Exploring the Evaluation Process for (Central) Auditory Processing Disorders

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Objectives
- Defining and Understanding APD
- Simulations
- Neurophysiologic Bases and Etiology of Auditory Processing
- Evaluation and Diagnosis of Auditory Processing
- Personal Research related to commonly used evaluation/screening tools
- Management of Auditory Processing

What Is an Auditory Processing Disorder???

- APD simulation exercise (following directions)
  - You can practice this yourself by googling
  - “Experience Auditory Processing Disorder for yourself”
- 2. Ladle Rat Rotten Hut
- 3. Goldilocks and the Three Bears.... (next slide)

APD (Decoding deficit)
- One open a chime, dare were tree pears who rivved in a widdle golch. Sunday when eating feckers, the bapa pear said “My marbridge is too hot”. The nana pear said “My marbridge is too old”, and the baby pear said “Yes but my marbridge is chuck light”

(Tillery, 1998)

ASHA (2005)
- Difficulty in perceptual processing of auditory information in the CNS as demonstrated by poor performance in one or more of the following skills
- AAA (2010)
- Building upon ASHA’s definition...
- British Society of Audiology:
  - Poor perception of both speech and non-speech sounds
  - Origin in neural function
  - A collection of symptoms that usually co-occurs with other neurodevelopmental disorders
Despite several consensus and position statements, disagreement abounds over what constitutes an APD. These issues may well be just matters of arbitrary definition, incapable of resolution by any scientific experiment, though in the fullness of time, some definitions will likely be found to be more helpful than others” – Dillon et. al, 2012 (p 98)

**Etiology of APD**
- Neurodevelopmental disorder
- Acquired/neurologic injury
- Risk factors?
  - Chronic OM
  - Genetics
  - Pregnancy/labor/delivery complications
  - Lead/CO exposure

**So is it or is it not a “Brain” Disorder?**
- YES! There is evidence for a neurobiologic basis!
  - Atypical electrophysiologic representations
    - BioMARK (Speech evoked ABR)
    - Corpus callosum / interhemispheric transfer
    - Brain imaging during dichotic listening

**Modality Specificity**
- Can APD be a truly AUDITORY ONLY disorder?
- Looking to show that APD may co-exist with but is not the result of dysfunction in other modalities

**Common Complaints/Symptoms**
- Delayed language development
- Phonologic/reading disorders
- Difficulty following multistep directions
- Poor auditory memory
- Poor auditory organization/sequencing
- Difficulty in noisy environments

**Academic Manifestations of APD**
- Poor expressive and receptive language abilities
- Poor reading, writing, and spelling
- Poor phonics and speech sound discrimination
- Difficulty taking notes
- Difficulty learning foreign languages
- Weak short-term memory
- Behavioral, psychological, and/or social problems resulting from poor language understanding and poor academic skills.
When Are Referrals Typically Made?

- 1st Grade: When children are not learning letter-sound correspondence
- 4th Grade: When reading, writing, and lecture become more advanced and less contextual (no pictures)
- 7th Grade: When reading and writing become less narrative (1st person).

(Bellis)

So how do we as clinicians best approach APD?

- Team based approach is best
- Screening first
  - Establish problem
  - Rule out contraindications
- Test battery approach to evaluation
  - Clinical decision analysis
- Diagnosis
- Individualized management

Questionnaires

Prior to Scheduling an Evaluation

- Obtain a detailed case history
  - More than standard case history
  - Interview parents on the phone
  - Find out parents’ goals for the evaluation

Prior to Scheduling an Evaluation

- Obtain other prior evaluation reports
  - Cognitive-Psychology
  - Speech-Language
  - IEP
- Rule out contraindications to testing
- Utilize screening questionnaires to determine need for evaluation and/or areas of difficulty
APD Screening Tools

- Screening tools help decide need for evaluation
- Several tools available
  - Screening Instrument for Targeting Educational Risk (SIFTER)
  - Fisher’s Auditory Checklist
  - Children’s Auditory Performance Scale (CHAPS)
  - Auditory Processing Domains Questionnaire (APD-Q)
  - Buffalo Model Questionnaire Revised (BMQ-R)

DILLMAN & STOODY (2013) ASHA

- Individualized
- Valid/reliable
- Efficient
- Verbal and non-verbal
- Age/language appropriate
Other Considerations for the Evaluation

- Treatment for pre-existing conditions
- Building in breaks the right way
- Following the guidelines for age and co-morbid disorders
- Behavioral observations are as important as test item responses

Clinical Decision Analysis

- Mathematical approach to describing the diagnostic utility of a test
  - Tells you likelihood that someone with a disorder will be identified as abnormal by an APD test (sensitivity)
  - Tells you likelihood that someone without a disorder will be identified as abnormal by an APD test (specificity)

Commonly used in determining the ability of retrocochlear measures to accurately detect pathology i.e. tumor vs. no tumor?

Clinical Decision Analysis (cont’d)

- Typically used to validate that an APD test is sensitive to CANS dysfunction by administering the test to individuals with known CANS lesions
- Doesn’t imply that all individuals with APD have identifiable CANS lesions, but does serve as way to confirm the measure is sensitive to the CANS

- Hurley & Musiek 1997
- Singer et al. 1998

Sensitivity and Specificity – Visual Analogy

- Typical positive/negative values
- True positive, true negative, false positive, false negative

Calculating Clinical Decision Analysis Values

<table>
<thead>
<tr>
<th>Test</th>
<th>With Disorder</th>
<th>Without Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>TP = 12</td>
<td>FP = 4</td>
</tr>
<tr>
<td>Negative</td>
<td>FN = 2</td>
<td>TN = 10</td>
</tr>
</tbody>
</table>

Efficiency of a Test Battery

- Clinical Decision Analysis can apply to a test battery
- Questions Clinician should ask:
  - Is battery more sensitive/specific than individual tests?
  - How many tests yield optimal sensitivity/specificity?
  - Which combinations of tests yield optimal sensitivity/specificity?
  - Criteria for diagnosis? (lax vs. strict)
Lax vs. Strict Criteria
- Lax criterion
  - Patient has to fail only one test in the battery
- Strict criterion
  - Patient has to fail all tests in the battery
- As you increase the size of your test battery:
  - Tradeoff:
    - Lax criterion will yield better sensitivity but poorer specificity
    - The strict criterion will yield better specificity but poorer sensitivity

How Many Tests???
- Can’t we use ONE test?

Research on Test Battery Efficiency
- Musiek et al 2011
  - Compared adult controls to adult “gold standard” or individuals with neurologic involvements
  - Normal hearing sensitivity, no interaural asymmetries
  - Tested using dichotic digits, low pass filtered speech, competing sentences, and frequency patterns

Musiek et al. 2011 - lax criterion
- Shows the relationship between the number of tests and sensitivity, specificity, and efficiency.

Musiek et al. 2011 - strict criterion
- Similarly shows the relationship between the number of tests and sensitivity, specificity, and efficiency.

Musiek et al. 2011 - Outcomes
- Does the battery provide improved sensitivity and specificity over using individual tests?
  - Yes, FP-CS battery with a lax criterion provides better sensitivity and efficiency than using any of the four (C)APD tests alone
- How many tests are needed to obtain optimal sensitivity and specificity?
  - For both criteria, best efficiency obtained for two-three test batteries. Four test batteries were negatively impacted by the poor efficiency of the FS test.
Musiek et al. 2011 - Outcomes

- Which test combinations give the best sensitivity and specificity?
- For both criteria, some combination of DD, CS, and FP provided the best CDA values. The highest values were achieved by FP-CS using the lax criterion.
- Should a lax or strict criteria be adopted in determining whether the patient passed or failed the battery?
  - There appears to be a slight advantage to using the lax criterion, though the CDA values for the strict criterion are very similar.

Oh So Many Test Battery Models...

- While we now know about the benefits of clinical decision analysis, and factor analysis, these principles aren't universally used.
- There are currently a few general “models” of APD evaluation that clinicians follow.
  - Minimal Test Battery
  - Buffalo Model
  - Bellis-Ferre

So what do we know so far???

- APD is heterogeneous – so no one test battery approach fits all....
- It is important to test multiple auditory processes – ie create a test battery.
- Test battery efficiency can be calculated if you have a group of individuals with known neurologic deficits.
- Diagnosis can change depending on lax vs. strict criteria.

But what are people in the field REALLY doing?????

And do their diagnostic choices greatly affect their patients’ evaluation outcomes?

APD Diagnostic Practices

- Most commonly used behavioral tests reported for diagnosis of APD:
  - speech recognition in noise (SCAN and Buffalo)
  - competing sentences (SCAN)
  - pitch (frequency) patterns
  - dichotic digits
  - Staggered Spondaic Word Test (Buffalo)
  - duration patterns
  - low-pass filtered speech (SCAN)

APD Test Batteries Used (‘Always’ or ‘Often’)

- Emanuel et al. 2011 “Survey of the Diagnosis and Management of Auditory Processing Disorders”
- APD Test Batteries Used (‘Always’ or ‘Often’):
  - 38% reported using a preset battery regardless of age or case history
  - 80% reported using a set minimum battery for all patients with additions based on individual case history and age
APD Diagnostic Practices

- Individual Tests Used ('Always' or 'Often')
  - Dichotic Listening Tests
  - SSW (Buffalo) 81%
  - Competing Words (SCAN) 55%
  - Competing Sentences (SCAN) 64%
  - Monaural Low Redundancy Tests
  - Filtered Words (SCAN) 67%
  - Auditory Figure Ground (SCAN) 67%
- Across all categories, the most popular tests were the SSW.
- pp. SIN, DD, SCAN, SCAN-C, CII, low pass filtered speech.
- and RGBT.

Our Clinical Protocol (at the time)

- Screening tools:
  - Fisher’s Auditory Problems Checklist, APD-Q, Case History, acquire other outside agency reports.
- Diagnostic tools (Custom Battery):
  - Full hearing evaluation with acoustic reflex threshold testing
  - APD battery, SCAN 3:5, diagnostic protocol, or Buffalo Central Test Battery for some or all
  - TAPS (for temporal sequencing, auditory memory, etc.)
  - ACIP (if attention is a concern)
  - Binaural interaction test (i.e. MLD)
  - Speech-language diagnostic tools performed concurrently
  - Other tools as needed

Methods

- Participants
  - Children ages 7-12
  - All participants had hearing thresholds ≤ 20 dB HL
    - M: 9
    - Female (n = 9)
    - Mean age 9 years
  - Research approved through University of Northern Colorado Institutional Review Board

Research Questions

1. Are the diagnostic outcomes different depending on which test battery is administered? (SCAN vs. BCTB)

2. Are there differences with how well different screening questionnaires predict diagnostic outcomes?

Participants – Children ages 7-12

All participants had hearing thresholds ≤ 20 dB HL

Male (n = 9)
Female (n = 9)
Mean age 9 years
Mean age 8 years

Research approved through University of Northern Colorado Institutional Review Board

Methods

- Screening questionnaires were administered to the parents of the participants prior to evaluation. These questionnaires include:
  - Fisher’s Auditory Problems Checklist
  - Auditory Processing Domains Questionnaire (APDQ)
  - Buffalo Model Questionnaire Revised (BMQ-R)
- Participants were given both the SCAN-3:C and the Buffalo Model Central Test Battery
Test Batteries

- The following subtests were given as part of each test battery:
  - SCAN 3:
    - Filtered Words
    - Auditory Figure Ground (±8 dB SNR)
    - Competing Words Directed Ear
    - Competing Sentences
  - Buffalo Central Test Battery
    - CID W-22 (in Quiet and Noise with +5 dB SNR)
    - Staggered Spondaic Words
    - Phonemic Synthesis Test

Diagnostic Outcomes of the Buffalo Central Test Battery vs. SCAN-3:C

Number of Participants with Disordered Scores Across All Subtests

Percent Agreement Between the APDQ Prediction & Diagnostic Test Outcomes

Percent Agreement Between the BMQ-R Prediction & Diagnostic Test Outcomes

Percent Agreement Between the Fisher's Auditory Checklist Prediction & Diagnostic Test Outcomes
1. Buffalo Central Test Battery and SCAN-3:C do not have similar sensitivity/specificity
- Is SCAN-3:C too specific? Is BCTB too sensitive?
- Confirmation that use of one preset battery or subtest in isolation is probably not best

2. Screening tool outcomes were variable:
- APDQ and BMQ were often in agreement, Fisher’s Auditory Checklist found “concern for APD” less frequently
- Caution should be used if only 1 screening tool is used to assess need for APD evaluation

Future Research
- Replication with larger sample
- Comparison of other analogous clinical tools (dichotic listening tests, auditory sequencing tests, etc.)
- Additional comparison of other questionnaires to test outcomes
  - CHAPS, SIFTER, etc.

Testing the Effect of Presentation Level on the SCAN-3
- Participants
  - Twenty-two young adult females (20-38, M = 22)
  - Twenty-three children (5-11, M = 8)
    - 13 girls, 10 boys

Effects of Presentation Level on the SCAN-3
**Implications?**
- Evaluation results may differ depending on method used to test
- Findings for competing sentences test were robust to different levels while filtered words was most susceptible

**Pulling it all together**
- A child is referred for APD testing so what’s a clinician to do?
- May need to use multiple screening tools, or just avoid them all together
- Using research findings to inform test battery creation
- Create a sensitive/specific/efficient battery

**Spatialized Processing Disorder???
- Another fairly new approach to APD
  - Listening in Spatialized Noise (LiSN) Test
  - Developed by National Acoustics Laboratory
  - Commercially available through Phonak

**Description**
1. Adaptive speech-in-noise-test
2. Target sentences - 0° azimuth initially at 62dB SPL
3. Competing speech - 0° or ±90° azimuth at 55dB SPL
4. 3-D auditory environment under headphones
5. Offers alternative to free-field testing
6. No special hardware required
7. Four LiSN-S conditions

**LiSN-S Research - Spatial Processing Disorder**

**LiSN-S Conditions**
85 participants recruited from NA LISN-S normative data studies.
Retested on LISN-S between 1 and 4 months after initial testing (average 2 months, 2 weeks).
Mean test-retest difference ranged from 0.05 dB to 0.5 dB.
RM ANOVA revealed no significant difference between test and retest (p = 0.307 to 0.974, age categorical variable).
Correlation between test and retest significant for all measures (p = 0.006 to <0.0001; r ranged from 0.3 to 0.6).

Nine children aged 6 to 11 years experiencing listening difficulties in class relative to peers who had no learning or attention disorder (SusAPD group).
Eleven children with confirmed learning or attention disorders (LD group).
Assessed on LISN-S and results compared to 70 age-matched controls.
Assessed with a traditional (C)APD test battery.

LISN-S vs. Traditional Battery (LD Group)

LISN-S vs. Traditional Battery - SusAPD Group

Spatial Advantage
Assessment Done, SPD is Diagnosed, What Next?

Regardless of the evaluation, a diagnosis means nothing without appropriate recommendations/management.

1. Teacher-directed strategies
2. Child-directed strategies
3. Language training
4. Classroom modification (+10 dB SNR)
5. Assistive listening device
6. Training in source discrimination

Auditory Training Research

- Develop deficit-specific remediation for children with a spatial processing deficit.
- Trains children to use binaural cues – i.e. differences in the timing and intensity of signals arriving at the ears from various locations – to attend to a target stimulus and filter distracting auditory signals.
- Used in the home (as well as schools/clinics).
- Provides detailed analysis, reporting and feedback.
- Alternative/adjunct to ALD’s and other management strategies.

LISN & Learn - Computer-based training

- Four games presented on PC over headphones
- Target sentences at 0º azimuth (initially 62 dB SPL)
- Competing stories at ±90º azimuth (55 dB SPL)
- Weighted up-down adaptive procedure used to adjust the signal level of the target
- SRT calculated over 40 sentences
- 131,220 unique sentences can be generated

Spatialized Processing Disorder Summary

- Helps better understand difficulties listening in noise
- Spatialized processing disorder highly related to those who are ‘suspected’ of having APD
- Diagnosed using the LiSN test
- People with SPD may benefit most from FM technology

Management/Intervention for APD

Other Strategies for Managing an Auditory Processing Disorder
Management: Intervention for APD
- Four main components
  - Environmental modification/management
  - Instructional Interventions
  - Therapy and Remediation Techniques
  - Compensatory Strategies
- Should be specific to individual deficits/areas of weakness
  - APD profile?

Accommodate the environment
- Allow for a longer response time
- Maintain a routine
- Write information on the board
- Use a cue word
- Maintain eye contact
- Repeat important information
- Use visual aids
- Encourage questions

- [Kamhi, 2011; Walker et al., 2011; ASHA, 2004a]

Classroom Seating Accommodations for Children with APD
- Preferential Seating:
  - Typically in the front of the class is where he/she will have better visual reception of the area, which is where most teaching takes place.
  - Reduce Background Noise
- Consider Your Distance

Classroom Seating (Continued)
- Children with APD should be seated where they can see the teacher without any difficulties and they are away from any distractions or noise (including highly distractible classmates).
- Being able to see the speaker is critical for the child with virtually any type of APD.
- Do not assume the best seat in the class is always the front row.

Classroom Modifications...
- Reduce external visual and auditory distractions.
- Divide room into smaller learning spaces
  - Bookshelf divider
  - Study corner
- Locate noise sources away from primary instructional areas
  - pets/aquariums
  - Pencil sharpeners
  - Computer printers
- Reduce reverberation
Teaching Strategies: Instructional Intervention

- Obtain visual attention: Face child, obtain eye contact
- Slow down speech
- Make the child responsible for understanding (cue students to look and listen)
- Think before criticizing
- Simplify directions
- Provide additional written or visual material
  - Multisensory instruction
  - Peer notetaker
  - Provide notes/guides ahead of time

Should I Recommend an FM system???

- May benefit the child if there are test results that suggest changes in SNR improve speech recognition

Therapy for APD

- Phonemic awareness training
- Listening comprehension training/story retell
  - Also helps with auditory sequencing
- Following directions training
- Binaural separation or listening in noise training
- Dichotic listening training

Other “therapy” Ideas/Activities

- Simon game – auditory memory and sequencing
- Inter-hemispheric training
  - Musical instruments
  - Martial Arts
- Commercially available materials
  - Earobics
  - Lindamood Bell
  - Fast ForWord
- Mobile Apps!

Compensatory and Metacognitive Strategies

- Active Listening
- Self Advocacy skills
- Teach/model various skills
  - Visualizing
  - Organizational
  - Chunking
  - Auditory rehearsal
- Encourage use of technology
  - FM, note taking system, voice recorder, captioning