Auditory Processing Disorders
The Functional Significance of Diagnostic Tests
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Children, their families, our clinical colleagues
WHAT IS REQUIRED OF A CHILD’S AUDITORY SYSTEM?

Real World Needs

- Recognize familiar sounds quickly
- Learn new sounds
- Tolerate noise and stimulus degradation
- Form auditory objects and position them in space
- Listen to one sound and ignore another
What is Required of the Auditory System?

- Signals must be audible
- Basic acoustic processing (discrimination and resolution) must be good: spectral and temporal clarity
- Binaural hearing must be functioning
- Selective, sustained and focused attention must be good
- Many signals must be well learned and predictable
- Integrity of the auditory nervous system must be intact

Perceptual Development

- Factors
  - Quality of sensory encoding
  - Ability to attend to and explore that encoded information
  - Prior experience and knowledge
  - Environment

- Most easily recognized stimuli are those that are familiar and well learned – why?

Gibson, E.J. 2000
Processes of Perceptual Development

- Neural patterns are reinforced in response to frequently occurring stimuli (imprinting)
  - Allows for rapid perception even with degradation
- Increased control over attention – selective and sustained (attentional weighting)
- When coded with prior knowledge stimuli are strengthened and thus can be degraded (unitization)
- Over time a finer level of detail is perceived (differentiation)

Goldstone, R., 1998

What do pediatric audiologists have to help them?

CURRENT CLINICAL ASSESSMENT BEYOND AUDIBILITY
**Auditory Skills**

- Sound localization and lateralization
- Auditory discrimination
- Auditory pattern recognition
- Temporal resolution, masking, integration, and ordering
- Auditory performance decrements with competing or degraded signals
- Memory and attention

*Asha, 2005*

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**Comprehensive Assessment Recommendations**

- Thorough case history
- Non-standardized but systematic observation of auditory behavior (e.g. checklists)
- Behavioural evaluation of
  - Temporal process (ordering, discrimination, resolution and integration)
  - Binaural processes (localization and lateralization)
  - Perception of low redundancy (filtered, compressed, degraded) and dichotic speech
- Electrophysiologic evaluation
- Speech-language assessment
**Clinical Practice,**
Emanuel et al., 2011, AJA

Of the 195 respondents, # reporting use always or sometimes

**Dichotic**
- SSW - 144
- Digits – 115
- SCAN,CS – 100
- Competing Sentences – 91

**Temporal Processing**
- Pitch Pattern – 138
- Random Gap – 68
- Duration Pattern - 55

**Monaural low redundancy**
- SCAN – AFG 101; FW 104
- Speech in Noise – 132

**Binaural Interaction**
- Binaural Fusion – 38
- MLD – 29

**Electrophysiology**
- ABR – 23
- MLR, Corticals - 13

Our experiences with this battery...

**COGNITION, BRAINSTEM NEURAL INTEGRITY, DISCRIMINATION SKILLS, ETC.**
63 Children Referred for APD Evaluation

Behavioral
- Staggered Spondaic Word Test (SSW)
- Auditory Fusion Test – Revised, a test of gap detection
- Filtered Words
- Pitch Pattern Sequence Test
- Competing Words (words in noise)

APD = 2 tests > 2 sd below expectations

Objective
- Click evoked ABR at slow and fast rates
- Acoustic Reflex Thresholds, ipsi and contra 500-2kHz

Also
- Surveys
- Cognitive Evaluation (Intelligence, academic achievement, language, phonology, memory, attention)

Basis Auditory Abilities

23 Children with no APD diagnosis
40 Children with APD diagnosis

2000 4000 8000

Quiet Word Discrimination Score

Right Ear Left Ear

40 children met APD criteria
23 did not
APD Test Results

Staggered Spondaic Word Test

Auditory Fusion Test - Revised

Other Central Auditory Tests

RELATION TO COGNITIVE SKILLS
RELATION TO OBJECTIVE MEASURES – BRAINSTEM NEURAL INTEGRITY

Click ABR Wave Latencies: APD & Non-APD

Left ear

Right ear
Wave I Latencies
APD & Non-APD

Wave V latencies
APD & Non-APD
V/I Amplitude Ratio
APD & Non-APD

Wave V amplitude
Wave I amplitude

Acoustic Reflexes
APD & Non-APD

Reflex Threshold
Ipsi-Contra Threshold Differences
APD & Non-APD

RELATION TO SUPRA-THRESHOLD DISCRIMINATION
Frequency & Level Discrimination
APD & Non-APD

Maxon & Hochberg (1982)
Jensen & Neff (1993)
He, Dubno & Mills (1998)

Temporal Resolution
APD & Non-APD

Irwin, Ball, Kay, Stillman, & Rosser (1985)
Fitzgibbons & Wightman (1982)
Spectral Resolution
APD & Non-APD

Threshold (dB SPL)

Age (years)

Flat
Notched

Veloso, Hall, & Grose (1990)
Hall & Grose (1991)

Masking Level Difference
APD & Non-APD

Thresholds

MLD

S\textsubscript{0}N\textsubscript{0} - S\textsubscript{0}N\textsubscript{0} (dB)

Age (Years)
Other projects using this diagnostic criterion

TYPICALLY DEVELOPING CHILDREN AND THOSE WITH APD

Speech Evoked ABR /ya/ with Rising and Falling Intonation
Follow Up: Acoustic Reflexes Growth Functions

Factors causing shallower ARGF

a. Decreased static compliance

b. Retrocochlear, brainstem pathology

Shallower Growth in Contralateral Reflexes for Children with APD

\[
\text{ARGF ratio} = \frac{\text{Ipsilateral ARGF's slope}}{\text{Contralateral ARGF's slope}}
\]

- Normal hearing adults
- Normal hearing children
- Children with APD
Inhibition of OAEs

Butler et al., IJA, 2011

Temporal Integration at Threshold

Children with APD

Adults & Typically developing children

Butler et al., IJA, 2011
Summary and final comments

REFLECTIONS ON OUR DIAGNOSTIC BATTERY

How Useful is a Diagnosis of APD Made Based Upon This Conventional Battery?

• Results only loosely related to the skills/abilities important to perceptual development.
• Co-morbidity with other disorders is going to be high.
• Underlying auditory neural integrity is often compromised, both with and without the diagnosis.
• Basic encoding abilities and often reduced, with and without the diagnosis.