dysfunction is the first step in the development of an effective plan for managing hearing loss.**

The series, entitled "New Perspectives in Hearing Assessment", includes bulletins that review key test procedures for diagnostic assessment of auditory function in children and adults.

# APPLICATION OF THE CROSSCHECK PRINCIPLE IS A RECURRING THEME IN THE SERIES.

**We'll highlight for clinicians the unique features and practical advantages of each procedure and how the pattern of test results leads to a clear and confident audiological diagnosis.**

What criteria should you consider in deciding whether a certain audiological procedure is really necessary for your patient? The answer to this question depends on the patient's history, chief complaint, and the overall objective of the hearing assessment. Clinicians need to bear in mind that each test contributes in a unique way to the diagnosis of hearing loss. Other clinically relevant questions include: Are there ways to evaluate the value each method adds to the audiological diagnosis and management of a patient? What weighting should be given to each procedure in the test battery?

The term "added value" refers to information that is useful or helpful in making a prompt and accurate diagnosis.

## WHEN MAKING AN AUDIOLOGICAL DIAGNOSIS, A PROCEDURE ADDS VALUE IF IT MEETS ONE OR MORE OF THE FOLLOWING CRITERIA:

- A reduction in the time required to complete an evaluation: If two test procedures are likely to yield the same result, the procedure that can be carried out in the shortest time should be chosen.

- Minimal cost of the evaluation: Cost includes the charge incurred by a patient or health care insurance entity and also expenses born by an audiologist who provides the services. Il two tests provide equivalent results, but one is associated with greater expenses due to test time, equipment cost, test personnel salary etc., the procedure with the lower fee or charge is preferable.

- Minimization of patient discomfort and enhancement of patient safety: Assuming diagnostic equivalence, procedures that pose the lower riusk of patient discomfort and/ or harm should take priority.

- Test reliability and validity: Test procedures should be selected based on the odds that they will yield valid and reliable test results for a specific patient, e.g., an infant or an older adult with cognitive impairment.

- Sensitivity to auditory dysfunction: Value added tests are procedures that detect auditory dysfunction for a specific patient based on history and chief complaint.

- Site-specific information on auditory dysfunction: The procedures is likely to detect dysfunction within a specific region or structure in the auditory system.

- Efficient and accurate diagnosis of hearing loss: The procedure is likely to contribute to prompter and more precise diagnose of auditory dysfunction.

- Effective management of hearing loss: The procedure is likely to contribute to decisions about how the patient should be optimally managed, i.e., will management be altered based on findings for the test procedure.

- Optimal patient outcome following audiological management: In combination with other tests, the procedure will improve the patient's outcome.

**It's important for clinicians to appreciate the strengths and limitations of each audiological procedure, and to consider them in developing a patient-specific diagnostic test battery.**

In 1976, Jerger and Hayes described the application of a test battery approach for hearing assessment. The test battery consisted of independent behavioral and objective tests for pediatric hearing assessment.

Jerger and Hayes coined the term “crosscheck principle” in describing the analysis of test findings. The crosscheck principle is quite simple: The results of any hearing test should be accepted only when they are confirmed or crosschecked by findings for one or more independent test procedures. The authors demonstrated with a series of five case studies that relying on auditory findings for any test in isolation often leads to erroneous diagnoses and, as a consequence, inappropriate management.

Jerger and Hayes emphasized that an accurate diagnosis of hearing loss depends on agreement between multiple test procedures. When the crosscheck article was published in the mid-1970s, most audiologists relied exclusively on behavioral auditory procedures for hearing assessment of children and adults. Jerger and Hayes described a test battery that included two objective test procedures that were then quite new ... aural immittance measures (tympanometry and acoustic reflexes) and the auditory brainstem response.

**Table 1 lists auditory tests in the diagnostic test battery described in the crosscheck principle article (Jerger and Hayes in 1976). Consistent with the modern day application of the crosscheck principle, clinicians should always combine value-added behavioral and electrophysiological procedures in the audiological assessment of children and adults.**

**Table 1. Independent tests that Jerger and Hayes combined in different ways in the original clinical application of the crosscheck principle (jerger & Hayes, 1976).**

01

| BEHAVIORAL PROCEDURES | OBJECTIVE PROCEDURES |
|---|---|
| **Pure tone audiometry (PTA)**<br>- Air conduction pure tone audiometry<br>- Bone conduction pure tone audiometry | **Acoustic immittance measurements**<br>- Tympanometry (226 Hz probe tone only)<br>- Acoustic reflexes with tonal stimulation and broadband noise in the contralateral condition |
| **Speech audiometry**<br>- Speech awareness threshold (dB)<br>- Speech recognition threshold (dB)<br>- Speech recognition (%) | **Auditory Brainstem Response (ABR)**<br>- Air conduction click stimulation<br>- Bone conduction click stimulation |

The crosscheck principle is based on the assumption that the diagnostic test battery consists of value-added tests.

The battery of value-added tests is characterized by optimal sensitivity and specificity. That is, there is sensitivity to the presence auditory dysfunction and the pattern of test results differentiates among sites of auditory dysfunction. Also, importantly, the pattern of test findings yields a valid diagnostic outcome. In other words, the test battery accurately measures what it is supposed to measure.

The diagnostic audiologic test battery has expanded considerably since the 1970s as a result of technological advances and the application of hearing science discoveries. A short list of these new developments includes:

- Development of a variety of diagnostic speech audiometry procedures, such as dichotic listening tests, tests of speech perception in noise, and clinical tests of temporal auditory processing.

- Aural immittance instruments with high frequency probe tone options, as well as the traditional low frequency (e.g, 226 Hz) probe tone.

- Wideband absorbance/ reflectance and tympanometry.

- Equipment permitting acoustic reflex measurement with stimuli presented ipsilaterally and contralaterally with respect to the ear with the immittance probe.

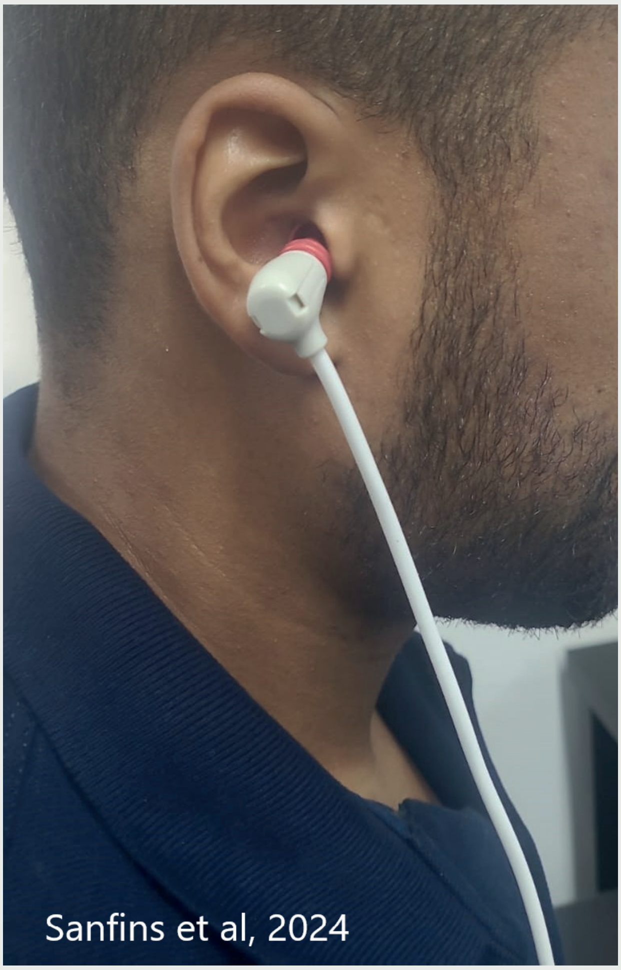
- The emergence in the late 1980s and early 1990s of clinical devices for the measurement of otoacoustic emissions (OAEs).

- An expansion of stimulus options for evoking the auditory brainstem response, including frequency-specific tone bursts and, more recently, broadband and narrowband chirp stimuli.

- Increased clinical application of electrocochleography (ECochG) techniques with the introduction of non-invasive electrode options (e.g., tympanic membrane and earcanal electrode designs).

- Commerically available auditory evoked response software for measurement of the auditory steady state response (ASSR).

- Application of clinical research in support of cortical auditory evoked responses, such as the auditory middle latency response (AMLR).

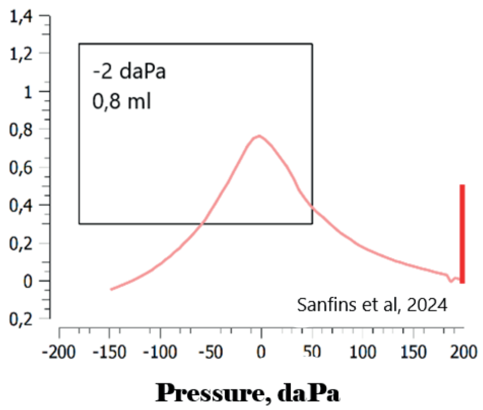


Sanfins et al, 2024

**Table 2. Current battery of independent tests for application of the crosscheck principle in hearing assessment of pediatric and adult patient populations.**

02

| BEHAVIORAL PROCEDURES | OBJECTIVE PROCEDURES |
| --- | --- |
| **Pure tone audiometry (PTA)**<br>- Air conduction pure tone audiometry<br>- Bone conduction pure tone audiometry<br>- Automated pure tone audiometry | **Acoustic immittance measurements**<br>- Tympanometry (226 Hz and 1000 Hz).<br>- Wideband reflectance/ absorbance<br>- Ipsilateral acoustic reflexes<br>- Contralateral acoustic reflexes<br>- Acoustic reflex threshold and latency |
| **Speech audiometry**<br>- Speech awareness threshold<br>- Speech recognition threshold (dB).<br>- Speech recognition (%). | **Auditory Brainstem Response (ABR)**<br>- Click stimuli (air- and boné conduction)<br>- Tone burst stimuli<br>- Chirp stimuli (broadband and narrowband) |
| - Speech perception in noise tests<br>- Spatial listening tests<br>- Dichotic listening tests<br>- Temporal processing tests | **Auditory Steady-State Response (ASSR)**<br><br>**Electrocochleography (ECochG)**<br><br>**Cortical auditory evoked responses**<br>- Auditory middle latency response<br>- Auditory late response<br>- Auditory P300 response |




**Future installments in this New Perspective in Hearing Assessment series will include reviews of each of these audiological procedures, with particular focus on their unique contributions to the diagnosis of hearing loss.**

We'll conclude this first installment of the New Perspective in Hearing Assessment series with a brief discussion of the relation of patient history and patient chief complaint to a patient-specific diagnostic test battery.

Relevant patient history, including a record of general health history and a specialized hearing health history, plays a critical role in decisions about which test procedures are most appropriate for a particular patient. The chief complaint (s) is the major reason (s) why the patient is seeking audiological care. In some respects, the chief complaint encapsulates in one or two words the most important and relevant aspect of the patient's history.

We offer in Table 3 some examples of connections between patient history and chief complaint and risk for site-specific auditory dysfunction. Patient risk for auditory dysfunction in a specific auditory region drives decisions about which test procedures are most likely to contribute to a prompt and accurate audiological diagnosis.

**Table 3. Examples of the relation between findings in a patient history (Hx) and the patient's chief complaint (CC) and the test procedures that are most likely to yield an accurate diagnosis for the patient. Review of a pediatric or adult patient's health history and hearing health history and the patient's chief complaint identify risk of auditory dysfunction in one of four general regions.**

**Value added objective (O) and behavioral (B) tests are then selected to enhance quick and accurate diagnosis of auditory dysfunction and, in turn, to effective patient management.**
**The ordering of procedures in the table corresponds generally to their diagnostic value and their sequence in the hearing assessment.**

03

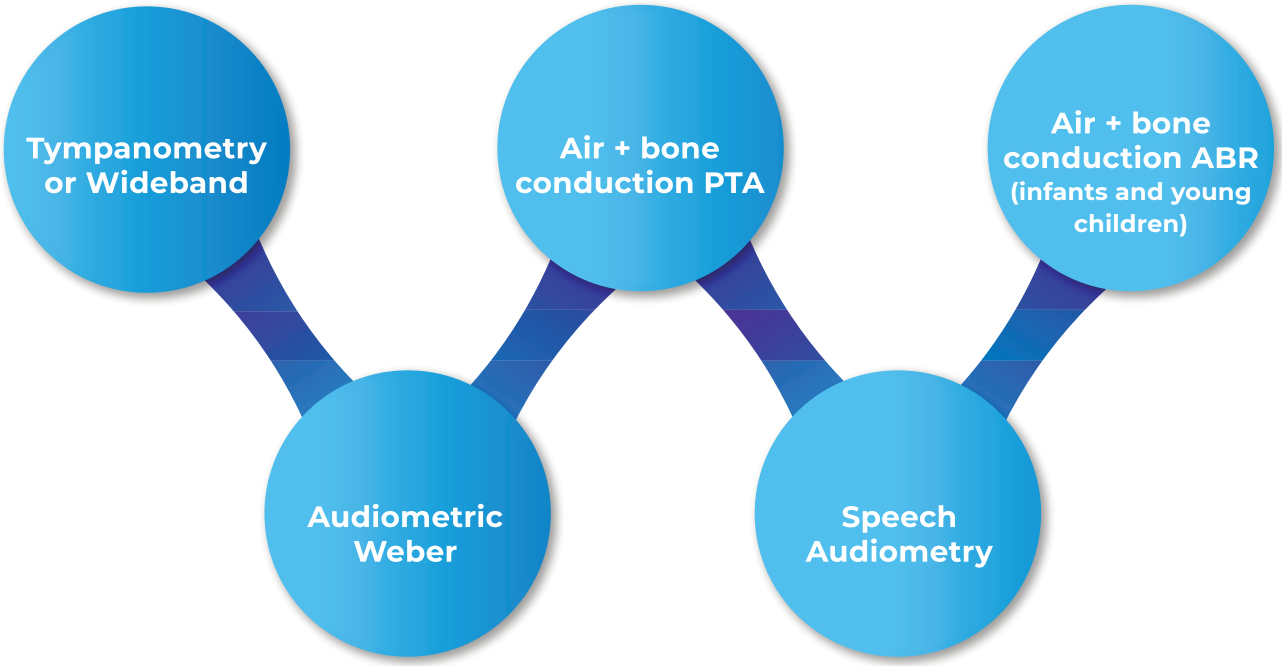
## Suspected Site of Dysfunction: Middle Ear

**Hx:** Allergies; Eustachian tube dysfunction; otitis media; chronic ear disease; otosclerosis; otologic trauma

**CC:** Pain; Discomfort; sensation of ear pressure; hearing loss

**Test Battery:**

- Tympanometry (O) or wideband absorbance/ reflectance (O)
- Air- vs. bone conduction pure tone audiometry if feasible (B); Air- vs. bone conduction ABR in infants and young children (O)
- Audiometric Weber test (B)
- Simple speech audiometry (B)



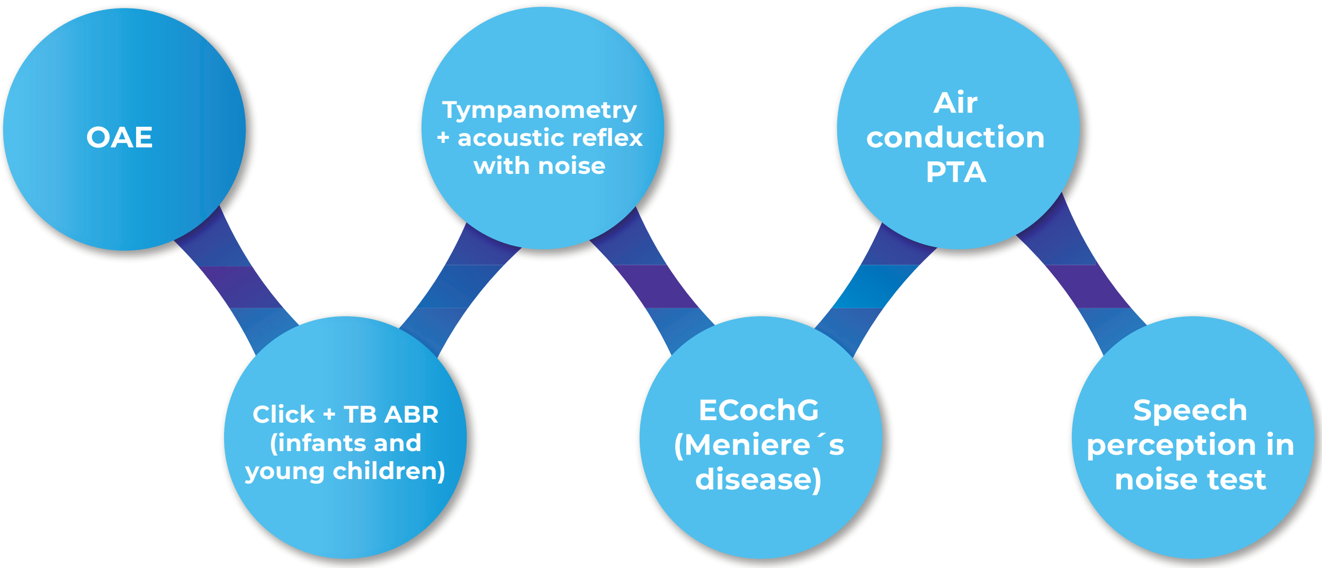
# Suspected Site of Dysfunction: Cochlea

**Hx:** Admission to intensive care nursery; infant risk factors; diabetes; cardiovascular disease; ototoxicity; sound (noise and/or music) exposure; Meniere's disease; autoimmune disease; kidney disease; temporal bone trauma; smoking; poor diet

**CC:** Hearing loss; tinnitus

**Test Battery:**

- Diagnostic otoacoustic emissions measurement (O)
- Tympanometry (O) to rule out middle ear dysfunction
- Acoustic reflex with broadband noise stimulus (O)
- Air conduction pure tone audiometry (B)
- Air conduction ABR with click and tone burst stimuli in infants and young children (O)
- Electrocochleography in suspected Meniere's disease
- Speech perception in noise test



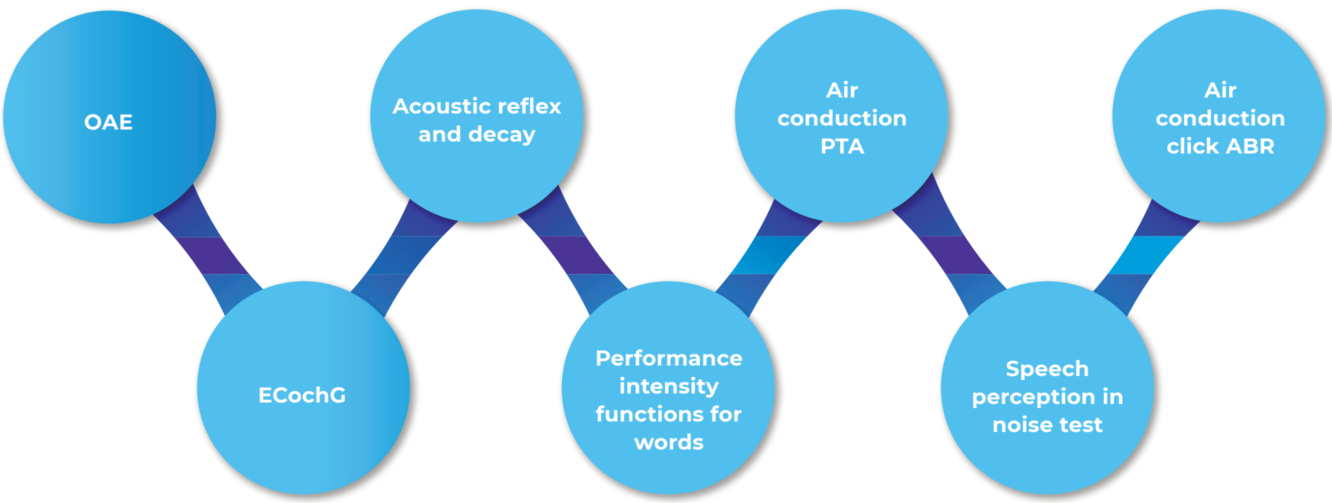
# Suspected Site of Dysfunction: Neural

**Hx:** Admission to intensive care nursery; head injury; suspicion of auditory neuropathy spectrum disorder (ANSD); vestibular or balance disorder; facial nerve dysfunction; neurological symptoms

**CC:** Asymmetrical hearing loss; Difficulty with speech perception in noise; tinnitus; vertigo

**Test Battery:**

- Diagnostic otoacoustic emissions measurement (O)
- Acoustic reflex thresholds and decay (O)
- Air conduction pure tone audiometry (B)
- Air conduction ABR with click stimuli (O)
- Electrocochleography (O)
- Performance intensity functions for words (B)
- Speech perception in noise test (B)



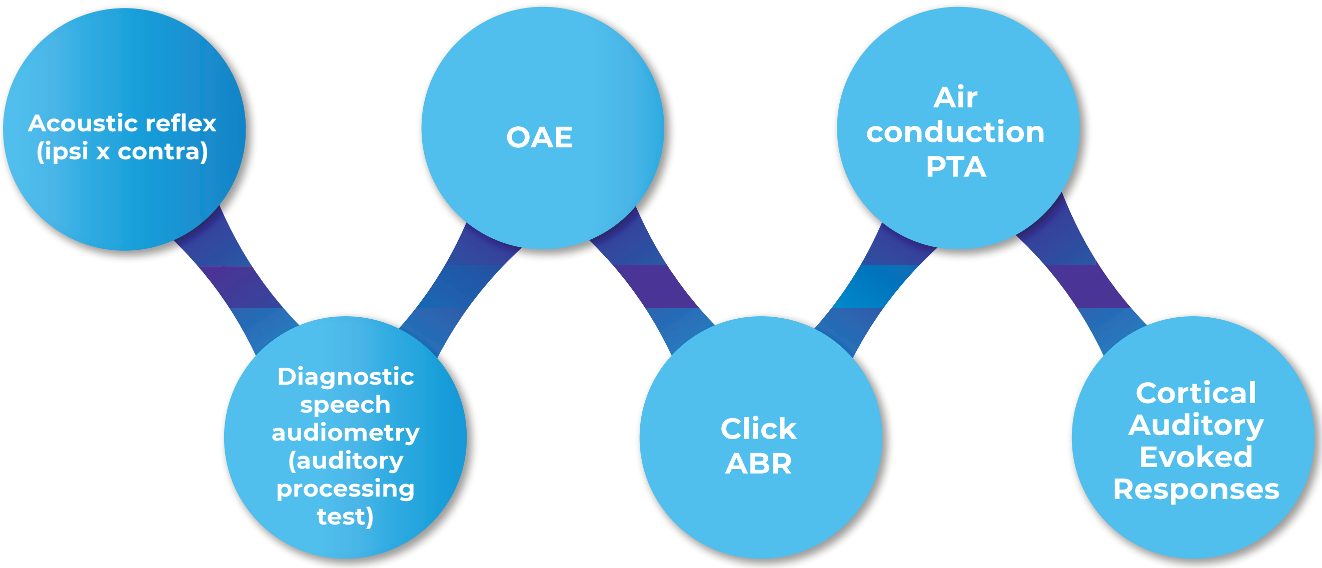
# Suspected Site of Dysfunction: Central auditory nervous system

**Hx:** Admission to intensive care nursery; head injury; neurological disease and/ orsymptoms; cardiovascular disease; cognitive impairment; dementia; risk factors for auditory processing disorder

**CC:** Hearing complaints, including difficulty with speech perception in adverse listening conditions

**Test Battery:**

- Ipsilateral versus contralateral acoustic reflexes (O)
- Diagnostic otoacoustic emissions measurement (O)
- Air conduction pure tone audiometry (B)
- Diagnostic speech audiometry, e.g., dichotic listening tests; speech perception in noise tests and other tests of auditory processing (B)
- ABR with click stimuli (O)
- Cortical auditory evoked responses (O)



Subsequent bulletins in the New Perspective in Hearing Assessment series contain more detailed discussions of selected procedures cited in Table 3, including the link between patient history/chief complaint and specific test procedures that are likely to add the most value to the diagnostic power of the test battery.

**We invite you to follow us on this journey in the New Perspective in Hearing Assessment in our next newsletters!**

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