

## Central Auditory Processing Disorders

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### Auditory Processing Disorders: The Confusion

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- Different abbreviations for the same thing!
  - APD
  - CAPD
  - (C)APD
  - CAP-D (not written this way, but often said this way)

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### Auditory Processing Disorders: The Confusion

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- There is a lot of interest in auditory processing disorders in recent years (good!), but a lot of misconception...
- “auditory processing” is often used loosely in different settings to mean different things--- APD or CAPD is applied (often incorrectly) to a host of difficulties and disorders.
- As a result, people are questioning that APD is a real diagnostic entity.

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Auditory Processing Disorders:  
The Confusion

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APD or CAPD is not (*or should not be*) the umbrella term used for every child who has difficulty listening or understanding spoken language.

- There are many reasons why someone may not understand oral language!
- ***But APD is one possible reason and thus it should be ruled out.***

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**BASIC PRINCIPLES**

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- Hearing is INVISIBLE
- Hearing is not the same as listening!
- Children need it louder!
- Children learn by overhearing others as well as the teacher
- Auditory processing skills are not fully developed until the early teen years

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**BASIC PRINCIPLES**

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- APD can **only** be diagnosed by an audiologist.
- Other professionals help in the differential diagnosis and management. (SLPs, educators, psychologists)
- It's often a TEAM approach!

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### Central Auditory Nervous System (CANS)

- Brainstem and higher
- Central system is very “redundant”
- As a signal enters the system, it is encoded or **reinforced** at each level as it moves through the CANS. This **redundancy or enhancement** of the signal is important for accurate processing.
- If this process is interrupted or the signal is not coded correctly, misunderstanding will occur.

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### Auditory Processing

- Auditory processing occurs throughout the entire system, even in the periphery.
- However, auditory processing or “central” auditory processing typically refers to ***what the brain does with the sound that the ear picks up.***
- A “hearing test” only evaluates one aspect of the auditory system: **sensitivity**. It does not evaluate how efficiently your ear (or brain) processes different timing cues, intensities or pitches.

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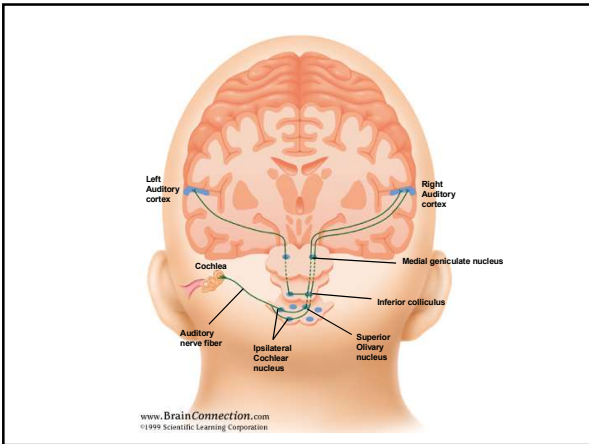
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### WE HEAR WITH OUR BRAINS!



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### We hear with our Brains!

- **Hearing happens in the BRAIN!**
  - Your ears are like a keyboard and your brain is the hard drive
  - Bad data in = bad data saved= bad data out!
  - Children whose brain's cannot **adequately represent** the signal will suffer in learning, language, reading and general communication.

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### Role of Redundancy in Auditory Processing

<ul style="list-style-type: none"><li>• <b>Intrinsic Redundancy</b><ul style="list-style-type: none"><li>○ Bilateral representation of each ear</li><li>○ Anatomic, physiologic, and biochemical overlap</li><li>○ Multi-sensory processing</li><li>○ Simultaneous processing of different auditory signals</li></ul></li></ul>	<ul style="list-style-type: none"><li>• <b>Extrinsic Redundancy</b><ul style="list-style-type: none"><li>○ Abundance of information within speech signal<ul style="list-style-type: none"><li>▪ Co-articulatory cues</li><li>▪ Semantic cues</li><li>▪ Syntactic cues</li></ul></li><li>○ Enable us to understand when only part of the signal is heard</li></ul></li></ul>
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### Intrinsic and Extrinsic Redundancy

- This principle is the basis for all auditory processing testing.
- The tests are designed to “stress” the system in order to evaluate where the breakdown is occurring.
- Test materials are purposely unclear, compressed, competing, etc.

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Intrinsic Redundancy (brain)	Extrinsic Redundancy (speech signal)	Speech Perception
NORMAL	NORMAL	NORMAL
NORMAL (No APD)	REDUCED (unclear signal)	NORMAL
REDUCED (APD)	NORMAL (clear, easy listening)	NORMAL
REDUCED	REDUCED	ABNORMAL




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### What is an Auditory Processing Disorder? (APD)

- “(C)APD is a **deficit in neural processing of auditory stimuli** that is not due to higher order language, cognitive, or related factors.” (ASHA, 2005)
- APD may be associated with difficulties in listening, speech understanding, language development, and learning.

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### Auditory Processing Disorder

- (Central) Auditory processing is defined by a set of skills that the CANS is responsible for...if you have a deficit in one of those key skills, you have an APD.
- In other words, APD (practically speaking) is defined by difficulty or dysfunction in an area of auditory processing.
- In it's purest form it is viewed as an **"input disorder"**. **A dysfunction in the underlying neural substrate that is responsible for a given skill.**

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### Auditory Processing Disorder

- Deficits in the perceptual processing of auditory information by the CANS will result in poor performance in one or more of the following behaviors:
  - Sound localization and lateralization
  - Auditory discrimination
  - Auditory pattern recognition
  - Temporal aspects of audition (e.g. temporal ordering, temporal resolution)
  - Auditory Performance decrements with competing acoustic signals
  - Auditory performance decrements with degraded acoustic signals

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### Prevalence

- The prevalence data for children is lacking...
- (C)APD found in approximately 3% of school-aged children
- 3% estimate based on clinical data, experience and the prevalence of co-morbid conditions

(from Chermak and Musiek's Central Auditory Processing Disorders)

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Neurologic Bases for APD

- Neuromorphological disorder (65-70%)
- Neuromaturational delay (25-30%)
- Neurologic disease or disorder (5%)

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Risk Factors for APD

- Family History
- Neurological dysfunction and disorders
  - Neonatal risk factors (e.g. premature birth, asphyxia)
  - Head injury
  - Seizure disorder
- Chronic ear infections in preschool years
- **Academic underachievement or failure**
- **Co-existing disorder**
  - Language or reading disorder, ADHD

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What do these children look like?  
Symptoms suggesting possible APD

- Heterogeneous group
- Children with APD will usually display some of the following behaviors:
  - Difficulty following oral directions or instructions
  - Says “what” or “huh” frequently
  - Difficulty listening in background noise
  - Difficulty locating sounds
  - Inattentive to sounds/difficulty paying attention to sound
  - Difficulty remembering spoken information
  - Misunderstands similar sounding words

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What do these children look like?  
Symptoms suggesting possible APD

- Poor academic performance
- Difficulty following long conversations
- Difficulty hearing phone conversations
- Language, reading, spelling or writing difficulties
- Flat/monotone voice when speaking or reading
- Poor music skills
  
- Difficulty taking notes in class
- Poor coordination
- Poor organizational skills
- Forgetful

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What do these children look like?

- These children typically have normal hearing.
- They often times have had several hearing tests.
- Symptoms of APD are similar to those of other disorders.
- These children often have other diagnoses (i.e. language, reading, ADHD, etc.)
- **Differential diagnosis is important!!**

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ADHD

- ADHD = the developmental impairments of executive functions.
- **Executive functions** are a set of cognitive skills that help control and regulate other abilities and behavior.
- Executive functioning is like the *Conductor of your brain*.
- These processes are located in the prefrontal lobe
- Continues to develop into early 20's.

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### ADHD

- Three basic types of ADHD
  - ADHD-I
    - Predominantly Inattentive Type
  - ADHD-H
    - Predominantly Hyperactive-Impulsive Type
  - ADHD-C
    - Combined Type
- **ADHD- I is the most difficult to separate from APD. Many overlapping symptoms.**

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### Perceived differences between ADHD and APD by physicians Chermack et. al (1998)

ADHD	APD
<ul style="list-style-type: none"><li>• <b>Inattentive</b></li><li>• <b>Distractible</b></li><li>• Hyperactive</li><li>• Fidgety/restless</li><li>• Hasty/Impulsive</li><li>• Interrupts</li></ul>	<ul style="list-style-type: none"><li>• Difficulty hearing in noise</li><li>• Difficulty following directions</li><li>• Poor listening skills</li><li>• Academic problems</li><li>• Poor auditory association</li><li>• <b>Distractible</b></li><li>• <b>Inattentive</b></li></ul>

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### APD vs. ADHD

APD	ADHD
<ul style="list-style-type: none"><li>• Input disorder</li><li>• Executive dysfunction is secondary</li><li>• Attention deficits are secondary</li><li>• <b>Bottom up processing</b></li></ul>	<ul style="list-style-type: none"><li>• Output disorder</li><li>• Management includes medication</li><li>• <b>Top down processing</b></li></ul>

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### APD vs. ADHD

<ul style="list-style-type: none"> <li>• Inattention related to <u>auditory</u> distraction</li> <li>• Can attend when they understand the material</li>   <li>• Both have problems with divided attention, but for different reasons.             <ul style="list-style-type: none"> <li>○ Listening so intently can't divide attention</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Inattention related to <u>internal</u> distractions, disorganization, and behavioral disturbance</li> <li>• Inattention regardless of comprehension</li> <li>• Divided attention             <ul style="list-style-type: none"> <li>○ Can't block out signals</li> </ul> </li> </ul> <p><b>*Comorbidity ranges from 45%-75%*</b></p>
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### Other Co-existing Disorders

- **Reading:** reading is a very auditory skill. Phonemic awareness is a critical skill to reading.
  - APD is closely related to phonological processing--- and the skill of reading--because you need good auditory processing for your brain to distinguish the elements of spoken language.
  - The subcortical representation of speech (encoding of timing and frequency) has been shown to be unstable in poor readers.
  - Struggling readers who are not responding well to reading intervention may have neural variability or inefficient processing of auditory cues.

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### Rhythm, Timing and Reading!

- A study by Woodruff et al. of Northwestern showed that children who were better able to sync to a beat had higher phonological awareness scores.
- Electrophysiological testing also showed that these same children have better encoding of speech at the brainstem level.
- Hearing and processing frequency and timing cues (auditory processing) are important for phonological awareness and later reading success.

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### Other Co-existing Disorders

- **Language:** Auditory processing and language processing happen on a continuum. Auditory processing happens first.
- The process of word retrieval and attaching meaning to what has been heard is considered language processing.
- Also, your ability to process auditorily (oral language) can affect developing language skills.
- Many kids with APD have weaknesses in grammar skills, vocabulary, and higher order language skills.

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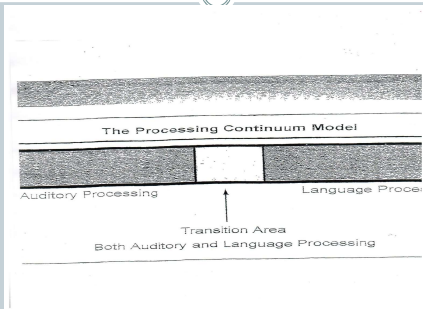
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### Processing Continuum Model



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### How do you diagnose an APD?

- Series of behavioral tests
- Full hearing test first
- 6-8 tests given from the central auditory test battery depending on age, attention, and deficits
- Secondary, related skill areas also very important to the test battery.

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### How do you diagnose an APD?

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- **At Beyond The Ear, we also screen or assess 4 other areas, as needed:**
  - Phonological Awareness
  - Auditory Attention
  - Auditory Memory
  - Language screening
- These are not primary auditory processing skills, but add a lot of value to the evaluation. It allows for a more comprehensive “look” at the child.

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### APD Evaluation at Beyond The Ear: Summary

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- Appointment lasts about 3-3½ hours (including feedback session).
- The testing includes:
  - Several tests of primary auditory processing skills (all performed in a sound booth).
  - Secondary tests in related areas
- A feedback session with parents:
  - Explain auditory processing
  - Go over all the results
  - Help come up with a list of recommendations/management plan.

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### Examples of the PRIMARY Tasks

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- **Auditory Figure-Ground:** Child is asked to repeat words or sentences in the presence of background noise
- **Dichotic Listening Tasks:** Child is asked to listen to two competing signals (words, sentences, numbers)
  - Dichotic Digits, Staggered Spondaic Words, Competing Words, Competing Sentences, etc.
- **Auditory Pattern Recognition:** Child is asked to copy auditory patterns
  - Frequency Patterns Test (high-high-low); Duration Pattern Test (short-long-short)

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### Examples of the PRIMARY Tasks

- **Temporal Resolution:** Child has to detect a silent interval among bursts of noise or tones.
  - Gaps in Noise (GIN) Test; Random Gap Detection Test
- **Auditory Closure Tasks:** Child is asked to repeat words or sentences that are muffled or said very quickly (time compressed). Performed one ear at a time.
  - Time Compressed Sentences; Filtered Words

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### Diagnosis

- In general, a diagnosis is given if the child scores **2 standard deviations or below on 2 or more tasks**. The tasks may or may not be related.
- Case history, teacher and parent report, and other evaluations are always taken into consideration (e.g. language evaluation)
- Usually the results reveal a **pattern**. When a child does very poorly across tests, it typically is less significant for APD.
- Deficits should be seen on more than one task if it is indicative of the CNS dysfunction.

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### Ages for testing

- **Screening program for 5 year olds**
  - Limited testing, but for some you can gain enough information to know if the child is at risk.
  - Can often see weaknesses, and then make early intervention recommendations
- **6-year-old group... borderline age.** Many of these children can complete enough of the test battery to know whether or not they have APD.
- **7 years old and above- full diagnostic evaluation**

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### Contraindications for APD testing

- **Intellectual capacity should be a consideration**
  - Someone with a full scale IQ of less than 80 may not be able to be tested.
  - There are exceptions, but parents need to understand limitations in interpreting test results
- **Severe expressive speech disorder (e.g. apraxia)**
  - Almost every test requires a verbal response
- **Hearing Loss**
  - > moderate loss; asymmetrical

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### Management: 3- fold approach!

- 1. Classroom modifications/teaching strategies
- 2. Auditory training/therapy
- 3. Coping strategies/compensation

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### Management: Classroom

- In the classroom: **make it easy!** Provide accommodation and modifications to help child succeed.
  - Preferential seating
  - Reduce noise sources
  - Visual guides, daily organizer
  - Teacher reminders/ comprehension checked frequently
  - FM system
  - Academic accommodations like extra time on tests, tests read aloud, etc.
- You have to consider *auditory fatigue* and *cognitive overload*.

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Classroom Amplification Systems:  
Benefits

- This technology is about “equal sound distribution”.
- The amplified sound gives an improved signal-to-noise ratio.
- It provides better access to the speech signal for all students. Easier listening means less auditory fatigue and more resources left over for learning.

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Classroom Amplification Systems:  
Benefits

- Studies show that children in amplified classrooms have...
  - higher spelling and reading scores
  - more on task behaviors
  - Better attention
  - Shorter test taking time
  - Less requests for repetition
  - Ease of listening
  - Enhanced sentence recognition
- Teachers have less vocal strain and less sick days

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Classroom Amplification: it's a must!

- Some teachers do not think they need to use it because they have a “loud” voice. But the truth is **louder speech is not clearer speech**.
- Raising your voice skews the ratio between the vowels and consonants actually making it less intelligible.
- Also, many systems come with a “pass around” or student microphone. Use of the microphone promotes improve expressive language skills and helps a child monitor his speech.

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## Management: Therapy

- Outside the classroom (in therapy): **make it difficult!** Challenge the child.
  - Therapy is an important component to the management
    - **\*\*best results are seen when therapy is frequent and intense\*\***
  - Children's brains have much plasticity and the brain can change with therapy.
  - Research has shown that even adult brains change with training.

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## Management: Coping Strategies

- Compensation strategies
  - Organizational techniques
  - Use of language
  - Teaching child how to take control of own listening environment
  - Deploy strategies: monitor and regulate performance
  - Visualization of steps to complete a task
  - Ask for help!

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## Prognosis?

- Outcomes are variable among children; however, many children respond well to therapy
- Success probably depends mostly on the underlying cause
  - Delay vs. Disorder
  - APD completely resolves in some children
    - Level of plasticity?
    - Maturation?
  - Other children improve their skills, but still have difficulty. These children do well with coping strategies and modifications in the learning environment

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### Case Study 1

- 10 year old male (5<sup>th</sup> grade)
- No significant medical history
- No family history of learning difficulties
- **Complaints:**
  - Does not follow directions well
  - Has stopped participating in class the last couple of years
  - Has been given conduct referrals for “not listening” in class
  - Hearing is “normal”
- Mother raised concerns with child’s ability to hear in background noise, his misunderstanding of similar sounding words, frequent need for repetition of information, inappropriate responses to questions.

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### Fisher’s Auditory Checklist

- Teachers rated this child as being characterized by:
  - ✦ Not paying attention or listening to instructions 50% or more of the time
  - ✦ Needs directions repeated frequently
  - ✦ Has difficulty following directions
  - ✦ Says “Huh?” and/or “What?” at least five times per day
  - ✦ Slow to respond
  - ✦ Mishears what is said
  - ✦ Easily distracted by background noise
  - ✦ daydreams frequently
  - ✦ Forgets what is said
  - ✦ Has a short attention span
  - ✦ Learns poorly when just asked to listen

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### Academics

- Academic areas such as spelling, math skills, reading comprehension and written language were rated as “fair”.
- Mother stated that child does not like school because he feels like he “misses things” and he feels like he gets in trouble for asking questions.

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**RESULTS: Primary CAP skills**

- Competing Sentences: Excellent (99% and 97%)
- Dichotic Digits: Excellent (90% Au)
- Gaps in Noise: Excellent
  
- Staggered Spondaic Words (SSW): below normal, but he appeared to mishear many words
  
- Frequency Patterns Test: mildly below average labeling, but normal when humming

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**RESULTS: Primary CAP skills**

- Filtered Words (unclear speech)  
**Expected: 66%-100%**  
Performed: R- 60%  
                  L- 28%
  
- Speech in Noise Test  
**Expected: 80-100%**  
Performed: R- 28%  
                  L- 40%

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**RESULTS: Related Skill Areas**

- Phonemic Synthesis Test: Passed
  
- ACPT (attention test): Passed
  
- TOWRE (reading efficiency test): average to above average

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### INTERPRETATION

Auditory processing disorder (APD) related to a **deficit in auditory closure and listening in noise.**

**NOT**  
Inattentive  
Naughty  
Never Listens!

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### Case Study 2

- 9 year old female (3<sup>rd</sup> grade)
- Medical history:
  - Ear tubes
  - Allergies
- No family history of learning difficulties
- Complaints:
  - Doesn't follow directions well
  - Needs information and directions repeated frequently
  - Says "what" a lot
  - Misunderstands words that sound similar

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### Fisher's Auditory Checklist

- Teachers rated this child as being characterized by:
  - Needs directions repeated frequently
  - Has difficulty following directions
  - Says "Huh?" and/or "What?" at least 3 times a day
  - Slow to respond
  - Mishears what is said
  - Doesn't understand words well
  - Forgets what is said
  - Has trouble recalling a sequence of information
  - Has some difficulty with phonics

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**Academics**

- Academic areas such as spelling, math skills, oral reading, reading comprehension, and written language were rated as “fair”.
- Teacher is concerned about child’s understanding of vocabulary.
- Teacher feels that the child needs to hear directions several times before the child “gets it”.

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**RESULTS: Primary CAP Skills**

- Competing Sentences: Excellent (96% & 98%)
- Dichotic Digits: Excellent (91% Au)
- Gaps in Noise: Excellent
- Staggered Spondaic Words: All conditions WNL
- Frequency Patterns Test: WNL
- Filtered Words: WNL
- Time Compressed Sentences: WNL (93% & 87%)
- Speech in noise: **Mild to moderate difficulty**

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**RESULTS: Related Skill Areas**

- Phonemic Synthesis Test: Well WNL
- Auditory Memory: primarily above average
- CELF-4 Language Screening: Passed
  - Has 5 subtests for ages 9-21 years old
    - Following directions
    - Repeating Sentences
    - Word associations
    - **Sentence construction**
    - **Problem solving**
  - Child had a **VERY difficult time with the last 2 sections.** Took a very long time to come up with answers and asked for repetitions.

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### INTERPRETATION

- Child does **NOT** have an auditory processing disorder.
- Child *likely* has a **language processing disorder** or weakness in higher order language skills
- **RECOMMENDATION:**
  - Refer to a speech language pathologist for language evaluation and potential therapy.

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### Comparison: Case 1 and Case 2

- **Similarities:**
  - Main complaint: Not following directions
  - Both were rated "fair" in many of the academic areas
  - No family history of learning disabilities
  - Many similar characteristic behaviors:
    - Says "what"
    - Mishears
    - Needs information repeated
    - Slow to respond at times
    - Forgets what was said
  - Differences:
    - One child has APD the other does NOT!
    - Different intervention strategies and recommendations

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### In Conclusion

- Processing of spoken language involves and intertwining of...
  - Auditory processing
  - Cognition
  - Language
- If there is a deficit in any of the processing stages, then that person's ability to understand a spoken message will be compromised.
- We cannot fully separate these, nor should we, but as professionals we need to do our best to delineate the problems in order to provide the best management plan.
- **Auditory Processing Disorder is one potential cause of listening difficulties!**
- "Careful differential diagnosis is critical to effective intervention."  
-H. R. Myklebust

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### Websites

- <http://www.listen-up.org/edu/capd.htm>
- Information about APD from a psychologist's perspective:
  - [www.crisiscounseling.com/articles/capd.html](http://www.crisiscounseling.com/articles/capd.html)
- American Academy of Audiology: [www.audiology.org](http://www.audiology.org)
- American Speech and Hearing Association: [www.asha.org](http://www.asha.org)
- Cognitive Concepts: [www.earobics.com](http://www.earobics.com)
- Scientific Learning: [www.scilearn.com](http://www.scilearn.com)

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