Back to Basics: Pediatric Audiology

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Back to Basics Webinar Series

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Diagnostic Audiologic Evaluation of Infants and Children

Christine Yoshinaga-Itano, Ph.D. & Sandra Gabbard, Ph.D. University of Colorado, Boulder, UCD-HSC

Practice guidelines

• Audiologic guidelines for the assessment of hearing in infants and young children: American Academy of Audiology August 2012
  

• Mona M. Dworsack-Dodge, Au.D.
• Judith Gravel, Ph.D.1 until her death 12/08
• Alison M. Grimes, AuD
• Lisa Hunter, Ph.D.
• Karen Johnson, Ph.D.
• Marilyn Neault, Ph.D.
• Jack Roush, Ph.D
• Yvonne Sininger, Ph.D.
• Anne Marie Tharpe, Ph.D.
• Wende Yellin, Ph.D., Chair
2011 National CDC EHDI Data

Source: CDC EHDI Hearing Screening and Follow-up Survey (HSFS)
www.cdc.gov/ncbddd/hearingloss/ehdi-data.html

Hearing Loss, 8.6%
No Hearing Loss, 48.3%
In Process, 2.7%
Died / Declined, 3.4%
Non-resident / Moved, 1.7%
LFU/LTD, 35.3%

Documented Diagnostic Status of Infants Not Passing Hearing Screening (U.S., 2011) Total Not Pass = 59,161

Documented Intervention Status of Infants with Hearing Loss (U.S., 2011) Total w. Hearing Loss = 5,170
Infants w. Documented Hearing Loss
Total = 28,698 (2005 – 11)

- Goal “ear specific assessment” to identify unilateral loss
- Frequency specific stimuli - to fit amplification
- ABR threshold estimation “attempted down to 20 dB nHL”
- “normal range” 20-30 dB for behavioral assessment of infants

Practice guidelines:
Amplification
- American Academy of Audiology amplification guidelines: infant/toddler
Audiological Evaluation
JCIH 2007

- Infants who have not passed the newborn screen “should receive follow-up audiological and medical evaluations with fitting of amplification devices, as appropriate, at no later than 3 months of age”
- All evaluations “should be performed by audiologists experienced in pediatric hearing assessment”
- Assessment “must include physiologic measures and, when developmentally appropriate, behavioral methods”

Audiological Evaluation
JCIH 2007

“Requires a test battery of audiological test procedures to assess the integrity of the auditory system in each ear, to estimate hearing sensitivity across the speech frequency range, to determine the type of hearing loss, to establish a baseline for further monitoring and to provide information needed to initiate amplification device fitting.”

Questions to be Answered for diagnosis
- Degree of loss
- Configuration of loss
- Type of loss
- Difference between ears
- Status of middle ears
Question to be answered for amplification fit

- Frequency specific thresholds in both ears, minimally 1 high frequency and 1 low frequency, typically 500 and 2000 Hz.

Optimizing the Audiologic Assessment Visit

- Appointment scheduled before discharge
- Appointment made at 1-2 weeks of age
- Advance Instructions to parents
  - Importance of visit
  - Sleep deprivation
  - Feed onsite
- Refer to EI when loss is identified but details (degree and type) are still being assessed

Audiological Evaluation Birth to 6 Months of Age JCIH 2007

- Child and family history
- Tympanometry using 1000 Hz probe tone
- Evoked OAEs (TEOAE &/or DPOAE)
- Click ABR with condensation and rarefaction clicks
- Frequency specific ABR, A/C & B/C
- Behavioral observation
Click response by age

- Decrease in latencies in first 12-14 months of life
- I, III, V most distinct until 3 months of age
- Need to use age norms

Advantages of Clicks

- Broad frequency bandwidth
- Abrupt, rapid onset results in identifiable wave forms
- Normative data used to provide information about latency that assists in determining type of loss & degree of loss

Disadvantages of Clicks

- Broad frequency bandwidth—not frequency specific, may miss
  - Low frequency losses
  - Losses centered at about 2K
  - High freq losses
- Need good neural synchrony
- May take time away from frequency specific testing
Click ABR Can Miss Hearing Loss

Stapells & Oates (1997)

Auditory neuropathy/auditory dyssynchrony

- Auditory neuropathy Spectrum Disorder (ANSD): if there is no ABR response to 2000 Hz by AC at the limits of the equipment, or if all ASSR thresholds are not within normal limits, an assessment for ANSD should be initiated.
- Using a high level (80 dB nHL) click stimulus in each of the two single polarities (rarefaction, condensation), record ABR, and plot two responses on top of each other, inspecting the waveform for cochlear microphonic (Starr et al., 2001) Repeat in opposite ear.

Auditory neuropathy/auditory dyssynchrony

- If CM is present, and the ABR waveform is poorly developed or absent, results may indicate ANSD and further threshold measures with ABR or ASSR should be discontinued.
- To distinguish CM from stimulus artifact, conduct one additional average with the earphone tubing clamped or disconnected. The CM should disappear. If not, it is probably stimulus artifact. If not done previously, conduct an OAE assessment.
Relationship Between Toneburst ABR and Behavioral


Tone Burst Threshold Detection
- 500 Hz 15-30 dB
- 1000 Hz 20-25 dB
- 2000 Hz 5-10 dB
- 4000 Hz 10-15 dB

VanderWerff et al. (2009) found that correction factors of 5 dB, 0 dB and -10 dB for 500, 2000 & 4000 Hz suggested by Stapells, 2000 produced excellent prediction of thresholds.

Bone Conduction ABR
- Mastoid placement of oscillator
- Head band versus hand held position
- Alternating clicks
- Time window-15 msec
- Maximum stimulus output=50-55 dB nHL
- Masking if ears are asymmetric
- Lower frequency spectrum than A/C Clicks
- Longer wave V latency than A/C Clicks
**Why Bone Conduction ABR?**

- Not necessary if click & tones are normal
- Latency-intensity function unreliable for diagnosis of conductive versus sensorineural hearing loss
- Management will be influenced by presence of air-bone gap
- BC ASSR is not recommended
- No age corrected norms ABR BC

**Air-bone gap**

- No correction for BC ABR 500 to 2000 Hz
- At 500 Hz only air-bone gaps that exceed 15-20 dB should be considered clinically significant for ME involvement in infants.
- Air-bone gap of about 15 dB is expected for uncorrected 500 Hz ABRs in an infant without ME involvement (VanderWerff et al., 2009)
BC attachment

- Attach with velcro or elastic band
- Coupling force of 400 to 500g recommended (latencies significantly longer and amplitudes smaller at lower force levels)

Latency-intensity function for diagnosing site-of-lesion?

**Conductive hearing loss**  Stapells et al (1985)

Latency-intensity function for diagnosing site-of-lesion?

**High Frequency Sensori-neural Hearing Loss**

Stapells et al (1985)
Issues in Infant ABR Assessment

- The ABR is NOT a hearing test!!
- Age Norms
- Limited test time
- Sedation beginning at 4-6 months of age: avoid unnecessary sedation when possible
- The closer to threshold the stimulus, the more responses need to be averaged.
- Appropriate stimulus
- Appropriate interpretation

Sedation

- May be necessary by 4-6 months of age to help improve SNR
- Need policies & procedures in place
- Propofol + mix of other drugs commonly used
- Medical support necessary before, during and after!

Clinical Application of Auditory Steady State Response (ASSR)

- Estimate threshold range
- Frequency specific for audiometric configuration
- Objective automated results
- Differentiate severe/profound HL (CI Candidacy)
ASSR Response

Estimated Audiogram
Range varies by trials

ASSR and Behavioral Thresholds

- In general, ASSR thresholds are within 10 dB of behavioral thresholds but differs by carrier frequency and test duration (Dimitrijevic et al., 2002 and Small & Stapells, 2006)
- Largest discrepancies when hearing is normal
- Best correlated for severe to profound hearing losses
- Differences greatest in the low frequencies

ASSR Summary: Part 1

- Frequency & amplitude modulated continuous tones
- Response amplitudes are smaller at lower stimulus intensities and will likely require longer test time
- Different frequency stimuli presented simultaneously or in sequence
- Vary intensity to estimate lowest present response
- Objective analysis of composite of responses
- High intensity stimulation possible (120 dB nHL)
ASSR Summary: Part 2

- Closer agreement to behavioral thresholds with high frequencies
- Closer agreement to behavioral thresholds for moderate-severe degrees of hearing loss
- Equipment available that can access clicks, tone bursts & ASSR

The Auditory Steady State Response Part I & II

Journal of American Academy of Audiology
Special Issue 13 (4 & 5), 2002

ASSR versus Behavioral Thresholds Case #1

- 22 mo old female
- Failed NBHS left
- Dx click ABR at 5 wks, 20 mo
  - Normal hearing (20 dB) AD
  - Moderate HL (55 dB) AS
- Fit unilateral HA, Speech/Language delays, HA rejected
- ASSR at 27 mo confirmed HL bilaterally
- Fit HAs, Speech/Language improved, HA not rejected
Case #1

ASSR versus Behavioral Thresholds - Case #2

- 1 mo old female
- Failed NBHS bilaterally
- Dx click/tone burst ABR at 2 wks
  - Severe-profound HL (NR 90 dB)
- ASSR at 1 mo confirmed profound HL
- Fit bilateral HA at 2 mo
- CI at 14 mo, awareness of sound

Case #2
Behavioral observations

• Can be used as an observation of global auditory development in newborns and infants under 6 months

Why Behavioral Observations and behavioral testing when possible?

▶ Behavioral responses represent true hearing
▶ Permits observation of infants auditory development
▶ Demonstrates auditory behaviors to parents and caregivers
▶ “Cross check” of physiologic measures
▶ Behavioral Thresholds confirm audiometric configuration
▶ BT Confirms conductive component
▶ BT Confirms threshold predictions
▶ BT begins at about 6-7 months

Behavioral Observations (0 to 6 months)

Auditory Behavior Index (Northern and Downs, Hearing in Children)
Recommendation for Behavioral Observations for newborn

- Use age appropriate techniques and use child’s developmental level.
- Use insert phones when possible.
- Use audiologist in room with child.
- Use quiet distracting toys.
- Use multiple reinforcers to keep attention.
- Use a variety of interesting stimuli.
- Always include as part of test battery!!!

VISUAL REINFORCEMENT AUDIOMETRY

- Those with developmental delays might require classical conditioning
- The VRA task is a 90 degree head turn.
- If response to the auditory stimulus alone is not elicited, the transducer should be changed to a bone vibrator and a low frequency signal (e.g. 250 Hz) or speech should be presented at a level known to provide tactile stimulation (e.g. 50 dB HL)
NEW FRONTIER IN BEHAVIORAL ASSESSMENT: VISUAL REINFORCEMENT INFANT SPEECH DISCRIMINATION (VRISD)

VRISD

• Why?
  – Purpose
    • Pre-linguistic infants – HAs & Cis – immediately after fitting/mapping
    • Any spoken language
  – Stimuli
    • /a/-/i/, /a/-/u/, /i/-/u/
    • /ba/-/da/, /pa/-/ka/ (place)
    • /ta/-/da/ (voicing)
    • /sa/-/sha/ (HF)

Stimuli

• Theoretically can be almost any paired contrast

• Must be ‘short’ duration – no phrases or sentences

• Synthetic vs. recorded live voice
Our Stimuli

- Recorded live voice (female)
- 500 ms duration
- 1200ms ISI
- Contrasts: a/u  u/i
  a/i  sa/sha

Ling Sounds-
- Representative of speech frequencies
- s and sh are high frequency
- a, i, u representative of vowel space

Oddball Paradigm

a a a a a a i i i a a a a
(background)  (target)
(a background)
------------------------head turn ----------------
Our set-up

- Infant in booth either in booster seat or on parent’s lap
- Assistant (distracter) seated in front of infant – hold infant’s attention midline
- Assistant (and parent) listen to music via headphones (to mask out VRiSD stimuli)

Scoring

- Stopping criteria - binomial probability statistic
- Typically no more than 15 trials
- Correct = headturn when change stimulus, no headturn when no change
- Incorrect = no headturn when change, headturn when no change
Parent Questionnaires

Auditory Skills Checklist – all ages, all degrees of HL
- 35 items – possible 2 points each
- Total points 70 maximum possible
LittlEars – infants- 12 months, severe to profound HL

HTTP://WWW.MARIONDOWNS.COM/OUR-RESEARCH/PEDIATRIC

Parent questionnaire: Auditory Skills Checklist:
Average Scores: Children with Hearing Loss
(Tyberg et al., 2013)
LittlEars: % in normal range
N=80

Hear Lab – Cortical auditory evoked potentials
• ma-ga-ta (low to mid-high frequencies) – across the speech spectrum – FRYE, HearLab
• Week after fitting look for presence/absence P1
• Potential use of CAEP for threshold search for children who cannot be sedated
• Approximately 50% children with AN/AD have P1s (Pearce et al., 2007; Rance et al., 2002; Cardon, 2013, Sharma & Cardon, 2011)
• Teagle, 2013 – gap detection predicts speech discrimination outcomes AN/AD

Barriers to Effective Diagnostic Audiologic Assessment
❖ Poor sensitivity of screening techniques in the identification of mild hearing loss
❖ Financial challenges of families to access appropriate services
❖ Lack of access to appropriate care from a qualified pediatric audiologist
❖ Challenges in differentiating conductive vs mixed vs sensorineural loss
❖ Labels (“mild”, “minimal”, “slight”) which may de-emphasize the effects
Infant Audiologic Assessment Conclusions

- Establish & follow protocol for test battery approach
- Be aware of possible neurologic abnormalities
- Do not discount the contribution of behavioral assessment and monitoring (every 3-6 months)
- Begin amplification process when loss is confirmed even if exact threshold determination is in process
- Once the diagnosis is made, begin intervention immediately!!!
- Skilled early intervention provider can assist in assuring audibility across the speech spectrum

Future Research Questions

- Unique diagnostic test battery?
- Bone conduction norms for ABR & ASSR?
- Effect of SPL in ear canal measurements on electrophysiologic tests in infants?
- Effect of positive CMV?
- CT to identify LVAS?
- Age of first eye exam?
- Effect on educational materials for parents in understanding of diagnosis?
- Multi-disciplinary evaluations at key transitional stages?
- Speech discrimination in noise at earliest possible age

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