Differentiating Central Auditory Processing Disorder (CAPD) and Attention Deficit/Hyperactivity Disorder (ADHD) in Clinical Practice

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• Topics to be covered in this presentation
  – Brain organization and neurobiological bases of ADHD and CAPD
  – Current definitions of ADHD (APA, 2013) and CAPD (ASHA, 2005; AAA, 2010)
  – Presenting symptoms of ADHD and CAPD
  – Methods of diagnosing ADHD and CAPD
  – Case Study

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
• 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

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.
Evidence of neurobiological bases underlying ADHD
- Reduced volume in
  • total cerebral volume
  • prefrontal cortex
  • striatum (basal ganglia)
  • dorsal anterior cingulate cortex
  • corpus callosum
  • cerebellum
- Delay in grey matter maturation, especially in prefrontal regions

Reduced white matter in corpus callosum
 Reduced cortical thickness
 Reduced fMRI activity in prefrontal/striatal regions

Heterogeneous presentation, likely no single common etiology
- Dopamine theory: Reduced dopamine reception/function leads to inefficient reward processing
- Genetic/environmental interactions
• Evidence supporting neurobiological bases of CAPD
  – Abnormal neurophysiologic representation of both speech and nonspeech signals
  – Atypical interhemispheric transfer
  – Atypical timing in system
  – Atypical hemispheric asymmetries
  – Neuromorphological abnormalities
  – Other

• Many of the pathways/structures implicated in CAPD overlap those important for attention.

• Therefore, co-morbidity of ADHD and CAPD likely arises from shared neuroanatomical substrates/networks.
• Cognitive control model of dichotic listening (Kompus et al., 2012)
  – Forced-left conditions strongly recruit prefrontal regions and striatum, especially in left hemisphere
  – Both forced-left and forced-right conditions recruited right-hemisphere regions (posterior portion of the inferior frontal sulcus, caudate nucleus, and superior parietal lobe)
  – Free-report (nonforced) condition supported well-recognized right ear advantage and appears to be a “purer” measure of sensory processing

Hugdahl et al., 2009
• Results suggest the possibility of two different sets of top-down brain networks that support
  – Attention Processes (fronto-parietal “attention control” regions) – recruited by forced-right conditions
  – Executive Cognitive Control Processes (medial-lateral frontal regions) – recruited by forced-left conditions
• Free report conditions likely reflect “true” perceptual asymmetries

• When taken together, the anatomical and behavioral evidence suggests a strong neuroanatomical basis for the often observed co-morbidity of CAPD and ADHD

• Nonetheless, CAPD and ADHD are distinct disorders that can be differentially diagnosed and that require deficit-specific intervention approaches

Definitions of ADHD and CAPD
ADHD (APA, 2013):

- Is a neurodevelopmental disorder defined by impairing levels of inattention, disorganization, and/or hyperactivity/impulsivity.
- Inattention/disorganization affects ability to stay on task, seeming not to listen, and losing materials at levels inconsistent with age/developmental level.
- Hyperactivity/impulsivity includes overactivity, fidgety, inability to stay seated, intruding into other people's activities, and inability to wait.

- In children, ADHD often overlaps with other "externalizing disorders" such as oppositional-defiant disorder and conduct disorder, and frequently occurs co-morbidly with other disorders such as specific learning disability
- ADHD frequently persists into adulthood, with social, occupational, and related ramifications

CAPD (ASHA, 2005; AAA, 1010):

- is a deficit in the perceptual processing of auditory stimuli, and the neurobiological activity underlying that processing
- 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
• Affects the perceptual and neural processes in CNS underlying:
  – Localization/lateralization
  – Discrimination
  – Auditory pattern recognition
  – Temporal processing
  – Performance with competing/degraded acoustic signals

Presenting Symptoms of ADHD and CAPD

<table>
<thead>
<tr>
<th>ADHD</th>
<th>CAPD</th>
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</thead>
<tbody>
<tr>
<td>1. Inattentive</td>
<td>1. Difficulty hearing in background noise</td>
</tr>
<tr>
<td>2. Distracted</td>
<td>2. Difficulty following oral instructions</td>
</tr>
<tr>
<td>3. Hyperactive</td>
<td>3. Poor listening skills</td>
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<tr>
<td>4. Fidgety/restless</td>
<td>4. Academic difficulties</td>
</tr>
<tr>
<td>5. Hasty/impulsive</td>
<td>5. Poor auditory association skills</td>
</tr>
<tr>
<td>6. Interrupts/intrudes</td>
<td>6. Distracted</td>
</tr>
<tr>
<td></td>
<td>7. Inattentive</td>
</tr>
</tbody>
</table>

Pediatrician and Audiologist Rankings of Presenting Symptoms in ADHD and CAPD (Chermak, Somers, & Seikel, 1998)
**Pediatrician and Audiologist Rankings of Presenting Symptoms in ADHD Predominantly Inattentive Type and CAPD (Chermak, Tucker, & Seikel, 2002)**

<table>
<thead>
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<th>ADHD (Most Common)</th>
<th>CAPD (Most Common)</th>
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<tr>
<td>Inattentiveness</td>
<td>Poor listening skills</td>
</tr>
<tr>
<td>Academic difficulties</td>
<td>Requesting repetitions</td>
</tr>
</tbody>
</table>

- **Symptoms Reported as Common ONLY in ADHD-PI:**
  - Inattentiveness
  - Daydreaming
  - Disorganization

- **Symptoms Reported as Common ONLY in CAPD:**
  - Auditory sustained attention deficit
  - Auditory selective attention deficit
  - Difficulty following oral instructions
  - Slower information processing
  - Poor memory
  - Difficulty discriminating speech

- **Symptoms Reported as Common to BOTH ADHD-PI and CAPD**
  - Academic difficulties
  - Distraction
  - Poor listening skills
  - Requesting repetition
  - Auditory divided attention deficit
  - Difficulty hearing in background noise

(Chermak et al., 2002)
Implications

• Both CAPD and ADHD are heterogeneous disorders
• While some behaviors overlap, several characteristics distinguish between the two disorders
• ADHD-Predominantly Inattentive Type is more challenging to differentiate from CAPD than is ADHD – Predominantly Hyperactive/Impulsive or ADHD – Combined

Methods of Diagnosing ADHD and CAPD

Diagnosing ADHD

• “No biological marker is diagnostic for ADHD” (APA, 2013, p. 61)
• Diagnosis is made primarily on the basis of symptoms checklists
• Diagnosis of ADHD includes the following types:
  – Predominantly Inattentive
  – Predominantly hyperactive/Impulsive
  – Combined presentation
  – (Other)
  – (Unspecified)
DSM-V Criteria (Cliff Notes Version)

• Persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development, as characterized by (1) and/or (2):
  – Inattention: (6 or more of the following symptoms persisting for at least 6 months...)
    • Careless mistakes/inattention to detail
    • Difficulty sustaining attention
    • Does not seem to listen (mind is elsewhere, even in absence of distractors)
    • Does not follow through on instructions
  – Hyperactivity and Impulsivity: 6 or more of the following symptoms persisting for at least 6 months:
    • Is fidgety
    • Often leaves seat when remaining seated is expected

• Has difficulty organizing tasks and activities
• Avoids, dislikes, or is reluctant to engage in activities requiring sustained mental effort
• Loses things necessary for tasks/activities
• Is easily distracted by extraneous stimuli
• Is forgetful in daily activities

• Symptoms were present prior to age 12 years
• Symptoms are present in two or more settings
• There is clear evidence that symptoms interfere with or reduce the quality of social, academic, or occupational functioning

• Symptoms do not occur exclusively during schizophrenia or other psychotic disorder and cannot be explained better by another mental disorder

• Diagnosis should specify whether it is combined, predominantly inattentive, or predominantly hyperactive/impulsive

• Use “Other ADHD” when full criteria are not met AND the clinician indicates the specific reason that the criteria are not met

• Use “Unspecified ADHD” when full criteria are not met and the clinician does NOT indicate the specific reason or in which there is insufficient information

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**Diagnosing CAPD**

• Purpose of Diagnostic Testing: To identify presence and delineate characteristics/nature of central auditory deficit

• Requires *audiologist-administered* diagnostic tests of central auditory function that have been shown to be sensitive/specifc for identification of disorders of the CANS
• Provides information regarding integrity of left-hemisphere, right-hemisphere, interhemispheric, and brainstem auditory structures

• May include psychophysical and/or neuro(electro)physiologic tests of central auditory integrity

• Leads directly to development of deficit-specific treatment and management plans

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
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 complex signals (e.g., speech-evoked ABR, complex ABR)

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., speech-evoked ABR)

Test Battery Interpretation

- Norm-referenced criteria
- Using the patient as his/her own control (inter- and intra-test pattern analysis using neurophysiologic tenets)
• A diagnosis of (C)APD is enabled only when performance on > 2 tests is abnormal AND the pattern of findings is consistent with underlying neuroscience tenets (ASHA, 2005; AAA, 2010)

• Lack of a pattern (e.g., poor performance on all measures, inconsistent findings across tests) argues for more global or motivational deficit, not (C)APD

• Differential diagnosis requires administration of sensitized tests of central auditory function and multidisciplinary input to evaluate functioning across domains

Patients with ADHD typically:
• Exhibit no clear auditory pattern (all normal or uniformly depressed; inconsistency in test performance)
• Exhibit poor performance on vigilance tasks (auditory and visual)
• Often report that their complaints are improved or ameliorated by medication
• When overall performance is considered, children with ADHD may perform more poorly (and similarly to children with CAPD) on behavioral tests of central auditory function than typically developing children.

Bellis, Billiet, & Ross, 2011

Bellis, Billiet, & Ross, 2011
However, when intra-test analyses are carried out (ear differences, response condition differences), behavioral tests of central auditory function are sufficient to differentiate children with CAPD from those with ADHD and from typically developing children.
Therefore, analysis of inter- and intra-test patterns of performance is CRITICAL for differential diagnosis of (C)APD and ADHD.
Case Study

• 10 y/o female, first seen in November, 2010
• Diagnoses: ADHD, PTSD, mood disorder NOS
• Borderline cognitive ability; however, scatter in test results suggested testing was not reliable
• Speech and language concerns included inadequate pragmatics, listening, reading, and writing

• Additional difficulties included significant impulsivity, anger control issues, and extreme social language concerns (including identifying common emotions, understanding social gaffes, and understanding conflicting messages)
• Auditory complaints included:
  – Difficulty hearing in noise
  – Difficulty following directions
  – Inability to interpret prosody (including humor, sarcasm, etc.)
• Psychologist, SLP, and foster parent all noted that auditory difficulties seemed “out of proportion” to her other difficulties, despite her complex presentation.
MLR – Left Ear

- Impressions:
  - Results support presence of central auditory deficit as a contributing factor to difficulties, possible right-hemisphere site of dysfunction
- Recommendations:
  - Environmental modifications
  - Central resources training
  - Direct remediation to include dichotic listening training and temporal patterning/prosody training

- Patient did not undergo any remediation as she was remanded to a residential facility for children with psychiatric disorders

- Epileptiform activity over right hemisphere was confirmed. Medications were adjusted, some progress was made relative to PTSD and mood disorder; HOWEVER, auditory and attention complaints persisted.
• Patient returned to our clinic in March, 2012 for continuing auditory complaints.
• Impressions:
  – Results continued to support presence of central auditory
deficit as a contributing factor to difficulties, consistent
with documented right-hemisphere site of dysfunction
  – Improvement in right-ear MLR noted; however, left-ear
MLR continued to support central auditory dysfunction
  – P300 absent, consistent with diagnosis of ADHD
• Recommendations (same as 11/10):
  – Environmental modifications
  – Central resources training
  – Direct remediation to include dichotic listening training
    and temporal patterning/prosody training
• Patient was discharged to foster home. Underwent 8 weeks of dichotic listening training.
• Temporal patterning/prosody training and other recommendations were not conducted due to unavailability of services
• Patient returned for post-therapy re-test in May, 2012.

CAPD Test Results: May, 2012

MLR-Right Ear
Significant improvements in central auditory function were observed following 8 weeks of dichotic listening training. These improvements were reflected in behavioral and electrophysiologic test measures. However, concerns regarding attention remained.

Summary

- CAPD and ADHD are distinct diagnostic entities
- CAPD and ADHD frequently co-occur, due to shared neuroanatomical substrates
- Differential diagnosis of ADHD and CAPD requires determination of whether the disorders are co-morbid, or whether ADHD or CAPD is the primary (or sole) disorder
• Inter- and intra-test pattern analysis of central auditory test results is critical for differential diagnosis of CAPD and ADHD
• Deficit-specific intervention is important for both disorders, as is a multidisciplinary team approach to differential diagnosis and management/treatment

References


