Auditory processing disorders: Beyond the audiogram

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The scenario: A school-aged child presents with the following:

- Difficulty hearing/listening in the presence of background noise
- Inconsistency in responding to auditory information
- Difficulty following auditory information presented at a "typical" rate
- Seems to be a long standing issue (parent says that they have noticed these behaviors, too, since preschool years)
- "Subtle yet significant"

From an audiologist's perspective, a range of potential explanations/etiologies

- Unilateral hearing loss
- Sensorineural hearing loss
  - Mild
  - High frequency
- Fluctuant conductive hearing loss
- A range of non-audiologic issues:
  - Attention
  - Cognitive impairment
  - Learning disabilities

From an audiologist's perspective, a range of potential explanations/etiologies

- A philosophical decision presents
- Obviously, this child needs to have audiometric testing to assess hearing status
  - How many children who were screened at school have a hearing loss that was missed?
  - Screening protocol, screening environment, or frequency of screening (specific grades screened)
- At that point, is assessment complete if the audiogram is "normal"?

This presentation focuses on…

- School aged children who present with "normal hearing" by audiogram
- The role of the audiologist in addressing both hearing and listening in children
- Assessment and management opportunities
- Idea is to "whet your whistle" when it comes to APD, tying this into our "pediatric week" and to challenge you to consider the role of audiologist in assessing hearing and listening skills

Role of hearing/listening in the life of the child

- Hearing is assumed and often overlooked…if that's true for hearing, even more true for listening, which is more subtle and complex
- Hearing/listening skills are scaffold for other types of information processing (language, attention, pragmatics, etc.)

Some thoughts to frame this presentation:

- Disorder of the auditory system, on the same continuum as hearing loss
- Complex issues: Can separate APD from other related disorders and also identify areas of overlap
- Recognize that these disorders often have a subtle presentation
- Environmental variation: Often present as typical in optimal listening environments, which does not address school
- Low incidence disorder

A basic premise: Bottom up and top down

Bottom up:

- How information is carried from ear to brain
- Peripheral hearing loss impacts information available for person to "work on" with "top down" skills
- The audiologist

- Top down
  - How information is acted on once it gets to the brain
  - The "filing cabinet" for auditory information
    - Organization, retrieval, categorization of auditory information
  - The speech/language pathologist

The concept of redundancy: Internal vs. external

- Intrinsic or internal redundancy: Built into the auditory system (both peripheral and central)…multiple representations and complex network
  - Certainly can be impacted by disorder of auditory system, such as tumor, demylinating disease, head injury, etc.

The concept of redundancy: Internal vs. external

- Historical view is "site of lesion" however we know that both auditory development and auditory disorder ("cerebral morphologic abnormalities") are involved in auditory processing abilities in children
- Why can't these issues be located on imaging studies?
  - Cellular level communication?
  - Type of imaging studies…evidence of differences in techniques like fMRI not present in previous imaging studies

The concept of redundancy: Internal vs. external

- Extrinsic or external redundancy: Built into the signal (syntax, morphology, semantics, etc) which enhance comprehension of the signal
  - Can be impacted by issues such as cognitive impairment (e.g. reduced cognitive abilities) or environmental issues (e.g. presence of background noise, etc).

Some thoughts to frame this presentation:

- Requires an interdisciplinary assessment
- Just as with any other auditory disorder, there's no "cure" at this point
- Clinical significance and statistical significance are not synonymous
- Current and future knowledge of auditory development and psychoacoustics will likely change the face of APD assessment and the ability to link to management issues
- This knowledge will come from a evidence based approach

Listening in children: Beyond the audiogram

- Considerations in auditory development
  - Central auditory nervous system skills continue to develop into adolescence
  - Improvement in listening in noisy environments continues to develop through about age 13
  - Increases in mylination of the corpus callosum through the late teens
- Issues of developmental psychoacoustics
  - Children have wider critical bands
  - Poorer listeners in less than optimal environments than adults
  - Comparing developing to disordered systems
  - WHAT IS THE ROLE OF THE AUDIOLOGIST?

Considerations and biases

- Audiologists "own" the auditory system
- Not every audiologist needs to assess APD…however, every audiologist needs to know about how to screen and facilitate appropriate referrals
  - Back to key points:
    - Low incidence population
    - Audiologists "owning" the auditory system and being "essential"
    - The "ear-bowel" connection
- The "audience"
  - APD diagnosis related to the educational setting
  - APD diagnosis as part of a "medical model"

One definition of APD based on a philosophical construct

- APD results from impaired neural function and is characterized by poor recognition, discrimination, separation, grouping, localization, or ordering of *non-speech sounds*. It does not solely result from a deficit in general attention, language or other cognitive processes
  - British Society of Audiology website

Auditory Processing Disorders Defined (perhaps more functional):

A breakdown in auditory abilities resulting in diminished learning (e.g. comprehension) through hearing, even though though *peripheral hearing sensitivity* is normal

Some excerpts related to this from the AAA Clinical Practice Guidelines (2010)

- APD is "…associated with a number of behavioral manifestations and a variety of symptoms, some of which may be quite subtle."
- "The processing of auditory information within the (CANS) is…complex, involving both serial and parallel processing within the auditory structures of the CANS itself, as well as shared processing with other sensory and/or higher order brain structures and systems (e.g. language, attention, and executive control)

- Based on this…
  - ◆Behaviors, symptoms, and levels of impairment observed in individuals with auditory processing disorders are "quite diverse" and heterogeneous (AAA, 2010)
  - ◆Brain is not compartmentalized, so significant interaction between auditory areas and areas responsible for other types of issues in the brain

Generalizations of behavior and expectations about site of lesion

- As idiosyncratic as the individuals they affect
- Most do not have origins identifiable at the structural level (rare)
- Brains are individualized and whether APD is developmental or acquired, CANS pathology does not respect functional neurological boundaries
  - » Phillips, 2002

Auditory Processing and the Impact on Language Impairment

- Early descriptions of auditory perceptual difficulties
  - Impairment in phoneme recognition and discrimination
  - Defective capacity for storing speech message
  - Impairment in processing speech at “normal” rates

Prevalence of APD

- 2-5% of school aged children estimated to have APD (Chermak and Musiek, 2007)
- Etiology not clear
  - True also for learning disabilities, attention deficit disorder, and other types of issues that can impact learning in children
    - Delay in development
    - Disorder of the central auditory nervous system
    - “Cerebral morphologic abnormalities (CMA)”--issues of wiring
    - Contrast with learning style

ASSESSMENT OF APD

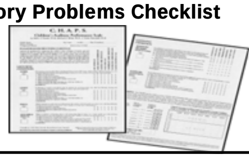
Assessment begins at time of request for appointment

- CHILD SPECIFIC
- In call to set up appointment, establish the following:
  - Age of the child (most literature suggests age 7 is earliest age for formal APD assessment)
    - Value of earlier assessment if parent has concerns—role of the audiologist
    - Tremendous variability in listening behavior for younger children
      - Auditory system development issues
      - Developmental vs. disordered?

- In call to set up appointment, establish the following:
  - Cognitive ability of the child
    - Criteria of normal cognitive abilities
    - Diagnosis of ASD (autism spectrum disorder)
    - Performance/verbal split
    - Criteria for learning disabilities (scatter)
    - Language bias of IQ testing
    - Referral source

Functional behaviors

- Note that for the most part, the types of questions that arise in children are NOT site of lesion but functional
- Requires "authentic assessment"
  - Children's Auditory Performance Scale (CHAPs) (Educational Audiology Association…edaud.org)
  - Screening Inventory for Targeting Educational Risk (SIFTER) (edaud.org)
  - Fishers Auditory Problems Checklist



Critical point

- The audiogram does not tell the entire story
- HOWEVER, whenever APD is suspected, an audiologic evaluation MUST be performed first
- Speech in noise difficulties must also be addressed
  - BKB-SIN test (for children) available from Etymotic Research
  - QSIN, HINT, SPIN for adults

Test materials available for behavioral APD assessment

- A significant number of tests available
- Normative data…psychometrically sound
- Building a test battery…based on skill areas?
- Linguistic loading—varying linguistic demands addresses a number of concerns in assessment
- No cookbook

Considerations

- Although this is an disorder that requires interdisciplinary input, it should be noted that speech/language, psychological, or other tests cannot be used to diagnose APD, even if they have the words "auditory" or "auditory processing" in their title (AAA, 2010)
  - Level of "control" needed
    - Test environment
    - Stimulus control
    - Test parameters

Controversy to provide context

- Is auditory processing different from language processing?
- Need to vary "linguistic loading" when possible on tasks…example is dichotic listening.
  - Consonant-Vowel (CV), digits, words, sentences (binaural separation or binaural integration tasks)

Newer APD assessment options

- SCAN-III
  - Pearson Publishing
  - Update of current SCAN with addition of tests, screening vs. diagnostic portions, and developing new normative data
- LiSN-S
  - Listening in Spatialized Noise—Sentences Test
  - Available from Phonak
  - Speech in noise OR APD?
  - Strong to determine issues with listening in background noise
  - Easy to administer

Newer auditory processing test options

- Multiple Auditory Processing Assessment (MAPA)
  - Available from Auditec of St. Louis
  - Developed to identify auditory processing disorders for children age 8 through adults
  - Includes 5 different subtests
  - Uses auditory skills in 3 of the "ASHA domains"
    - Monaural low redundancy
    - Auditory Pattern Temporal Ordering
    - Binaural integration/binaural separation (BIBS)

Newer auditory processing test options

- Gaps in Noise (GIN) test (Musiek et al, 2005)
  - Based on psychoacoustic literature for gap detection (so similar to the British model)
  - Advantages of low cognitive demands, ease of administration
  - Early maturation of temporal maturation, appropriate for children age 7 or older

The special case of young children

- Auditory Skills Assessment (ASA)
  - Available from Pearson
  - Ages 3:6-6:11
    - Speech discrimination
    - Phonological Awareness
    - No speech processing
    - Speech discrimination in noise
    - Mimicry

Electrophysiologic assessment

- Pro:
  - By-passes language processing
  - Specific focus on the auditory system (no issues with motivation)
  - May be unique measure of system and improvement
- Con:
  - Lacks functional link--speculative
  - "Disease model"
  - May not be specific enough to address issues on the "cellular level"
  - Cost/benefit

Selection of Auditory Electrophysiological Procedures (AAA, 2010)

- Limitations of availability of equipment (multichannel recording); may only be available in laboratory settings
- Define clinical situations where there are clear indicators for auditory evoked response tests, including
  - Behavioral assessment fails to demonstrate clear pattern of deficits
  - Neurologic disorder is suspected
  - Site of lesion assessment

Questions of value of electrophysiology in the "functional listening skill world"?

- Biological Marker of Auditory Processing: BioMARK or BioMAP
  - http://www.soc.northwestern.edu/brainvolts/projects/documents/BioMARK_9.8.08.pdf
  - Speech syllables used to assess "neurological processing of sound" with brainstem evoked responses
  - Can monitor progress with aural rehabilitation

Linking assessment to management

Linking assessment to rehabilitation and management

- Environmental modifications
- Compensatory strategies
- Direct intervention

Environmental modifications

Focus on noise and signal-to-noise ratio

- How does noise effect a listener's perception of speech?
  - Noise has a detrimental effect on the perception of consonants
  - Consonants "carry the meaning of speech"
  - Decreasing consonant perception decreases overall speech intelligibility, decreasing the meaning of communication for the listener

- Clearly, the acoustical conditions in a given listening environment can present a challenge for any listener
- Most remarkable for those with an auditory disorder, including the continuum of both peripheral and central hearing losses

A common suggestion: Preferential seating as a solution

- Inexpensive
- Easy
- Face validity (reducing distance between the speaker and listener's ear)
- However: Leavitt and Flexer, 1991 indicate that the only true preferential seat is 6" away from the speaker's mouth

Sound-field amplification

- Not to be a substitute for acoustical treatment (often proposed as this due to cost)
- Very beneficial if the major issue in the room is ambient noise
- Can also offset effect of distance
- Not effective if the issue is reverberation…in some cases can make it worse for children not close to a speaker (Boothroyd, 2004)

Sound-field options

- Option of FM or Infrared:
  - Depends on the space, the needs, etc.
- Front Row to go
  - http://www.gofrontrow.com/
- Lightspeed
  - http://www.lightspeed-tek.com/
- Audio Enhancement
  - http://www.audioenhancement.com/
- Supportive Hearing Systems (Simeon)
  - http://fmhearing.com

New option: Phonak Dynamic Soundfield

http://www.phonak.com/com/b2b/en/products/more_products/soundfield/dynamic_soundfield.html

Personal FM

- The most effective way to enhance and optimize the speech audibility index (SAI) for a child with a hearing loss of any variety—peripheral or central (Boothroyd, 2004)
- Can increase the signal-to-noise ratio up to +15 dB for child farthest from the teacher—reduces issues of proximity and noise

New technology outpacing the life of older technology (or what's so special about this next new thing?)

- iSense has Phonak's Dynamic FM platform
  - iSense adapts volume automatically - based on the level of background noise
  - iSense's output stays within safe limits – at all times

Direct therapeutic approaches

Direct therapy approaches

- A number available
- Controversies and overgeneralizations
- The "promise" of psychoacoustic approaches
  - May drive both assessment and management
  - Dichotic listening approach described by Moncrieff

Listening/auditory training

- Recent evidence supports the impact of training on neural plasticity and in turn on functional auditory behaviors.
- Phillips (2003) points out changes in the auditory cortex, representing the neuroplasticity of the system, as a result of behavioral training, have been well documented in animal models.
- Thompson (2000) describes how treatment/therapy enhances the "representational plasticity" of the CANS, resulting in the ability to engage new neural networks post-treatment.

Listening training

- Some of the best evidence for changes in auditory function related to environmental changes and experiences are from both children and adults that have received cochlear implants.
- Improvements in communicative behaviors following implantation appear to be positively influenced by the rate of plastic changes in central auditory pathways (Sharma et al., 2004).

Direct treatment approaches: What's new?

- Key words: Adaptive and challenging
- Capitalize on neuroplasticity
- Aural rehab. Programs
  - Speech in Noise
    - LACE (available from Neurotone.com)
  - Dichotic listening
    - DIID
    - ARIA

Approaches that incorporate research on plasticity

- Newer approaches that provide direction for APD training/habilitation/rehabilitation
  - Moncrieff: Dichotic listening skills: ARIA
  - Musiek: Dichotic interaural intensity difference (DIID) training
  - Sweetow, LACE
  - Jirsa, P-300 research; Kraus, BioMARK research

Dichotic listening training

- Dichotic interaural intensity difference training (DIID)
- Building less dominant ear…promising in ear dominant deficits
- Similar protocol with more data to be commercially available soon from Moncrief

LACE

- Listening and Communication Enhancement (LACE) program (developed by Robert Sweetow, Ph.D, distributed by Neurotone http://www.neurotone.com/)
  - Developed to address listening deficits in adults with peripheral hearing loss

Compensation strategies

Modifications of listening environment

- Develop understanding of strengths and weaknesses in terms of listening and learning
- Encourage use of visual cues or other multisensory cues that provide benefit
- Assist in recognizing “easy” and “difficult” listening situations

Other modifications of listening environment

- Speaker strategy development:
  - Impact of rate of speech on comprehension
  - Understand signal-to-noise-ratio and facilitate ways to enhance it
- Use of visual and other modality cues

Rephrasing/repeating

- Repetition is good but only if acoustically better presentation than the first presentation (how does one do that…reduce distance, increase the volume…allows listener to be able to fill in missing information)

Rephrasing/repeating

- Rephrasing: Can be used if information is added that will clarify the original misunderstanding (e.g. vocabulary not familiar to the listener)

Friel-Patti, Finitzo, Freeman, 1993

- Comprehension is dually the responsibility of the listener and the speaker
- When failure occurs, it is as much the responsibility of the speaker as the listener
  - Rate
  - Pausing
  - Phrasing
  - Prosody
  - Increasing Predictability

Communication can be influenced by the speaker

- "Clear speech" Series of seminal papers that address the impact of speakers rate, mode, etc. on listener comprehension
  - Where basic science and clinical practice come together
  - See references for specifics, however basic principles are related to Friel-Patti, etc.

Some compensatory approaches:

- Teacher strategy development (or how audiology becomes essential):
  - Impact of rate of speech on comprehension
  - Understand signal-to-noise-ratio and facilitate ways to enhance it
  - Concept of "clear speech": tenants that contribute to effectively presenting oral information
- The role of the speaker in communication/comprehension
  - The "evangelical" model
  - The "lunch menu" man
- Auditory fatigue
- Use of visual and other modality cues
- Assist child in recognizing "easy" and "difficult" listening situations

Conclusions

Conclusions

- Audiology opportunities to work with adults with auditory processing issues, either those with "normal" audiograms or those that have peripheral hearing loss
- Meets a significant need and makes audiology "essential" to that patient's care
- Particularly for those patients with normal hearing acuity, they are often the ones that most want assistance

Mistaken belief that APD is something new or vogue

- Mykelbust defined CAPD in 1954
- Filtered word testing used as site of lesion assessment in adults beginning in the 1950's
- Dichotic listening protocols used clinically in patients with temporal lobe lesions beginning in the early 1960's (Kimura, 1961)

Final thoughts

- **"The reality of CAPD can no longer be doubted. It is a distinct entity across the entire age range. It appears to derive from at least two analogies of auditory perception--loss in the ability to separate auditory foreground from auditory background and failure of the fine temporal resolution necessary to the analysis of speech…" (Jerger, 1998)**

When we, as audiologists, move beyond the audiogram, we can meet the needs of patients and their families and contribute to the development and success for that child!

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