Best Practices in Audiology

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Our old and worn out audiologic test battery
Defining “best practices” and “standard of care”
The concept of value added tests (VATs)
Modern diagnostic audiology and audiologic rehabilitation

- Aural immittance measures are still valuable
- OAEs add value to audiologic assessment
- Early infant hearing loss diagnosis and intervention (EHDI)
- Identification of auditory processing deficits
- Rehabilitative technology and techniques

Best Practices in Audiology: Modern Audiometers

Audiology Test Battery: 60+ years Ago

- Test battery at the beginning of our profession, in order of test administration
  - Air-conduction pure tone audiometry
  - Bone-conduction pure tone audiometry
  - Speech reception thresholds
  - Word recognition (PB word lists)
  - Uncomfortable loudness level (UCL), i.e., loudness discomfort level (LDL)


Raymond Carhart

Audiology in the 1950s and 1960s: Equipment

- GSI 162 Speech Audiometer
- GSI E800 Bekesy Audiometer
- Early Maico Audiometer

Best Practices in Audiology: An Update is Long Overdue

<table>
<thead>
<tr>
<th>Procedure</th>
<th>% performing procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure tone audiometry: air conduction</td>
<td>100%</td>
</tr>
<tr>
<td>Pure tone audiometry: bone conduction</td>
<td>100%</td>
</tr>
<tr>
<td>Word recognition</td>
<td>95%</td>
</tr>
<tr>
<td>Speech reception threshold</td>
<td>91%</td>
</tr>
<tr>
<td>UCL (LDL) for speech</td>
<td>83%</td>
</tr>
<tr>
<td>Tympanometry</td>
<td>45%</td>
</tr>
<tr>
<td>UCL (LDL) for tones</td>
<td>45%</td>
</tr>
<tr>
<td>Acoustic reflexes</td>
<td>20%</td>
</tr>
<tr>
<td>Otoacoustic emissions (OAEs)</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: The Hearing Journal, December, 2002
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Best Practice is Evidence-Based Practice (EBP)

- "Those who fall in love with practice without science are like a sailor who steers a ship without a rudder or compass, and who can never be certain whither he is going."
- Leonardo Da Vinci (1452-1519)

Categories for Strength of Evidence used in Developing Clinical Guidelines

- Grade I: Evidence is strong and usually obtained from randomized controlled trials or well-designed clinical studies.
- Grade II: Evidence is from clinical studies that were based on retrospective data analysis, clinical trials that were not randomized and/or carefully-controlled, or from panel consensus based on existing guidelines and practice patterns.
- Grade III: Evidence is secondary in that it is based on current or long-standing practice without substantial supporting basic or clinical data.

Evidence-Based Practice: Categories of Research Evidence (ASHA, 2004)

- 1a: Well-designed meta-analysis of randomized controlled trials
- 1b: Well-designed randomized controlled trials
- 2a: Well-designed controlled studies without randomization
- 2b: Well-designed quasi-experimental studies
- 3: Well-designed non-experimental studies, i.e., correlational and case studies
- 4: Expert committee reports, consensus conferences and clinical experience

Evidence-Based Practice:
Focusing on the Goal, Not the Process

Identification
- Screening
- History
- Self-Referral
- Professional referral
Evidence-Based Practice: Focusing on the Goal, Not the Process

Identification → Diagnosis
- Screening
- History
- Self-Referral
- Professional referral
- Hearing loss
- ANSD
- APD
- Tinnitus
- Vestibular disorder

Evidence-Based Practice: Focusing on the Goal, Not the Process

Identification → Diagnosis → Intervention
- Hearing loss
- ANSD
- APD
- Tinnitus
- Vestibular disorder
- Hearing aids
- Aural Rehab
- Counseling
- Cochlear implant (s)
- Vestibular rehab
- Drugs
- Surgery

Evidence-Based Practice: Categories of Research Evidence (ASHA, 2004)

Identification → Diagnosis → Intervention → Outcome
- Hearing loss
- ANSD
- APD
- Tinnitus
- Vestibular disorder
- Hearing aids
- Aural Rehab
- Counseling
- Cochlear implant (s)
- Vestibular rehab
- Drugs
- Surgery
- Effective communication
- Efficient communication
- Academic success
- Quality of life

Evidence-Based Practice is Standard of Care: Definitions of Standard of Care
- Consistent with local, regional or national clinical practice
- Follows guidelines or recommendations on clinical practice approved by national multi-disciplinary professional committees or panels, e.g., Joint Committee on Infant Hearing
- Follows guidelines or recommendations on clinical practice approved by national professional organizations, e.g., AAA or ASHA
- Is consistent with statements of
  - Scope of Practice
  - Code of Ethics
- Is in compliance with Federal guidelines for clinical practice and services, e.g., Joint Committee on Accreditation of Healthcare Organizations (JCAHO)

Best Practices in Audiology: Specific Sources for Practice Guidelines (Standard of Care in the USA)
- Guidelines for different clinical practices, e.g.,
  - Diagnostic audiometry in adults
  - Pediatric diagnostic audiology
  - Hearing aids and amplification
  - Auditory processing disorders (APD) assessment and management
  - Tinnitus assessment and management
- Selected sources of guidelines
  - V.A. guidelines by Joint Commission (Audiology Today)
  - Tinnitus guidelines (www.audiology.org)
  - Joint Committee on Infant Hearing (JCIH) 2007 Statement
  - Guidelines for auditory processing disorders. AAA (2010)
  - Guidelines for otoacoustic emissions (OAEs). AAA (in progress)
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The Concept of Value Added Tests (VATs):
Fundamental Criteria for Inclusion in a Test Battery

- Value added tests (VATs)
  - Procedure adds value to the description of auditory status for the patient, including information that is:
    - Not available from other procedures,
    - Obtained quicker than with another procedure
    - Useful in managing the patient
    - Contributes to better outcome for the patient
- OAEs are an example of a VAT
- Some traditional test procedures do not invariably add value, e.g.,
  - SRT
  - Bone conduction pure tone audiometry
  - Word recognition in quiet at 40 dB SL

A Modern Diagnostic Audiologic Test Battery

In the order of testing for new patients. Test time 30 minutes - 1 hour.

- Objective measures
  - Otoacoustic emissions (OAEs)
  - Aural immittance measures
    - Tympanometry
    - Acoustic reflexes (crossed vs. uncrossed conditions)
- Behavioral measures
  - Pure tone audiometry (automated technique as appropriate)
    - Inter-octave frequencies (e.g., 3000 and 6000 Hz)
    - High frequency (> 8000 Hz) audiometry as indicated
    - Bone conduction measurement as indicated
  - Speech audiometry
    - SRT as indicated
    - Word recognition with recorded materials (10 most difficult words first)
    - Screen auditory processing as indicated

We Hear with Our Brain! Efficient Sensitive and Specific Assessment of the Central Auditory Nervous System
Procedures for Central Auditory Assessment (As Indicated)

- Behavioral measures
  - Speech-in-noise tests
  - Distorted speech tests
  - Dichotic listening tests
  - Temporal processing and sequencing tests
  - Spatial hearing tests
  - Screening measures for phonological awareness skills

- Objective measures
  - Auditory brainstem response:
    - Non-speech
    - Speech signals
  - Cortical auditory evoked response (speech and non-speech signals)
    - Auditory middle latency response
    - Auditory latency response (N1, P2)
    - Auditory P300 response

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Aural Immittance (Impedance) in the 1940s: Otto Metz (1905-1995)

A Simple System for Categorizing Tympanograms

James Jerger
"Father of Diagnostic Audiology"
Observed Impedance Measurements in 1960 in Denmark

GSI 1720 "Impedance Bridge"
Clinical Guidelines for Diagnosis of Infant Hearing Loss (0 to 6 months): Year 2007 JCIH Position Statement

- Child and family history
- Otoacoustic emissions
- ABR during initial evaluation to confirm type, degree & configuration of hearing loss
- Acoustic immittance measures (including acoustic reflexes) using high frequency (1000 Hz) probe tone
- Supplemental procedures (insufficient evidence to use of procedures as "sole measure of auditory status in newborn and infant populations")
  - Auditory steady state response (ASSR)
  - Acoustic middle ear reflexes for infants < 4 months
  - Broad band reflectance
- Behavioral response audiometry (if feasible)
- Parental report of auditory & visual behaviors
- Screening of infant’s communication milestones

Low (226 Hz) versus High (1000 Hz) Probe Tone for Infant Tympanometry

Wideband Power Reflectance for Assessment of Middle Ear Dysfunction (Case of Otitis Media)

Acoustic Stapedial Reflex (Anatomy adapted from Borg)

Plotting the Results of Acoustic Reflex Measurements

- Abnormal Acoustic Reflex
- Vertical pattern
  - Mild conductive hearing loss pattern or efferent (7th CN) pattern (normal tympan and no air bone gap) on right ear

Acoustic reflex patterns ("faces")
- Conductive/efferent pattern
- Sensory pattern
- Neural pattern
- Brainstem pattern

Crossed (contralateral)
  - Sound in ear
  - Right
  - Left

Uncrossed (ipsilateral)
  - Probe and sound in ear
  - Right
  - Left

Plotting the Results of Acoustic Reflex Measurements
Plotting the Results of Acoustic Reflex Measurements

- **Abnormal Acoustic Reflex**
- **Inverted "L" pattern**
  - Moderate or severe conductive hearing loss on right ear

- **Contralateral (Crossed)**
  - Sound Right
  - Probe Left

- **Ipsilateral (Uncrossed)**
  - Sound Right
  - Probe Right

---

**Diagonal pattern**

- **Severe sensory hearing loss or 8th nerve auditory dysfunction on right ear**

- **Contralateral (Crossed)**
  - Sound Right
  - Probe Left

- **Ipsilateral (Uncrossed)**
  - Sound Left
  - Probe Left

---

**Horizontal pattern**

- **Brainstem auditory dysfunction**

- **Contralateral (Crossed)**
  - Sound Right
  - Probe Left

- **Ipsilateral (Uncrossed)**
  - Sound Right
  - Probe Right

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**Estimation of Hearing Sensitivity with Acoustic Reflex Thresholds with Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)**

- **ART in dB HL**
- **Hearing Loss in dB HL**

- **BBN**
- **Pure tone signal**

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**Linkage between Diagnostic Procedures and Intervention Outcome: Aural Immittance Measurement**

- **Diagnostic information**
  - Differentiation of middle ear versus sensory auditory dysfunction
  - Objective confirmation of sensory hearing loss (acoustic reflexes)
  - Objective evidence of retrocochlear auditory dysfunction (acoustic reflexes)
  - Objective evidence of central auditory nervous system dysfunction (acoustic reflexes)

- **Impact on Intervention Outcome**
  - Prompt medical management of middle ear disorder
  - Cost effective and lower risk decisions regarding further diagnostic test procedures (e.g., ABR under anesthesia)
  - Timely referral for otologic consultation and MRI referral
  - Timely referral for APD assessment or neurological consultation

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Recording OAEs: Relevant Anatomy and Physiology

- Outer hair cell motility
- Prestin motor protein
- Stereocilia
  - Motion
  - Stiffness
- Tectorial membrane
- Basilar membrane mechanics
  - Dynamic interaction with outer hair cells
- Stria vascularis
- Middle ear propagation in and out
- External ear canal
  - Stimulus presentation
  - OAE detection

Best Practices in Audiology: Evidence-Based Clinical Applications of OAEs in Pediatric Populations

- **Pediatric Applications**
  - Infant hearing screening
  - Diagnosis of auditory dysfunction in infants and young children
  - Identification of auditory neuropathy spectrum disorder
  - Monitoring ototoxicity
  - Pre-school/school screenings
  - Identification of false and exaggerated hearing loss

Best Practices in Audiology: Evidence-Based Clinical Applications of OAEs in Adult Populations

- **Sensitive measure of middle ear status**
- **Sensitive and specific measure of auditory dysfunction in noise/music exposure**
- Diagnosis of false or exaggerated hearing loss
- Cochlear versus retrocochlear dysfunction
- Assessment of tinnitus & hyperacusis
- Auditory processing disorders (r/o cochlear deficit)
- Industrial hearing screening and conservation

OAEs in Early Detection of Outer Hair Cell Dysfunction

- Normal OHC (OAEs)
- Abnormal OHC (OAEs)

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Linkage between Diagnostic Procedures and Intervention Outcome: Otoacoustic Emissions (OAEs)

- **Diagnostic information**
  - Early detection of cochlear (outer hair cell) dysfunction
  - Objective confirmation of sensory auditory dysfunction in infants
  - Frequency specific details on cochlear dysfunction
- **Impact on Intervention Outcome**
  - Preventative steps for persons at risk for noise/music hearing loss
  - Effective and appropriate management of false or exaggerated loss
  - Effective and appropriate management of tinnitus
  - Early intervention for permanent sensory hearing loss in infants
  - Early intervention for ANSD
  - Decision to include FM technology in management of APD
Year 2007 Joint Committee on Infant Hearing (JCIH): Protocol for Evaluation for Hearing Loss In Infants from Birth to 6 months

- Child and family history
- Evaluation of risk factors for congenital hearing loss
- Parental report of infant’s responses to sound
- "Clinical observation of infant’s auditory behavior. Behavioral observation alone is not adequate for determining whether hearing loss is present in this age group, and is not adequate for the fitting of amplification devices."
- Audiological assessment
  - Auditory brainstem response (ABR)
    - Click-evoked ABR with rarefaction and condensation single-polarity stimulation if there are risk factors for auditory neuropathy
    - Frequency-specific ABR with air-conduction tone bursts
    - Bone-conduction stimulation (as indicated)
  - Otoacoustic emissions (distortion product or transient OAEs)
  - Tympanometry with 1000 Hz probe tone
  - Supplemental procedures, e.g.,
    - Electrocochleography (ECochG)
    - Auditory steady state response (ASSR)
    - Acoustic reflex measurement (for 1000 Hz probe tone)

Diagnostic Value of the Click-Evoked ABR: Differentiation Among Types of Auditory Dysfunction

<table>
<thead>
<tr>
<th>Normal</th>
<th>Conductive</th>
<th>Sensory</th>
<th>Neural</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Graph showing latency in ms]</td>
<td>[Graph showing V/I ratios]</td>
<td>[Graph showing V/I ratios]</td>
<td>[Graph showing V/I ratios]</td>
</tr>
</tbody>
</table>

Limitation of Click-Evoked ABR: Lack of Frequency-Specificity

- Normal click ABR
- Abnormal or no click ABR

Goal of Early Diagnosis of Infant Hearing Loss: Estimation of Auditory Thresholds for Initial Hearing Aid Fitting

- Noise threshold
- Speech threshold
- Average hearing threshold
- Unaided SPL-Gram
- Fitting range
Frequency-Specific ABR Test Protocol: Stimulus Parameters and Research Needs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Selection</th>
<th>Rationale/Research Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transducer</td>
<td>ER-3A inserts</td>
<td>Numerous infant advantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accurate in-ear SPL verification</td>
</tr>
<tr>
<td>Type</td>
<td>Tone bursts</td>
<td>Available on all systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clinical trials of chirp stimuli</td>
</tr>
<tr>
<td>Ramping (window)</td>
<td>Blackman</td>
<td>Less spectral splatter</td>
</tr>
<tr>
<td>Frequencies</td>
<td>1, 5, 2 K Hz</td>
<td>Sequence varies clinically</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High frequency option (&gt; 4000Hz)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normative data for infants</td>
</tr>
<tr>
<td>Duration</td>
<td>2-0-2 cycles</td>
<td>Abrupt onset frequencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equivalent intensity for each frequency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 plateau &lt; spectral splatter</td>
</tr>
</tbody>
</table>

Frequency-Specific ABR Test Protocol: Acquisition Parameters and Research Needs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Selection</th>
<th>Rationale/Research Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artifact reject</td>
<td>On</td>
<td>Minimize muscle artifact</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weighted averaging of all data</td>
</tr>
<tr>
<td>Analysis time</td>
<td>20 ms</td>
<td>Encompass delayed wave V and SN10 after wave V</td>
</tr>
<tr>
<td>Sweeps</td>
<td>1000 or 2000</td>
<td>Produce adequate SNR</td>
</tr>
<tr>
<td>Reliability</td>
<td>2 or 3 runs</td>
<td>&quot;if it doesn’t replicate, you must investigate&quot;</td>
</tr>
</tbody>
</table>

FREQUENCY-SPECIFIC AUDITORY BRAINSTEM RESPONSE (ABR): Relation to Audiogram (Oates & Stapells, 1998)

Correction Factors for Converting ABR Thresholds in dB nHL to Estimated Behavioral Thresholds in dB HL (or EHL)

<table>
<thead>
<tr>
<th>Source</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCEHP</td>
<td>-15 dB</td>
<td>-10 dB</td>
<td>-5 dB</td>
<td>0 dB</td>
</tr>
<tr>
<td>Bagatto (2006)</td>
<td>-20 dB</td>
<td>-15 dB</td>
<td>-10 dB</td>
<td>-5 dB</td>
</tr>
<tr>
<td>Hall (2007)</td>
<td>-15 dB</td>
<td>-10 dB</td>
<td>-10 dB</td>
<td>-10 dB</td>
</tr>
</tbody>
</table>

Steps in Accurate Estimation of Auditory Thresholds

- With ABR system, obtain average normal behavioral thresholds (from 3 to 5 normal hearing adults) for click and each tone burst signal
- Minimally click plus 500, 1000, 2000, and 4000 Hz
- Calculate "dial" reading that is equivalent to 0 dB nHL
- With ABR system
- In typical test environment (s)
- ABR thresholds in dB nHL are not equal to pure tone hearing thresholds in dB HL
- Subtract 10 dB from ABR threshold to estimate auditory threshold (dB HL)
- Plot estimated auditory thresholds on "tone burst ABR audiogram"
**Best Practices in Audiology: What About Chirp Stimuli for Auditory Threshold Estimation with ABR?**

- What are chirp stimuli?
- What is the clinical advantage of chirp stimuli versus traditional stimuli?
- Examples of chirp evoked ABRs and clinical advantages
- Evidence in support of clinical advantages of chirps
- Remaining question about chirp evoked ABR ... are they appropriate also for patients with moderate to severe hearing loss

**Chirp Stimuli in ABR Measurement: Promising So Far Yet Questions Remain**

**Cochlear Excitation Patterns for Click versus Narrow Band Stimulation**

- Continuous, narrow band stimuli
- Transient, broad band stimuli

**Temporal Compensation via Input Compensation**

(Courtesy of Claus Elberling)

**Chirp Temporal Waveform**

- Low frequencies
- High frequencies

**peRETSPLs:**

- CE-Chirp Octave Bands vs. Tone Bursts

- ISO 389-6: 2-1-2 Tone Burst
- peRETSPLs (blue = tone bursts)
- 3A Insert Earphones using 711 ear simulator
- Range of 0.4 to 1.8 dB difference

Conventional Click versus CE Chirp Evoked ABR
(1 year 4 month old boy with speech & language delay who failed hearing screening in nursery. Parents do not speak English)

85 dB nHL Click, rarefaction, 21.1/sec
I = 1.46 ms
V = 6.67 ms
I-V = 5.21 ms

45 dB nHL Click
25 dB nHL Click
20 dB nHL Click
20 dB nHL CE Chirp
15 dB nHL Click
15 dB nHL CE Chirp

4000 Hz Chirp Evoked ABR
Stimulus rate = 37.7/sec
Total sweeps = 2622; Total test time = 69.5 seconds

Right Ear
80 dB nHL
684 sweeps
60 dB nHL
405 sweeps
20 dB nHL
512 sweeps
10 dB nHL
512 sweeps

2000 Hz Chirp Evoked ABR
Stimulus rate = 37.7/sec
Total sweeps = 2318; Total test time = 61 seconds

Right Ear
85 dB nHL, Tone Burst
722 sweeps
35 dB nHL
570 sweeps
25 dB nHL
456 sweeps
15 dB nHL
512 sweeps

4000 Hz Conventional versus Chirp Evoked ABR

Left Ear
50 dB nHL, Tone Burst
50 dB nHL
50 dB nHL
50 dB nHL
50 dB nHL
50 dB nHL
50 dB nHL

Electrophysiologic Estimation of the Audiogram:
One year 4 month boy

<table>
<thead>
<tr>
<th>Frequency in Hz</th>
<th>1K</th>
<th>2K</th>
<th>3K</th>
<th>4K</th>
<th>6K</th>
<th>8K</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 dB HL</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>40 dB HL</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>30 dB HL</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>20 dB HL</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>10 dB HL</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
</tbody>
</table>

Right Ear
Frequency in Hz
PT
ABR
ASSR

Left Ear
Frequency in Hz

Acoustic Spectrum:
CE-Chirp Octave Bands vs. Tone Bursts

Air-Conduction Calibration CE-Chirp Octave Bands (lined) and 3.1 kHz Tone Bursts (shaded)

Courtesy of East Carolina University
Adults: CE-Chirp Amplitudes

- Wave V amplitudes were significantly greater at 60, 40, 20 dB nHL.
- Greater amplitudes are consistent with previously published research.


Adults: CE-Chirp Octave Bands

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    - Auditory steady state response (ASSR)
    - Acoustic reflex measurement (for 1000 Hz probe tone)

Clinical Measurement and Applications of Bone Conduction ABR: Selected Research Evidence

- Stuart A, Yang EY & Green WB (1994). Neonatal brainstem responses to air- and bone-conduction clicks: 0 to 96 hours postpartum. JAAA, 6, 163-172
Bone Conduction Auditory Brainstem Response
(Case: 6 year old girl with Treacher Collins syndrome and bilateral aural atresia. Previous diagnosis: Probable left "dead ear")

Anatomy of the Skull in Infants:
An Advantage in Ear Specific Bone Conduction ABR

Maturation of Bone Conduction ABR:
Increased Inter-Aural Attention in Infants

- Conclusion: Bone conduction stimulation up to 30 dB nHL in infants will activate only the ipsilateral cochlea

Two-Channel Bone Conduction ABR Recording:
Applying ECOG Principles to Verify the Test Ear

ABR: Protocol for Bone Conduction

- B-70 or B-71 bone vibrator
- Mastoid placement
  - 10 dB increase in intensity
  - Less electrical interference with recording electrodes
- Leave insert earphones in ear canals after air conduction ABR
- Increased distance between inverting electrode and transducer
- Alternating click stimuli to minimize stimulus artifact
- Slower rate (e.g., 11.1/sec) as needed to enhance wave I
- 30 to 3000 Hz (low frequencies enhance response amplitude)
- Begin near maximum intensity level (about 50 dB nHL)
- Identify wave I in ipsilateral array to verify test ear
- Plot latency/intensity function for wave V for BC vs. AC

Bone Conduction:
Effect of Transducer Factors
Bone Conduction: Head Band Placement for Infants

Posterior Placement Away from Electrodes

Adjusting the Head Band for Infants

Clinical Measurement and Applications of Bone Conduction ABR: Click or Tone Burst Bone Conduction Stimulation

- Rationale for click only
  - Air conduction tone burst information is most useful
  - Test time is unacceptably lengthy with addition of tone burst bone conduction recordings
  - Confident identification of ABR is more likely with click versus tone burst stimulation
  - Provides information needed for management decisions

- Rationale for tone burst stimulation
  - Consistent with protocol for behavioral audiometry
  - Click stimulation may underestimate conductive component
    - Only estimates air-bone gap in the high frequency region
    - Conductive hearing loss is usually greatest in low frequency region

Example of Estimation of Air-Bone Gap with ABR
Clinical Measurement and Applications of Bone Conduction ABR: Standard of Care in Diagnostic Assessment of Infants and Young Children

- Conclusions
  - Bone conduction ABR is an essential component of the test battery for infants and young children
  - Test results are generally optimal in infants
  - Adhere to a specific bone conduction test protocol
  - Click evoked bone conduction ABR is usually adequate to differentiate sensory versus conductive or mixed hearing loss

Best Practices in Audiology

- Our old and worn out audiologic test battery
- Defining "best practices" and "standard of care"
- The concept of value added tests (VATs)
- Modern diagnostic audiology and audiologic rehabilitation
  - Aural immittance measures are still valuable
  - OAEs add value to audiologic assessment
  - Early infant hearing loss diagnosis and intervention (EHDI)
  - Identification of auditory processing deficits
  - Rehabilitative technology and techniques

AAA Clinical Guidelines on Auditory Processing Disorders (www.audiology.org)

Risk Factors for APD in Children

- Neurological dysfunction and disorders (physicians), e.g.,
  - Neonatal risk factors (e.g., asphyxia, CMV)
  - Head injury
  - Seizure disorders
- Chronic otitis media in preschool years (otolaryngologists)
- Language disorders resistant to treatment (speech pathologists)
- Older siblings with APD (parents, teachers)
- Academic underachievement or failure (pre-school and Head Start teachers, classroom teachers, and educational psychologists)
- Poor listeners (pre-school and Head Start teachers, classroom teachers, and educational psychologists)
- Family history of academic underachievement (parents)
- Co-existing disorders (multiple professionals)

Auditory Processing Disorders in Adults: Etiologies

- Aging of the central auditory nervous system
- Longstanding evidence
- Recent findings
- Combined peripheral and central auditory disorders
  - Central auditory dysfunction with progressive peripheral hearing loss
  - Peripheral hearing loss with progressive central auditory dysfunction
- Dementia and psychiatric Neuropathological disorders, e.g.,
  - Neoplasms
  - Cardiovascular disease
  - Dementias (Alzheimer’s dementia)
  - Schizophrenias?
  - Parkinson’s Disease
- Traumatic head injury
  - Motor vehicle accidents
  - Gunshot wounds
  - Military blasts and explosions

Auditory Processing Disorders in Adults: Risk Factors and Clinical Indications

- Medical history (etiologies in previous slide)
- Audiological history
  - Communication complaints greater than expected by audiogram
  - Deterioration in communication abilities with stable audiogram
  - Unusually poor benefit from amplification
- Audiological findings
  - Abnormality for crossed versus uncrossed acoustic reflexes
  - Speech audiometry
    - Very poor speech perception
  - Rollover on PI PB functions
  - Problems with speech in noise
  - Slow response time and processing speed
  - Poor benefit from amplification
Consequences of Late Identification of Auditory Processing Disorders (APD)

- **Children**
  - Reading failure
  - Academic failure
  - Psychosocial problems
  - May require long-term remediation

- **Adults**
  - Unemployment
  - Under employment
  - Psychosocial problems
  - Incorrect diagnosis, e.g., Dementia
  - Mismanagement
  - Poor quality of life

Assessment of APD: Peripheral Test Battery (< 20 minutes)

- Otoacoustic emissions (OAEs)
  - Diagnostic protocol, e.g.,
    - 500 to 8000 Hz
    - ≥ 5 frequencies per octave
  - OAEs are abnormal in 35% of children undergoing APD assessment

- Aural immittance measures
  - Tympanometry
  - Acoustic reflexes
    - crossed vs. uncrossed conditions for peripheral and CNS

- Pure tone audiometry
  - Inter-octave frequencies (e.g., 3000 and 6000 Hz)
  - High frequency (> 8000 Hz) audiometry (as indicated)

- Speech audiometry
  - Word recognition with recorded materials (10 most difficult words first)

APD ASSESSMENT:
Behavioral Test Battery for Auditory Processes (1)
(ASHA, 2005; AAA, 2010)

- Auditory Discrimination Tests: Assess ability to differentiate similar acoustic stimuli that differ in frequency, intensity, and/or temporal parameters, e.g.,
  - Difference limens for frequency, intensity, and duration
  - Psychophysical tuning curves
  - Phoneme discrimination

- Auditory Temporal Processing and Patterning Tests: Assess ability to analyze acoustic events over time, e.g.,
  - Sequencing and patterns
  - Gap detection (Gaps in Noise, DIN, test)
  - Forward and backward masking

- Dichotic Speech Tests: Assess ability to separate (i.e., binaural separation) or integrate (i.e., binaural integration) disparate auditory stimuli presented to each ear simultaneously, e.g.,
  - Dichotic CVs
  - Dichotic digits
  - Dichotic words
  - Dichotic sentence identification

APD ASSESSMENT:
Behavioral Test Battery for Auditory Processes (2)
(ASHA, 2005; AAA, 2009)

- Monaural Low-Redundancy Speech Tests: Assess recognition of degraded speech stimuli presented to one ear at a
  - Performance-intensity PI-PB functions
  - Speech-in-noise or speech-in-competition
    - Synthetic sentence identification with ipsilateral competing message (SSI-ICM)
    - Listening in Spatialized Noise-Sentences (LiSN-S)
    - Hearing In Noise Test (HINT)
  - Speech In Noise (SIN or QuickSIN) test

- Binaural Interaction Tests: Assess binaural (i.e., diotic) processes dependent on intensity or time differences of acoustic stimuli, e.g.,
  - Localization & lateralization (e.g., LiSN-S)

Linkage between Diagnostic Procedures and Intervention Outcome

Measures of Auditory Processing

- Diagnostic information
  - Identification of central auditory nervous system dysfunction
  - Differentiation among types of auditory processing deficits

- Impact on Intervention Outcome
  - Timely referrals for
    - Comprehensive APD assessment
    - Speech-language consultation
    - Neurological consultation
    - Neuro-psychological consultation

- Implementation of treatment, including:
  - Auditory training, e.g., Earbobics or LACE (Listening and Communication Enhancement)
  - FM technology
  - Amplification

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Best Practices in Audiology: Application of Current Hearing Aid Technology in Rehabilitation

Best Practices in Audiology: Electroacoustic Evaluation of Hearing Aid Technology in Rehabilitation

Best Practices in Audiology: Application of FM Technology in Rehabilitation

Best Practices in Audiology: Bone Anchored Implant Technology and Rehabilitation

Cochlear Implants

Bone Anchored Hearing Devices

Best Practices in Audiology: Cochlear Implant Technology with Standard of Care Rehabilitation

Best Practices in Audiology: Auditory and Cognitive Training in Rehabilitation
Best Practices in Audiology: Conclusions

- Technology exists for efficient sensitive and specific diagnosis of peripheral and central auditory dysfunction
- Guidelines for best practices in audiology
  - Identification of hearing loss
  - Diagnosis of hearing loss and other related dysfunction
  - Rehabilitation of hearing loss
- We have technology for medical and non-medical rehabilitation of hearing loss and auditory processing disorders
- The final measure of evidence-based practice is enhanced and optimal patient outcome

Best Practices in Audiology: Thank You! … Questions?

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