31-year-old male  
- Ex United States Marine with significant history of head trauma:  
  - Multiple head injuries during military training  
  - Auto accident involving LOC  
- Diagnoses:  
  - PTSD  
  - ADHD  
  - Depression  
- Medications: Wellbutrin
Primary complaints:
- Difficulty hearing in noise
- "Hearing loss" (i.e., must turn up television, cannot hear on phone)
- Tinnitus in quiet environments
- Headaches (primarily temporal)
- Memory difficulties
- Inaccurate time perception
- Difficulty completing some tasks while hyper-focusing on others
- Reading retention difficulties

- Hyper-vigilance
  - Difficulty controlling anger
  - No music, visual-spatial, or related concerns

Peripheral auditory status within normal limits (audiometry, immittance, OAEs)
Pre-Therapy Corticals

- All other electrophysiologic responses (ABR, MLR, P300) within normal limits
- Impressions: Patient meets AAA (2010) diagnostic criteria for CAPD likely involving primary auditory cortex in left hemisphere affecting binaural separation/integration and auditory closure
- These findings may account, at least in part, for patient’s complaints of “hearing loss” and hearing in noise difficulties

HOWEVER, CAPD is likely not the sole (or even primary) cause of the patient’s difficulties due to attention-related behaviors exhibited during testing and non-auditory sequelae reported
Recommendations

- Environmental accommodations including asking for clarification/repetition, having instructions provided in writing
- Central resource strategies including attribution training

Direct Auditory Training:
- Dichotic Listening Therapy, 30-45 minutes per day, 5-6 days per week, for 6 weeks
- Target ear: right
- Competition ear: left

Post-Therapy Evaluation

- Improvements noted:
  - “Hearing” on phone, television
  - Possible improvement in hearing in noise (had little opportunity to evaluate during previous six weeks)
- Continued complaints re: attention, memory (including remembering stories heard during therapy), headaches, tinnitus, hypervigilance
Post-Therapy CAPD Results

Post-Therapy Corticals

Impressions:
- Significant improvements noted in both behavioral and electrophysiologic central auditory function
- Improvements transferred to untrained skills (i.e., auditory closure)
- Criteria for CAPD no longer met
- Ongoing complaints in higher-order, more global attention, memory, and related functions
Post-Therapy Recommendations

- Medical follow-up for persistent attention-related concerns, particularly as relates to medication management
- Medical follow-up for possible TMJ due to reports of headaches and tinnitus, endorsement of grinding/clenching, and normal peripheral auditory status

Consider additional cognitive re-training activities relative to attention, memory, and related skills, to include psychological follow-up and monitoring

Summary

- Remediation can result in improvement in both behavioral and electrophysiologic central auditory function
- Improvements can generalize to untrained skills
- CAPD can co-exist with other viable diagnoses; auditory intervention may not be sufficient to address all of the patient’s complaints
Therefore, a multidisciplinary approach to diagnosis and intervention of CAPD is critical, especially when co-morbidity of disorders is suspected or known.

Questions?
To ask a question, please type your question into the chat box in the lower left corner of the screen and click on the “Send” button located right below the box.
Jay R. Lucker, EdD

- Associate Professor
  - Dept. of Communication Sciences & Disorders
  - Howard University
  - Washington, DC
- Private Practice Specializing in Auditory Processing Disorders
  - Greater Metro DC Area

From the ASHA Tech Report

- "The audiologist should be sensitive to attributes of the individual. Attributes may include, but not be limited to, language development, motivational level, fatigability, attention, and other cognitive factors; the influence of mental age; cultural influences; native language; and socioeconomic factors."
- ASHA Technical Report on APD

Functional APD (fAPD)

- As a professional specializing in auditory processing I never thought that someone would function as if they had APD but maybe not really have APD
- I have seen more clients that I can count for APD testing
- There are four that stand out as concerns for me questioning do they really have APD or...
- Are the functioning as if they have APD but they do not have APD
Today's Presentation

- To demonstrate the point, the following two cases are presented
- One is an adult
- The other is a young child
- The cases are presented with their APD test data
- Discussion will pursue looking at what this professional identified as likely, underlying reasons that both clients would function as if they had APD problems

Sample Case: 29yo, female

- Brief Hx:
  - I received a call from this woman asking if I did APD testing on adults. She reported that she is visually impaired, uses a guide dog as well as a cane to get around. She said that she has always depended on her hearing to help her because of her vision problem, but noticed, recently, that she cannot understand what she hears.
  - She went to her state office for people with disabilities to request additional disability funding b/c of the additional “hearing loss” she has developed – they required further testing

Sample Case: 29 yo, female

- Brief Hx continued
  - She went to an audiologist and was found to have perfectly normal hearing in both ears
  - Audiologist said that she felt maybe from the woman’s complaints, she might have an auditory processing deficit (APD) but she, the audiologist, did not do APD testing.
  - Woman found me and we set up appointment
- Complaints:
  - Understanding what people say in quiet, worse in noise, gets some words not all the words people say
Sample Case: 29 yo, woman

- Audiological testing (did only pure tones, SRT, and WRS) since she had a complete audiological less than one month prior to my assessment
  - All pure tone results normal
  - SRT normal
  - Loudness tolerance was above 100 to 110dBHL both ears
  - WRS in quiet at 50dBHL = she started missing some words in quiet which is unexpected: results were 72% (RE) and 68% (LE) (Later I re-administered same test different word but at 70dBHL thinking she might need louder signal="too loud make it softer"
  - At 40dBHL results were 96% in each individual ear

- SIN (S/N+5): 50dB speech/45dB noise
  - RE = 40% and LE = 0%
  - Q/N difference = 32% (RE) and 68% (LE) – norms are 17% for each ear
  - If we think her potential is 100% in quiet, these results would be Q/N of 60% (RE) and 100% (LE)

- SCAN-A (before the SCAN-3 was developed)
  - FW: SS = 10  AFG: SS = 8
  - CW: SS = 6  CS: SS = 12
  (100% correct)

Note the differences in SIN and AFG?

Sample Case: 29 yo, woman

- SSW Test:
  - 8CN: 6–0–1–12  8–1–1–9
  - Conditions RNC = 15 (1)  RC = 1 (2)  LC = 2 (4)  LNC = 20 (1)
  - RB:
    - Ear = 0
    - Order = -8 (-2)
    - Type A = 1 (3)
    - Reversals = 10 (1)
    - Delays = 27 (0)

- Dichotic Digits: 100% RE and 90% LE
Sample Case: 29 yo, woman

- Time Compressed Sentences (pre–SCAN–3)
  - 0% Compression practice items = 4 out of 10 sentences correct
  - 40% Compression = 8 correct out of 10
  - 60% Compression = 7 correct out of 10
- Phonemic Synthesis Test (PST)
  - Quantitative score = 18 (23)
  - No qualitative errors
- Auditory Continuous Performance Test (ACPT)
  - Norms only for children up to 11 years – 11 months
  - She made absolutely no errors and no delayed responses

Sample Case: 29 yo, woman

- Behavior Observations During Testing
  - On the WRS testing, she would often incorrectly repeat words and then correct herself – the scores provided are for her initial responses; if we added in the self-corrected responses, her WRS scores would have been 100% correct for each individual ear
  - She was self-correcting her responses such as “Say the word ‘an’.” She said, “arm,” pause, “or is it “am” or “an”?
  - She complained the noise was too distracting but NOT on the AFG of SCAN?

Conclusions

- What do you think?
- Does she have APD?
- What about the unusual behaviors noted?
- Try to recall the case history information – why did she come for today’s testing?
Sample Case: 7y – 11m old, female

Brief Hx:
- A parent contacted me regarding her daughter – almost 8yo – just completed second grade
- Parent said her daughter did not perform well in school and the school tested her only a few months before parent called me and found her daughter ineligible for any special education services (IEP) or accommodations (504 plan)
- Mom said that the outcome from a private (not through the school) OT assessment suggested that her daughter had auditory processing deficits and wanted to provide a listening therapy training

Mom did not want to do the listening therapy if it were not appropriate so she decided to do a comprehensive APD eval and contacted me – we set up the appointment

Mom also provided the school evaluations and the private OT assessment for my review

Here is what these evaluations indicated in summary…

School psychologist
- IQ above the mean (100) in all areas
  - Verbal 110
  - Working Memory 108
  - All subtests above the mean (above 10) Digit Span memory 113 almost 1 SD above the mean
- BASC – 2
  - Teacher all areas normal including behavior, attention, emotional, learning
  - Parent identified normal behavior, attention, problems for emotional (may be anxiety) and learning
Sample Case: 7y – 11m old, female

- Educational (WJ-III Tests of Achievement)
  - All academic areas normal with the lowest scores in the high 90’s (mean = 100) and all of the verbal areas (reading, oral language, comprehension) were above the mean
  - Comments: Had to repeat things to her; she was slow to respond; constantly looked to evaluator to see if her response was “OK”

- Speech-Language
  - Receptive & Expressive Vocabulary above 115 (+1 SD above the mean)
  - CELF-4 overall SS = 111 (near +1 SD above the mean) all scores above the mean
  - Had to repeat items sometimes; slow to answer

Sample Case: 7y – 11m old, female

- Audiological testing
  - ALL pure tone results normal between -5 and 5 dB
  - SRT normal agree with PTA
  - Loudness tolerance was above max: 100 to 110dBHL both ears
  - WRS in quiet at 50dBHL
    - RE quiet = 80%
    - LE quiet = 72%
    - A lot of hesitation before responding - constantly looked to evaluator to see if her responses were “OK”
  - SIN (S/N+5)
    - RE = 80% (Q/N difference = 0%)
    - LE = 84% (Q/N difference = +8% better than quiet)

Sample Case: 7y – 11m old, female

- SIN (S/N+5):  
  - Better noise than quiet performance suggested something odd was going on, so I decided to re-test WRS using a different list of words at a later time in the testing
  - RE & LE 100% in quiet (I did not retest noise)
  - Q/N differences based on this
    - RE = 20% (norm = 22%)
    - LE = 16% (norm 23%)
  - Question I asked myself - why the difference in WRS Quiet results? Why the constant hesitation in responding and why does she always have to look up to me to see if she is correct. I constantly cued her she was doing “great” (thumbs up)
Sample Case: 7y – 11m old, female

- SCAN-3-C
  - FW = 11
  - AFG +8 = 10
  - AFG +12 = 16
  - CW-Free Recall = 10
  - CW-Directed Recall = 11
  - CS = 12
  - TCS = 11
- Ear Advantage = NONE were significant
- Baseline TCS 0% missed three items (practice) had to re-administered encouraging her to "take a guess" I did this AFTER the CS???

Sample Case: 7y – 11m old, female

- SSW Test:
  - 8CN: 0–2–1–1 1–6–3–0
  - Conditions RNC = 0 RC = 5 (9,7) LC = 7 (16, 12) LNC = 2 (4,2)
  - RB:
    - Ear = 6 (10, 6)
    - Order = –4 (–13, –8)
    - Type A = 3 (5)
    - Reversals = 31 (6)
    - Delays = NONE
    - No other RBs

Sample Case: 7y – 11m old, female

- Comprehensive Test of Phonological Processing (CTOPP)
  - Elision = 9
  - Blending Words = 14
  - Blending Nonwords = 13
  - Segmenting Words = 12
  - Segmenting Nonwords = 11
  - Nonword Repetition = 14
  - Memory for Digits = 12
- Auditory Continuous Performance Test (ACPT)
  - Errors of Omission = 0 - 1 - 1 - 1 - 1 - 2 - 1 = 6
  - Errors of Commission = 0 - 0 - 1 - 1 - 2 - 1 = 5
  - Total Errors = 11 (31) + Vigilance = 1 (4)
Sample Case: 7y - 11m old, female

- Behavior Observations During Testing
  - As reported above, she was often hesitant to respond. This was mostly seen on initial tests
  - WRS in quiet, SIN, and during the monaural measures on the SCAN
  - Then, the hesitations were no longer present which is why she had no delayed responses on SSW.
- She was constantly looking to the evaluator for reassurance she was performing “ok”
  - Consistently gave her smiles, looks of “you’re doing fine,” verbal statements like “great work”, thumbs up

Conclusions

- What do you think?
- Does she have APD?
- What about the unusual behaviors noted?
- So, what’s really going on?
- Remember mom’s input on the BASC–2!

Conclusions continued

- I spoke with mom – really her biggest concern is that her daughter does not seem to listen and does not respond when asked questions?
- She always looks to mom for reassurance and I realized I had mom in room with me while I tested so was the girl looking to ME or to her mother
- What would you conclude?
- Does she have APD? Her presenting symptoms all suggest APD!
There may be times when you will see clients who clearly present with symptoms suggesting they have APD.

You need to consider the client’s presenting case history and issues that can affect auditory processing test results having nothing to do with APD itself.

These clients function like they have APD but they do not have APD – only consistent finding for all four subjects I have seen with fAPD is that they all have a large number of SSW reversals.

To ask a question, please type your question into the chat box in the lower left corner of the screen and click on the “Send” button located right below the box.

Jay R. Lucker

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Case Study Presentation

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Introduction

To ensure privacy, the case presented here is not of an actual individual but based on findings one might obtain in a clinic setting.

Background

The tests administered and interpretation of results are based on my conceptualization (model) of how individuals process spoken language.

This model views "Spoken-Language Processing" as the intertwining of auditory processing (bottom-up) with cognitive (e.g., attention, memory, sequencing) and language processing (top-down).

The model is being updated to include speech-reading but this presentation will focus on auditory spoken-language processing.

Thus, the spoken-language processing approach subsumes auditory processing.
Background- cont’d

It is my belief that audiologists possess tools that allow us to better understand why an individual may be breaking down in the everyday processing of speech.

I feel we limit ourselves when we strive to solely examine auditory processing aspects, an approach that does not necessarily allow us to derive a clear picture as to why an individual may be breaking down.

For example, an individual may feel they may not be processing speech as quickly and accurately as his or her peers. We have assessment tools that may allow us to determine why more easily than other professionals.

Spoken-Language Processing Skills That May Be Examined

1. Aspects of Phonological Awareness (awareness of and ability to manipulate syllables/phonemes) and Phonics (sound-symbol associations)
2. Lexical (Word) Decoding Speed
   - speed/accuracy which speech stimuli can be processed, and, in turn, corresponding words activated from long-term memory
3. Short-Term Memory Retention
4. Auditory-Linguistic Integration
   - the ability to combine the suprasegmental information in right hemisphere with the linguistic information in the left hemisphere

Spoken-Language Processing Skills- cont’d

5. Sequencing
6. Temporal Resolution
7. Span of Apprehension (Short-Term Memory Span)
8. Auditory Attention
   - Selective Attention (Figure Ground, Binaural Separation)
   - Divided Attention
   - Sustained Attention/Impulsivity
Background- cont’d

In addition to the medical history, clients are asked to complete a customized spoken-language processing questionnaire that I have developed.

This questionnaire encompasses the client’s (parents’) perception of:
- present processing abilities/difficulties
- social profile (such as attentiveness, frustration, fatigue, anxiety, etc.)
- various compensatory strategies used, and
- present core academic skills (or, if adult, when attended school)

Background- cont’d

Before an individual is seen for an evaluation, the individual must be assessed relative to their cognitive capabilities and basic language skills.

Because a cognitive deficit can cause generalized processing deficits, individuals require a general IQ 85 or greater.

Children’s basic language skills should be within age norms, though I do see children with a language deficit if an SLP requests further information as to what may be underlying/subsequent to their difficulties (usually milder language impairments).

Relative to adults, I not only see individuals relative to suspected processing related issues, but also subsequent to strokes, traumatic injuries, etc.

Client Profile

Background
- Ms. XX is a 52 year old, adult female. Approximately one year prior to being seen for the spoken-language processing evaluation, she experienced a stroke in the left hemisphere (secondary to a low flow rate state via a brain embolism) which significantly impacted her vision, hearing and speech
- Vision has improved over time, as well as her ability to understand speech, though significant processing related difficulties still persist
- Ms. XX was an office manager prior to the stroke but has not yet returned to work
Client Profile - cont’d

Academic Profile

- Ms. XX was an above average student in elementary/high school but exhibited some difficulty in spelling—especially when providing written responses—such as passages/compositions, and worked hard to memorize spelling of words

- She did not have much difficulty following/comprehending teachers but did have much difficulty blocking out noise

Client Profile - cont’d

Communication Profile

- Words having similar sound structure are difficult to distinguish

- Ms. XX relies greatly on context to figure out what has been said and prefers written versus verbally presented information

- Experiences difficulty in the area of word finding/retrieval

- Received speech-language therapy for 9 months prior to the evaluation—diagnosed with a mild-to-moderate receptive/expressive language disorder plus phonemic awareness difficulties

A central auditory processing evaluation was recommended by the SLP to gain more insight into some of the processing-related issues.

Specific Processing Related Issues

Ms. XX often has difficulty with:

- understanding verbal instructions
- responding to questions easily and accurately
- organization and following directions
- mixing up speech sounds

and almost always has difficulty with:

- following speech if someone speaks quickly and prefers that people slow down their rate of presentation
- listening in the presence of background noise
Social Profile

Ms. XX reports that she usually:
- is easily frustrated and fatigued
- needs time to think and respond, and,
- often terminates conversations when she becomes overwhelmed/frustrated

Results

Hearing Assessment
Normal hearing sensitivity and normal middle ear test findings (i.e., normal middle ear mobility and acoustic reflex thresholds).

Spoken-Language Test Findings

Test of Auditory Perceptual Skills-Revised
- Auditory Numbers Forward:
  SS = 59, < 1%ile (4 digits forward vs typical 7 digits)
- Auditory Word Memory:
  SS = 71, 3%ile
- Auditory Sentence Memory:
  SS = 68, 2%ile

The pattern of the findings indicate that Ms. XX performed extremely poorly on all aspects of short-term memory span assessed (be it digits/unrelated words, or sentence stimuli that have much linguistic/contextual redundancy), suggesting a severe spoken-language processing deficit.
Lindamood Auditory Conceptualization Test-3

Ms. XX achieved a standard score of 92 (30%ile), a finding that is within the average range.

Although this result is within average age norms, a further analysis of the results indicates that Ms. XX exhibited difficulty in the subsection involving higher order mental manipulation/representation of speech sounds within (multi) syllabic context—possible subtle sequencing related issue.

Phonemic Synthesis Test

Ms. XX scored 17/25, a score that is significantly greater than 2 SD below the mean.

Upon completion of testing (one week later), I readministered the erred items:
- first via CD again (able to get 1/8 erred items)
- then for remaining erred items, via live voice + speechreading (but at same rate of presentation), able to get 5/7 erred items

Thus, Ms. XX benefited from the additional speech-reading cues. This suggests that Ms. XX’s difficulty on the auditory-only, CD presentation was due to auditory perceptual/processing difficulty rather than due to phonemic synthesis (blending) difficulties.

Note there are many individuals I’ve evaluated who do no better with speech-reading, thus, likely a true phonemic synthesis deficit.

Staggered Spondaic Word (SSW) test

Area of Dysfunction analysis:
The results were analyzed using Jack Katz’s recommended “TEC” scoring protocol. The results revealed the likeliest location of dysfunction to be in the left auditory reception area (Heschl’s Gyrus) and/or the language processing area.
(SSW) test- cont'd

1. Significant Right Non-Competing, Right-Competing, and Left Competing conditions
   - my analysis of the pattern of findings is indicative of lexical-decoding speed difficulty; no evidence of inter-hemispheric transfer difficulty (i.e., right competing was actually somewhat poorer than left competing condition)

2. Order Low/High
   - more errors are present in the second spondee of each item), which is consistent with lexical decoding speed difficulty

3. Three reversals (versus normal limit of one)
   - indicative of some organization/sequencing difficulty

Speech-in-Noise

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Recognition in Quiet</td>
<td>96%</td>
<td>92%</td>
</tr>
<tr>
<td>Word Recognition in Noise</td>
<td>48%</td>
<td>80%</td>
</tr>
<tr>
<td>Difference Score</td>
<td>48%</td>
<td>12%</td>
</tr>
<tr>
<td>Significant</td>
<td>Yes (&gt; 5 SD)</td>
<td>WNL</td>
</tr>
</tbody>
</table>

Competing Sentences Test

Ms. XX scored:
- Right ear = 10% (extremely significant)
- Left ear = 80% (> 2 SD)
- Diotic * = 100%

* Diotic is same presenter but heard in both ears. The diotic (quiet) condition shows that the decrease in performance is due to the presence of competing stimulus and not sentence length, presentation rate, or presentation level.

The fact that Ms. XX did fair in the left ear but so poorly in the right ear suggests that the area of difficulty is significantly more so in the left Heschl’s Gyrus area rather than the language processing region, otherwise the left ear result would likely have been impacted as significantly (though likely language processing area impacted at least to some degree).
**Pitch Pattern Sequence Test (PPS)**

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Verbal Score</td>
<td>70%</td>
</tr>
<tr>
<td>Verbal Score</td>
<td>65%</td>
</tr>
<tr>
<td>Verbal (Children Task)</td>
<td>100%</td>
</tr>
</tbody>
</table>

The pattern of the findings are consistent with prolonged processing speed difficulty; that is, Ms. XX performed better when the inter-stimulus intervals were longer (adult to children’s version), thus, allowing more time to process and identify the tones that were presented.

**Random Gap Detection Test**

Average Random Gap Detection threshold was greater than 40 milliseconds (msecs).

The mean gap detection thresholds for ages 11+ years is 7.8 msec with a mean standard deviation of 3.9 msec.

In fact, when I presented a single tone followed by a two-tonal presentation with a gap of 40 msecs present, Ms. XX could not distinguish between the two presentations.

**Interpretation of Findings**

Ms. XX exhibits normal hearing sensitivity in both ears and significant spoken-language processing difficulty. Ms. XX’s primary processing difficulties appear to be in the areas of:

- temporal resolution
- lexical (word) decoding speed
- higher order phonological awareness/phonics skills
- somewhat in sequencing

In turn, Ms. XX exhibited difficulties in (1) selective auditory attention to target messages in the presence of competing speech stimuli (especially in the right ear) and in noise (right ear only) and (2) short-term/working memory span.
Implications of Findings

Individuals with significant temporal resolution and lexical decoding speed difficulties exhibit increased processing time/mental load, while the lexical decoding speed difficulty is often associated with word/concept retrieval difficulty with spoken language information.

The above findings along with the sequencing difficulty likely underlie the significantly reduced short-term memory span.

Ms. XX’s sequencing deficit predicts that she would have some difficulty with following/carrying out directions, organization/planning, and spelling.

The speech-in-noise and CST findings indicate that Ms. XX will have difficulty in noisy settings, especially if the main talker were to be on her right side.

Specific Recommendations for Further Assessment

1. Speech ABR for each ear separately to determine if there is indeed differences in processing for each ear.

2. Assessment of Temporal Resolution for each ear separately to see if the temporal resolution difficulty was only in one ear (impacting overall performance) or more global (e.g., language processing region) and impacting both ears.

Specific Management Recommendations

1. Structured program with a goal of improving Ms. XX’s ability to perceive and distinguish speech sounds (e.g., being able to perceive short-duration, rapidly changing speech sound segments- such as /t/ versus /p/, /b/).

This can be done by structuring speech sessions to focus on attaining this goal, the use of commercially available programs (LIPS or Wilson programs) or software- such as Earobics (Adult version).
Management Recommendations- cont’d

2. Because of the lexical-decoding speed difficulties that are evident, it would be worthwhile to determine if this is due to lexical disorganization in addition to poor temporal resolution.

Therefore, Ms. XX would benefit from a comprehensive assessment by an SLP of her word finding/retrieval skills, lexical organization/categorization.

Management Recommendations- cont’d

3. Because of the sequencing difficulty noted, this should be evaluated further to determine if this is an area that needs to be addressed.

This can include an evaluation by an SLP utilizing tests that can delineate an individual’s ability to reconstruct/organize spoken language as well as by an OT to see if there are generalized sequencing related issues.

Question re Recommendations

If we see that the difficulties are ear specific, yet, impact overall performance, do we provide training just to that one ear (e.g., work on improving temporal resolution/ability to perceive phonemes just in right ear)?
Management
Recommendations- cont’d

In addition to these specific recommendations, a number of compensatory strategies, accommodations and enhancement of S/N ratio is discussed in the accompanying document to this presentation.

Questions

To ask a question, please type your question into the chat box in the lower left corner of the screen and click on the “Send” button located right below the box.
Diagnosis of APD (ASHA, 2005)

- 2 SD below normal performance on any two tests or 3 SD below normal performance on any one test
  - Enormous variety of tests used – no standard procedure
  - No ear specificity for diagnosis of abnormality
- How can this diagnosis guide treatment?

Characterizations of “APD”

- Case 1: Poor in LE on Dichotic Digits and poor in RE on Gaps in Noise
- Case 2: Poor in both ears on Speech-in-Noise and Frequency Pattern Test
- Case 3: Poor in both ears on Dichotic Digits and Masking Level Difference
- Case 4: Poor in LE on Dichotic Digits and LE on Speech-in-Noise
- Case 5: Poor SCAN composite score, poor both ears on Dichotic Digits, poor in both ears on Compressed Words
  - Heterogeneous results leading to single diagnosis

How would you treat them?

- Case 1: Poor binaural integration LE, poor temporal processing RE
- Case 2: Poor speech-in-noise and pattern recognition in both ears
- Case 3: Binaural integration and poor speech-in-noise both ears
- Case 4: Binaural integration and speech-in-noise, LE
- Case 5: Poor FW, AFG, CW and CS overall, poor binaural integration and time-comp speech both ears
Other Factors that Influence Tests

- Attention
  - Inconsistent pattern of responses
  - Vigilance decrement across test span
- Verbal working memory
  - Problems with tasks involving multiple critical elements
- Language
  - Poor comprehension of verbal material
- These can affect overall performance, but can any of these occur in only one ear?

Amblyaudia

- A new diagnostic term for a specific type of auditory processing disorder that occurs in one ear only
- Compare with “amblyopia” or “lazy eye”
- Consider a “lazy ear”
  - Indistinct processing of sensory input
  - Suppression by dominant side of information ascending from non-dominant side
  - Can lead to poor decoding of auditory signal at level of cortex

Amblyopia

- Developmental disorder of spatial vision
  - Associated with strabismus, anisometropia, or from deprivation early in life
- Reflects neural impairment from disruption in normal visual development
  - Ciuffreda, Levi, & Selenow, 1991
  - Levi, 2006

Amblyaudia

- Developmental disorder of binaural hearing
  - Associated with deprivation early in life, i.e. OMK
- Reflects neural impairment from disruption in normal auditory development
  - Popescu & Polley, 2010
  - Hall, Grose, & Pillsbury, 1995
Diagnosing a “lazy ear”

- Apparent in SRT or WRS?
  - Patients with amblyaudia perform normally on monaural word tests
- What about pure tone audiometry?
  - Typically normal and symmetrical
- What about retrocochlear hearing loss?
  - Must be ruled out by careful audiolodic test procedures
  - Asymmetry can be a red flag for a retrocochlear disorder

What is amblyaudia?

- “Amblyaudia is a developmental disorder related to brain organization and function rather than what is typically considered a “hearing loss” (damage to the cochlea),” from the Wikipedia description of its physiology.
  - One research group hypothesizes that amblyaudia develops following auditory deprivation as in a child with chronic OM (Whitton & Polley, 2011)
  - Amblyaudia could also be congenital and exacerbated by the presence of chronic OM in early childhood

Diagnosing amblyaudia

- Standard audiometric procedures rule out hearing loss, retrocochlear disorder
- Is apparent only during tests of dichotic listening
  - DL places the two ears in competition
  - Puts stress on binaural auditory system
  - Reveals asymmetry between parallel auditory pathways
Dichotic Listening

• One stimulus to the right ear
• Different stimulus to the left ear
• Listener is asked to
  – Repeat both (Binaural Integration)
  – Repeat only one (Binaural Separation)

Many Dichotic Listening Tests

• Dichotic CVs (Berlin, 1973; Hugdahl, 1986)
• DDT (Musiek, 1983)
• SSW (Katz, 1986)
• SCAN Competing Words (Keith, 1986)
• Randomized Dichotic Digits Test (Strouse & Wilson, 1999; Moncrieff & Wilson, 2009)
• Dichotic Words Test (Moncrieff, 2011)
• Dichotic Nonsense Words Test (Cheyney & Moncrieff, in preparation)
Amblyaudia

- Diagnosed by significant weakness in one ear with normal or significantly better performance in other ear during dichotic listening tasks
- A disorder of the auditory system characterized by indistinct processing of auditory information despite normal hearing
- May be related to suppression of information in one auditory pathway by activity in the other, dominant pathway
  - Suppression also noted following surgical development of a unilateral conductive hearing loss in an animal model (Popescu & Polley, 2010)
  - Has led to the suggestion that amblyaudia may be related to auditory deprivation early in development (Whitton & Polley, 2011)

Case 1:

- Female, age 10
- Normal PTA, AR, Tymps, OAEs

<table>
<thead>
<tr>
<th>Test</th>
<th>Non-dominant</th>
<th>Dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAN-s CW</td>
<td>20%</td>
<td>80%</td>
</tr>
<tr>
<td>RDDT – 2 pairs</td>
<td>25%</td>
<td>72%</td>
</tr>
<tr>
<td>DWT</td>
<td>34%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Case 2:

- Male, age 7
- Normal PTA, AR, Tymps

<table>
<thead>
<tr>
<th>Test</th>
<th>Non-dominant</th>
<th>Dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDDT – 2 pairs</td>
<td>22%</td>
<td>78%</td>
</tr>
<tr>
<td>DWT</td>
<td>56%</td>
<td>86%</td>
</tr>
</tbody>
</table>
Case 3:

- Male, age 9
- Normal PTA, AR, Tymps, OAEs

<table>
<thead>
<tr>
<th>Test</th>
<th>Non-dominant</th>
<th>Dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAN-3 CW</td>
<td>13%</td>
<td>73%</td>
</tr>
<tr>
<td>RDDT 2-pairs</td>
<td>6%</td>
<td>94%</td>
</tr>
<tr>
<td>DWT</td>
<td>48%</td>
<td>52%</td>
</tr>
</tbody>
</table>

Can Suppression Be Remediated?

- In children with amblyaudia, the dominant ear appears to suppress the non-dominant ear during dichotic listening tasks
- Reports are similar to deficits in visual tasks with amblyopia
- Can we learn from therapy approaches with amblyopia?
- Can the ears be “readjusted” to reduce suppression from dominant pathway?

Treatment Approach

<table>
<thead>
<tr>
<th>Amblyaudia</th>
<th>Amblyopia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce the intensity of input to the dominant ear during dichotic listening tasks</td>
<td>Prevent or limit use of better eye and promote use of ambyopic eye</td>
</tr>
<tr>
<td>Systematically increase intensity to dominant ear if non-dominant ear performance remains high</td>
<td>Cycloplegic drugs (atropine) result in blurred vision in dominant eye</td>
</tr>
<tr>
<td>Continue training until two ears can perform more equivalently during dichotic listening tasks at equal intensity</td>
<td>Partial or total occlusion of dominant eye</td>
</tr>
<tr>
<td>Clinical appointments in sound booth</td>
<td>Normal activities or specific training of visual tasks</td>
</tr>
</tbody>
</table>
ARIA
AUDITORY REHABILITATION FOR INTERAURAL ASYMMETRY

Phase 1 Results

Phase 2 Results

Results of APD Evaluations

Males
Females
ARIA Training 3 X week

- Significant improvements in non-dominant ear
  - Digits: $t = -2.296, p = .061$
  - Words: $t = -3.159, p = .020$

Comparison of Two Groups

Training Results

- ARIA can reduce interaural asymmetry in children diagnosed with amblyaudia
- Training one time per week is effective
- Some children may need only one ARIA session of 4-6 weeks
- Children with more severe amblyaudia may require multiple sessions of ARIA
- Children without training may not show significant improvement in asymmetry
Case 1:
- Female, age 10
- Normal PTA, AR, Tymps, OAEs

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<tr>
<td>RDDT – 2 pairs</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>DWT</td>
<td>34%</td>
<td>85%</td>
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Post-ARIA Results

<table>
<thead>
<tr>
<th>Post-ARIA</th>
<th>Test</th>
<th>Non-dominant</th>
<th>Dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RDDT – 2 pairs</td>
<td>89%</td>
<td>94%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>86%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Case 2:
- Male, age 7
- Normal PTA, AR, Tymps

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### Post-ARIA Results

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<tbody>
<tr>
<td>1</td>
<td>RDDT – 2 pairs</td>
<td>50%</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>60%</td>
<td>76%</td>
</tr>
<tr>
<td>2*</td>
<td>RDDT – 2 pairs</td>
<td>58%</td>
<td>81%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>70%</td>
<td>76%</td>
</tr>
<tr>
<td>3</td>
<td>RDDT – 2 pairs</td>
<td>81%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>72%</td>
<td>78%</td>
</tr>
</tbody>
</table>

### Case 3:
- Male, age 9
- Normal PTA, AR, Tymps, OAEs

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<td>94%</td>
</tr>
<tr>
<td>DWT</td>
<td>14%</td>
<td>74%</td>
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### Post-ARIA Results

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<td>86%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>22%</td>
<td>72%</td>
</tr>
<tr>
<td>2*</td>
<td>VA-DRT</td>
<td>46%</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>52%</td>
<td>68%</td>
</tr>
<tr>
<td>3</td>
<td>RDDT – 2 pairs</td>
<td>53%</td>
<td>53%</td>
</tr>
<tr>
<td></td>
<td>DWT</td>
<td>36%</td>
<td>56%</td>
</tr>
</tbody>
</table>
Coding and Reimbursement

- ICD-9-CM Diagnostic Code: 388.40
  - Abnormal auditory perception, unspecified
- Charge code: 17021585
  - Aural Rehab - Postlingual

Concluding Remarks

- Comprehensive audiologic evaluation is important
  - Including AR thresholds and OAEs
- ARIA is not a "magic bullet"
- Most children will need follow-up language therapy
  - Amblyaudia may have interfered with earlier therapeutic approaches
  - Better interaural symmetry may lead to improved outcomes from traditional therapies
  - Problems with attention and verbal working memory may linger
Many Thanks

- Diane Wertz, M.S.
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Questions

To ask a question, please type your question into the chat box in the lower left corner of the screen and click on the “Send” button located right below the box.

References