(Central) Auditory Processing Disorder
“A Hearing Loss of the Brain”

Saravanan Elangovan, Ph.D
Dept of Audiology & Speech Pathology
East Tennessee State University
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(Central) Auditory Processing Disorder: “A Hearing Loss of the Brain”

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- (Central) Auditory Processing
- Brief Review of Neuroanatomy
- Auditory Processing Disorder (APD)
  - Behavioral Manifestations of APD
- Assessment of APD
- Management of APD
Introduction

- For a lay man, when someone talks about hearing abilities, he/she would think primarily of the processing that occurs in the ear; that is, the ability to detect the presence of sound.
  - Likewise, when someone is described as having a hearing problem, we assume that this individual has lost all or part of the ability to detect the presence of sound.
- However, the ability to detect the presence of sounds is only one part of the processing that occurs within the auditory system.
Introduction

- There are many individuals who have no trouble detecting the presence of sound, but who suffer from other types of auditory difficulties.
  - Such as difficulties understanding conversations in noisy environments, problems following complex directions, difficulty learning new vocabulary words or foreign languages, etc.
- These difficulties, especially in young children, can affect their ability to develop normal language skills, succeed academically, or communicate effectively.
Introduction

- Since these individuals appear to "hear normally," the difficulties these individuals experience are often presumed to be the result of other problems such as attention deficit, a behavior problem, a lack of motivation, or other psychological problems.

- Because of this, the individual may receive medical and/or remedial services that may not directly address the underlying "auditory" deficit.
(Central) Auditory Processing

- Katz, Stecker & Henderson (1992) described central auditory processing as "what we do with what we hear."

- Broad definition … “the efficiency and effectiveness by which the Central Nervous System (CNS) utilizes auditory information”
(Central) Auditory Processing

Central auditory processes refer to auditory system mechanisms and processes responsible for the following behavioral phenomena (ASHA, 1996) -

- Auditory discrimination
  - Ex., /pa/ vs. /ba/
- Auditory pattern recognition
- Auditory Memory
  - Ability to remember information like directions or lists
(Central) Auditory Processing

- Auditory performances with degraded signals (auditory closure)
- Binaural localization and lateralization
- Auditory performance with competing acoustic signals
  - Cocktail Party Effect
- Temporal aspects of audition – Identifying finer time aspects within auditory stimuli
  - Perception of Intonation, stress, rhythm in speech
### Brief Review of Neuroanatomy

<table>
<thead>
<tr>
<th>Auditory Structure</th>
<th>Key Contributions to Auditory Processing</th>
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<tbody>
<tr>
<td>Auditory Nerve</td>
<td>Breakdown of incoming signal from cochlea into constituent components via phase-locking, tonotopic organization, adaptation, and suppression for relay to higher CANS structures</td>
</tr>
<tr>
<td>Cochlear Nuclei</td>
<td>Contrast enhancement of modulations and transients in the signal and preliminary feature extraction via convergence and divergence and differential cell responses</td>
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<tr>
<td>Superior Olivary Complex</td>
<td>Coding of binaural cues via convergence and divergence from ipsilateral and contralateral cochlear nuclei for localization, lateralization, and binaural integration</td>
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<tr>
<td>Inferior Colliculus</td>
<td>Further enhancement of amplitude modulations and binaural cues; division of ascending pathway into primary and diffuse auditory systems</td>
</tr>
<tr>
<td>Medial Geniculate Body</td>
<td>Primary way station for information between brainstem and cortex; coding of stimuli with slowly changing acoustic parameters such as vowels and syllable contrasts differing in duration; additional binaural encoding, contrast and modulation enhancement, feature extraction, and complex signal processing; multimodality integration</td>
</tr>
<tr>
<td>Primary Auditory Cortex</td>
<td>Coding of rapid acoustic events necessary for fine-grained discrimination, especially of consonant stimuli; development of the concept of auditory space for localization</td>
</tr>
<tr>
<td>Auditory Association Cortex</td>
<td>Recognition of linguistic stimuli, comprehension of spoken language, some language formulation capacity</td>
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Brief Review of Neuroanatomy

- Yet another structure that is important in central auditory processing and language comprehension is the corpus callosum.
  - Role includes localization, auditory figure-ground abilities, linking of prosodic and linguistic input for judging communicative intent, pragmatics, etc
- Corpus callosum is one of the last cortical structures to reach physical maturity.
Language, Literacy & Auditory Processing – Shared Anatomy

Computer image of a brain showing areas of intense activity when words are being heard. (Posner & Raichle, 1994)
What is an Auditory Processing Disorder?

- Children and adults with auditory processing disorder (APD) are a heterogeneous group of people who have difficulty using auditory information to communicate and learn.

- It is a deficit in the processing of auditory input which may be exacerbated in unfavorable acoustic environments and is associated with difficulty listening, speech-language understanding, language development and learning (Jerger and Musiek, 2000)
Auditory Processing Disorder (APD)

- Definition: “APD is broadly defined as a deficit in the processing of information that is specific to the auditory modality.”

- The prevalence of APD in children is estimated to be as high as 3 to 5% (Chermak & Musiek, 1998), with it being twice as prevalent in males.
Some Behavioral Manifestations of APD
(Schminky & Baran, 2000)

- Difficulty hearing in noisy situations
- Difficulty following long conversations
- Difficulty hearing conversations on the telephone
- Difficulty learning a foreign language or challenging vocabulary words
- Difficulty remembering spoken information (i.e., auditory memory deficits)
- Difficulty taking notes
Behavioral Manifestations of APD

- Difficulty maintaining focus on an activity if other sounds are present
- Difficulty with organizational skills
- Difficulty following multi-step directions
- Difficulty in directing, sustaining, or dividing attention
- Difficulty with reading and/or spelling
- Difficulty processing nonverbal information (e.g., lack of music appreciation)
Auditory Processing Disorders: Indicators in Early School Age Population (e.g., kindergarten)

- Behavior typical of peripheral hearing loss, but normal audiogram
- Scatter in results on psychological and language tests, with weakness in auditory domains
  - Verbal IQ score lower than performance IQ score
- May have poor musical skills
- Problems with fine and/or gross motors skills
- Teacher and/or parent concern about hearing and listening abilities (and the audiogram is normal)
- Difficulty learning rhymes
Auditory Processing Disorders: Indicators in Early School Age Population

- Has difficulty following multi-step directions
- Poor reading and spelling skills (remediation not effective)
- Responds inappropriately in the classroom
- Reluctant to participate in class discussions
- Positive history of middle ear disease and hearing loss
Problems in testing and diagnosing APD

- Other types of childhood disorders may exhibit similar behaviors.
  - E.g., Attention Deficit Hyperactivity Disorder (ADHD), language impairment, dyslexia, autistic spectrum disorders, cognitive impairment.
- Some audiological test batteries may fail to distinguish APD from children with other problems.
Problems in testing and diagnosing APD

- Moreover, these conditions are not mutually exclusive.
- Other confounding factors, e.g., lack of motivation, attention, present medications, motor skills, native language, cooperation and understanding, fatigue, etc.
AUDITORY PROCESSING DISORDERS (APDs):
Co-existing Disorders (Co-morbidity)
Differentiation Between APD & ADHD

- Only 2 (i.e., inattention & distractibility) of the 11 most frequently cited behaviors reported as common to both condition.
  - Chermak et al., 1998

- Further, the attention deficits of ADHD are pervasive and supramodal, affecting all modalities more or less equally.

- Individuals with APD demonstrate attention deficits restricted to auditory modality.
APD and ADHD

- Distinct deficits seen with APD includes –
  - Left-ear deficit on dichotic speech tests
  - Depressed auditory performances with ipsilateral/contralateral competition

<table>
<thead>
<tr>
<th>Attention Deficit Hyperactivity Disorder</th>
<th>Auditory Processing Disorder</th>
</tr>
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<tbody>
<tr>
<td>Inattentive</td>
<td>Difficulty hearing in noise</td>
</tr>
<tr>
<td>Distracted</td>
<td>Difficulty following oral instructions</td>
</tr>
<tr>
<td>Hyperactive</td>
<td>Poor listening skills</td>
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<tr>
<td>Fidgety or restless</td>
<td>Academic difficulties</td>
</tr>
<tr>
<td>Hasty or impulsive</td>
<td>Poor auditory association skills</td>
</tr>
<tr>
<td>Interrupts or intrudes</td>
<td>Distracted</td>
</tr>
<tr>
<td></td>
<td>Inattentive</td>
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Diagnosis of APD

- The purpose of the auditory processing evaluation is to help define the specific auditory processing difficulties that a child may be experiencing and to recommend appropriate remediation.

- Performance on auditory processing tests is measured according to chronological age expectancies.
  - Development of the auditory processing pathways continues up to age 12 or 13 years.
Diagnosis of APD requires a multidisciplinary approach

- Detailed case history and audiological evaluation to check peripheral hearing
- Tests of language, cognition (e.g. verbal and non-verbal reasoning), and short term auditory memory
  - Speech-Language pathologists, Pediatric Psychiatrist/Psychologists, Psychoeducational evaluations.
- Other: Observation of the child in the classroom (Teacher/Educational Diagnostician), Visual testing.
APD testing: Screening Procedures

- Screening by Questionnaire: Observation of target behaviors via questionnaires
  - Fisher's Auditory Problems Checklist (Fisher 1985) for Kdg.to grade 6
  - Children’s Auditory Processing Performance Scale (CHAPPS) by Smoski, 1990

- Screening by Test
  - Dichotic Digits test (Musiek, 1983)
  - Screening gap-detection tests
  - SCAN-C Test for Auditory Processing Disorders in Children (Keith, 1986)
Auditory Test Battery (~ 90 minutes)

- Some specific auditory processes tested include -
  - Auditory performance with competing acoustic signals. Ex., SCAN auditory-figure ground subtest
  - Auditory performance with degraded acoustic signals. Ex., SCAN filtered words subtest
  - Dichotic Listening Tests. Ex., Dichotic Digits Test
  - Pattern Recognition Tests. Ex., Pitch Pattern Test
  - Phonemic Decoding Skills. Ex., Phonemic Synthesis Test
Management of APD

- Management programs for individuals with APD need to be designed with consideration to the specific deficits identified during assessment.
- There are three different approaches that are tailored to each individual (Ferre, 1997).
Management of APD

Environmental Modifications

- The goal is to improve access to orally presented information.
- Include –
  - The use of electronic devices that assist listening
  - Reducing background noise and reverberation,
  - Methods of altering the learning environment so that the child with APD can focus his or her attention on the message are used (such as preferential seating in classrooms).
Classroom Assistive Listening Devices

Personal FM
Headset Style

Sound Field FM

Infrared
Management of APD
Compensatory Strategies

- The goal is to assist listeners in strengthening their central resources including language, problem solving, memory, attention, and other skills.

- These encourage the individual with APD to take on an active role to facilitate effective communication. Examples include
  - Requesting repetition or Paraphrasing of information
  - Chunking – grouping parts of a whole message into smaller units.
  - Organizational aids
Management of APD
Direct Intervention

- Deficit specific management aimed to improve auditory processing as well as language and academic performance.
  - Auditory training is a commonly used as an intervention for improving auditory processing.
    - Intervention by speech pathologist on a one-on-one or group sessions
    - Computer-assisted auditory training programs
Computer-assisted auditory training programs

- Can be used in the clinic, school or home environment.
- They target literacy skills, language, attention, problem-solving, and memory.
- Research suggests that computer-based therapy is highly motivating and enjoyable.
- Two commonly used programs –
  - Earobics (Cognitive Concepts)
  - FastForWord (Scientific Learning Corporation)
Earobics

• This program is available in 3 levels: for young children, older children and adolescents/adults.
• Is also available for parents or professionals (home or clinic use)
• Instructions available in 10 languages
FastForWord

- Based on research that showed children with abnormal temporal processing and language learning impairment could have their phonological awareness improved in parallel with their temporal processing

- Consists of 11 individual products -
  - Fast ForWord Language series
  - Fast ForWord Literacy series
  - Fast ForWord Reading series

http://www.scilearn.com/
Apps to improve Auditory Processing Skills
Conclusion

- Assessment and management of APD should be a multidisciplinary approach.
- Assessment and Management should be individually tailored based on presenting complaints, age, intelligence, language skills and other co-morbid conditions.
Conclusion

"Have you ever tried to join a conversation but, because you had missed some of what had been said, your contribution was off the topic? Unless you were with close friends or family…, it is likely that one of two things happened: either the others in the discussion politely ignored your input….or…glances were exchanged along with barely suppressed titters of laughter discreetly behind cupped hands….Can you imagine this situation occurring almost every time you try to converse? … For individuals with (C)APD this is a frequent occurrence, making social communication a chore rather than a pleasure“

(Bellis, p63-64, 2002).