

**(C)APD Part One:  
Definition, Screening, and  
Diagnosis**

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**Definition  
and  
Nature of (C)APD**

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**To develop a definition of  
(C)APD, we must first  
understand the NATURE of  
auditory processing and its  
disorders.**

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**What does the science tell us about the nature of (C)APD?**

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The evidence to guide our endeavors is drawn from many disciplines:

- Cognitive neuroscience
- Neuropsychology
- Cognitive psychology
- Auditory neuroscience
- Psycholinguistics
- Neurobiology/general neuroscience
- Others

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**Modality Specificity**

- Modality specificity as a criterion for diagnosing (C)APD (McFarland & Cacace, 1995; Cacace & McFarland, 1998)
- (C)APD is a disorder that is *specific to the auditory modality* (Jerger & Musiek, 2000).

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**Are definitions of (C)APD that require complete modality specificity as a diagnostic criterion ecologically valid?**

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**Is the demonstration of complete modality-specificity required for diagnosis of other disorders involving the auditory system?**

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**Fundamentals of Brain Organization**

- Few, if any, entirely compartmentalized areas of the brain responsible for a single sensory modality
  
- Evidence of convergent sensory "tracks," multisensory neurons, and neural interfacing

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- Multimodality influences affect even the most basic neural encoding and manipulation of sensory stimuli
- Processing of sensory data is interdependent and integrated, and supported by cognitive domains and language representations

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**Information Processing Theory:  
Applications to (C)APD**

- Bottom-up factors in auditory processing:
  - “Data-driven”
  - Acoustic properties of auditory stimulus
  - We cannot discount the influence of the auditory periphery on “central” auditory processing!

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- Top-down factors in auditory processing:
  - “Concept-driven”
  - Includes attention, language, cognition, executive function
  - Will affect the sensory percept – thus, we cannot discount the influence of higher-order factors on auditory processing, either!

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■ Research is emerging to support the nonmodularity of central auditory dysfunction:

- Bellis et al. Use of visual analogs to central auditory tests; auditory and multimodal findings in interhemispheric dysfunction.
- Kraus et al. Impact of visual system, limbic system, and other factors on temporal processing at brainstem level.

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Auditory processing is neither exclusively bottom-up nor top-down; it consists of interactive networks and multiple information sources that guide pattern identification and interpretation. The relative influence of top-down or bottom-up processing is influenced by changing listening demands.

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Therefore:

Any definition of (C)APD that specifies complete modality-specificity as a diagnostic criterion is neurophysiologically untenable.

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**Relationship of (C)APD to Language, Learning, and Communication**

**Lack of association between basic auditory processes and language/learning outcomes (e.g., Bishop et al., 1999; Watson & Kidd, 2002)**

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Associations between auditory processing and language/learning outcomes *depend upon the type of auditory deficit, type of language/learning difficulty, and unique confluence of the individual's bottom-up and top-down abilities* (e.g., Bellis & Ferre, 1999; Cestnick & Jerger, 2000; Heath et al, 1999)

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Evidence of abnormal neurophysiologic representation of auditory (especially speech) signals in children with language-based learning and reading disorders (e.g., Abrams et al., 2006; Banai et al., 2005; Kraus et al., 1996; Warrier et al., 2004; Wible et al., 2004, 2005).

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Therefore:

Heterogeneity of *both* (C)APD and learning and related disorders precludes a simple one-to-one correlation between basic auditory processes and higher-order sequelae across large numbers of diverse subjects.

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### Brain Organization and Co-Morbidity

- Organization of the CNS underlies co-morbidity of disorders, e.g., (C)APD and
  - ADHD
  - Learning or Language Disorder
  - Other

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### Resource Allocation

- Resource allocation occurs across systems and modalities
- Therefore, disproportionate allocation of resources to one system/task/skill (e.g., audition) may leave little left over for other tasks (e.g., comprehension, memory).

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**Toward an ecologically valid operational definition:**

- (C)APD (ASHA, 2005):
- is a deficit in the perceptual processing of auditory stimuli, *and the neurobiological activity* underlying that processing

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- Evidence supporting a neurobiological basis to (C)APD
  - Abnormal neurophysiologic representation of both speech and nonspeech signals
  - Atypical interhemispheric transfer
  - Atypical timing in system
  - Atypical hemispheric asymmetries
  - Other

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**(C)APD**

- may lead to or be associated with difficulties in higher-order language, learning, and communication function; but the relationship is far from simple
- cannot be *attributed to* higher-order language, cognitive, or related confounds
- may co-exist with, but *is not the result of*, dysfunction in other modalities

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■ **Affects the perceptual and neural processes in CNS underlying:**

- Localization/lateralization
- Discrimination
- Auditory pattern recognition
- Temporal processing
- Performance with competing/degraded acoustic signals

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**Abilities such as phonological awareness, attention to and memory for auditory information, auditory synthesis, comprehension and interpretation, and similar skills may be reliant upon or associated with intact central auditory function...**

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**BUT**

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**they are considered higher-order cognitive/ communicative and/or language-related functions and, thus, are *not included* in the definition of (C)APD**

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The terms *auditory processing*, *phonological processing*, *language processing*, and *cognitive processing* are NOT synonymous, although the skills may be inter-related and the behaviors may be similar.

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**Definition/Nature of (C)APD Informs Diagnosis:**

**Because of the interactive nature of auditory processing, to document a *(central) auditory deficit*, you must use:**

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- Test tools that have *documented* sensitivity and specificity to *known* dysfunction of the CANS
- Tools developed/validated for other purposes (i.e., learning disability, language impairment) **CANNOT** be used for this purpose!
- Because (C)APD is an auditory disorder, the audiologist diagnoses (C)APD.

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**Definition/Nature of (C)APD  
Informs Intervention:**

**Intervention for (C)APD  
should:**

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- be a multidisciplinary endeavor, and should address both bottom-up and top-down skills
- be individualized and deficit-specific (the diagnosis drives the treatment)

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■ focus on improving access to auditory information, strengthening central resources, and remediating the auditory deficit

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## Auditory Processing Assessment and Diagnosis

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### Definition of Terms

■ **Diagnosis:** Determination of presence and nature of disorder

■ **Assessment:** Data-gathering process to examine current levels of functioning and strengths and weaknesses

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■ All (C)APDs do not lead to speech or language difficulties

■ All speech, language, and related difficulties are not due to or associated with (C)APD

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**The Audiologist's Role**

■ (C)APD is an *auditory* disorder; therefore, the *audiologist* diagnoses (C)APD

■ The audiologist must have the necessary training and skills to do so

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**The SLP's Role**

■ SLPs and other professionals collaborate in the *assessment* of individuals suspected of (C)APD for both differential diagnostic and intervention purposes

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**■ The SLP is uniquely qualified to delineate the cognitive/ communicative and speech/ language factors that may be associated with (C)APD**

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**Screening  
for  
(C)APD**

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**Screening for (C)APD**

- Purpose:**
- To determine need for further testing**
- To reduce over-referrals**

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### Screening for (C)APD

(Jerger & Musiek, 2000)

■ **Screening by questionnaire:**

- Difficulty hearing/understanding in noise
- Difficulty following spoken directions
- Difficulty discriminating/identifying speech sounds
- Inconsistent responses to or awareness of auditory information

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■ **Screening by Test:**

- Dichotic Digits Test
- Gap Detection Test

■ **Under age 6-7: Use questionnaires**

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■ **Does this really reduce over-referrals????**

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### Screening for (C)APD

(Bellis, 2003)

- Review of “other systems” is a key component of screening
  
- Screening is focused on answering four primary questions:

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1. Are the current evaluations sufficient in scope?
2. Is there a likelihood of (C)APD?
3. Can the child participate in the evaluation?
4. Would results of assessment add information that would affect management?

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### Outcomes of Screening

- Referral for comprehensive assessment
  
- Referral for other testing/follow-up
  
- Interim Recommendations
  
- Other

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## A New Screening Tool!

- Richard, G. J., & Ferre, J. M. (2006). Differential screening test for processing. East Moline, IL: LinguiSystems, Inc.
- Screens a variety of processes along the auditory-language processing continuum.
- Includes clear instructions for results interpretation and referral.

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- Three Levels:
  - Level One (Acoustic Subtests): Dichotic Digits, Temporal Patterning, Auditory Discrimination
  - Level Two (Acoustic-Linguistic Subtests): Phoneme Manipulation, Phonic Manipulation
  - Level Three (Linguistic Subtests): Antonyms, Prosodic Interpretation, Language Organization)

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- The tool is designed to be administered by “a *trained professional familiar with the differential aspects of auditory and language skills involved neurologically in processing tasks*” (manual, p. 12).
- This is a **screening** tool, NOT a diagnostic tool!

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**Diagnosing  
(C)APD**

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**Principles of (C)APD Diagnosis**

- **Purpose of Diagnostic Testing: To identify presence and delineate characteristics/nature of central auditory deficit**
- **Requires *audiologist-administered* diagnostic tests of central auditory function**

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- **Provides information regarding integrity of left-hemisphere, right-hemisphere, interhemispheric, and brainstem auditory structures**

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- May include psychophysical and/or neuro(electro)physiologic tests of central auditory integrity
- Leads directly to development of *deficit-specific* treatment and management plans

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**Diagnostic Tests for (C)APD**

- Must employ a test battery approach that assesses various levels/loci within the CNS, as well as different perceptual processes
- The tests chosen should meet accepted psychophysical and scientific standards , should control for higher-order confounds, and should be appropriate to the individual being tested!

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**Most importantly:**

**The tests used should have been demonstrated to be sensitive, reliable, and efficient for identification of CANS dysfunction**

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Because of the interactive nature of auditory processing, to document a (*central*) auditory deficit, you must use:

- Test tools that have *documented* sensitivity and specificity to *known* dysfunction of the CANS
- Tools developed/validated for other purposes (i.e., learning disability, language impairment) CANNOT be used for this purpose!

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### **Behavioral Tests (Categories)**

- **Dichotic Speech Tests**
- **Temporal Patterning Tests**
- **Tests of Other Temporal Processes**
- **Monaural Low-Redundancy Speech Tests**
- **Auditory Discrimination Tests**
- **Tests of Localization/Lateralization**

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### **Electroacoustic Measures**

- **Otoacoustic Emissions**
- **Acoustic Reflexes**
- **Acoustic Reflex Decay**

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### **Electrophysiologic Test Tools (Categories)**

- Standard ABR, MLR, Corticals, P300
- Multi-channel MLR and Corticals to speech and nonspeech signals (electrode and ear effects and hemispheric asymmetries)
- Other (e.g., MMN, etc.)
- Brainstem responses to speech (i.e., BioMARK)

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- **Electrophysiologic and related measures may play an important role in the objective demonstration of neural deficits in the auditory system in many cases, as well as in the documentation of treatment efficacy. They may also indicate which patients might benefit from training (e.g., BioMARK!)**

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### **Test Battery Interpretation**

- Norm-referenced criteria
- Using the patient as his/her own control (pattern analysis using neurophysiologic tenets):

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- **Intra-test analysis (including ear differences)**
- **Inter-test analysis**
- **Cross-discipline analysis**

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- **A diagnosis of (C)APD is enabled only when performance on  $\geq 2$  tests is abnormal AND the pattern of findings is consistent with underlying neuroscience tenets (ASHA, 2005)**
- **Lack of a pattern (e.g., poor performance on all measures) argues for more global or motivational deficit, not (C)APD**

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- Levels of Interpretation**
- **Site-of-dysfunction-based interpretation**
  - **Process-based interpretation**
  - **Functional deficit profiling**

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**Process-Based Interpretation**

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**Purpose**

- **To identify the auditory deficits using results of behavioral central auditory testing and other data to determine specific areas of auditory dysfunction that need to be targeted**

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- **Auditory performance with competing acoustic signals**

**Binaural Separation (BS) – assessed by dichotic tests involving directed attention (e.g., Competing Sentences)**

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■ **Auditory performance with competing acoustic signals**

**Binaural Integration (BI) – assessed by dichotic tests involving report of both ears (e.g., Dichotic Digits)**

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■ **Auditory performance with degraded acoustic signals**

**Auditory Closure – assessed by tests of monaural low-redundancy speech and those involving ipsilateral competition (e.g., Filtered Speech, Time-Compressed Speech)**

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■ **Auditory Pattern Recognition**

**Auditory Patterning/Temporal Ordering (APTO) – assessed by temporal patterning tests (e.g., Frequency and Duration Patterns)**

**Includes aspects of nonspeech discrimination, interhemispheric transfer, sequencing, and specific temporal processes**

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■ **Auditory Discrimination**

**Complex auditory skill**

**Element of virtually all central tests**

**Can be directly assessed through difference limens for nonspeech stimuli, speech-sound discrimination tasks, etc.**

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■ **Temporal Aspects of Audition**

**Critical for discrimination, localization/lateralization, prosody perception, etc.**

**Can be assessed through direct measures of temporal resolution (e.g., gap detection), temporal masking, temporal integration/summation, etc.**

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**Discrimination and temporal processing also can be assessed indirectly through electrophysiologic indicators of neural representation and discrimination (e.g., MLR, Cortical Responses, MMN, BIOMAP)**

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**\*\*Remember: TIMING IS EVERYTHING!\*\***

**ALL (C)APDs LIKELY HAVE SOME DEFICIT IN TEMPORAL PROCESSING!**

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■ **Sound Localization/Lateralization**

**Critical for speech-in-noise skills and other auditory functions**

**Tapped by tests such as MLD, binaural interaction tests, LISN**

**Additional research needed**

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**Functional Deficit Profiling (includes site-of-dysfunction based interpretation)**

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■ **Functional Deficit Profiling**

■ **Involves examination of auditory and cross-discipline data for patterns that conform to well-established neurophysiologic and neuropsychologic tenets**

■ **Not intended to be a “catch-all,” cookie-cutter approach to interpretation and programming treatment**

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■ **Key to interpretation, diagnosis, and effective treatment: Presence of patterns that make sense based on scientific foundations and principles**

■ **Functional deficit profiling serves as a guide for clinicians to assist them in understanding these patterns**

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**ONE Subprofiling Method:  
The Bellis/Ferre Model**

■ **Involves integration and pattern analysis of auditory and multidisciplinary findings**

■ **Three primary profiles:**

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### **Auditory Decoding Deficit**

■ **Auditory deficits indicate left-hemisphere (primary auditory cortex) pattern:**

- **Bilateral or right-ear deficit on dichotic speech tasks**
- **Poor performance on auditory closure tasks**
- **Poor phoneme discrimination**
- **Reduced LH electrophysiologic responses (MLR, cortical)**
- **Poor temporal resolution abilities**

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■ **Associated difficulties in left-hemisphere functions:**

- **Phonological decoding (word attack) difficulties**
- **Speech-in-noise problems**
- **Better performance with visual/multimodality cues**
- **Other phonological and language-based concerns**
- **Better Performance than Verbal IQ**

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### **Prosodic Deficit**

■ **Auditory deficits indicate right-hemisphere pattern:**

- **Left-ear deficit on dichotic speech tasks**
- **Poor temporal patterning performance (BOTH humming and labeling)**
- **Reduced RH electrophysiologic responses (MLR, cortical)**
- **Elevated frequency, intensity, duration difference limens**

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■ **Associated difficulties in right-hemisphere functions:**

- Sight word reading and other Gestalt patterning difficulties
- Problems with prosody perception
- Poor pragmatic skills
- Sequencing difficulties
- Other RH difficulties (e.g., visual-spatial skills, math calculation, better verbal than performance IQ)

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**Integration Deficit**

■ **Auditory deficits indicate inefficient interhemispheric transfer:**

- Left-ear deficit on dichotic speech tasks (opposite for nonspeech)
- Poor temporal patterning performance (labeling ONLY)
- Traditional electrophysiologic responses (MLR, cortical) often normal; may see reduced hemispheric asymmetry to speech stimuli

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■ **Associated interhemispheric difficulties:**

- Poorer performance with multimodality or visual cues
- Sound-symbol association difficulties
- Speech-in-noise and localization difficulties
- May have subtle difficulties in other interhemispheric tasks (bimanual/bipedal activities, etc.) but not "true" sensory integration dysfunction

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### **A Fourth Subprofile?**

- Brainstem timing deficit
  
- Abnormal performance on BioMARK, associated with speech-in-noise complaints, reading deficits, and other symptoms
  
- Indicates potential for success with auditory training

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### **Differential Diagnosis: Some Generalizations**

- **AD/HD:**
  
- No clear auditory pattern (all normal or uniformly depressed; inconsistency in test performance)
- Different functional sequelae per DSM-IV TR
- Poor performance on vigilance tasks
- Often ameliorated by medication

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- **Autism:**
  
- No clear auditory pattern (all normal or uniformly depressed)
- Presence of self-stimulating and other non-auditory behaviors per DSM-IV TR
- Overall developmental delay
- But timing/prosody deficits may underlie some pragmatic concerns (future research needed)

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**■ Language Processing Disorders:**

- No clear auditory pattern (often all normal) or difficulty comprehending instructions**
- Input skills (i.e., discrimination, etc.) fine with poor higher-order comprehension difficulties for written and spoken language**

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**■ Mental Retardation:**

- No clear auditory pattern**
- Evenly developed (reduced) skills across all areas with achievement commensurate with capacity**

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**■ Poor Motivation:**

- No clear auditory pattern**
- Poor consistency and reliability of responses**
- “Deficits” disappear with reinforcement**
- Behavioral indicators of poor attention/motivation**

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### Summary

- Accurate assessment and diagnosis of (C)APD requires:
- Ecologically valid definitions of (C)APD
- Evaluation of a variety of processes and CANS sites
- Multidisciplinary input

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- The key to interpretation and differential diagnosis:
- Analysis of findings for neurophysiologically tenable PATTERNS consistent with CANS dysfunction

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### Questions???

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**Recommended General Readings**

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