Central auditory processing disorders: Review and case study
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Abstract
In this review paper, the prevalence and characteristics of central auditory processing disorder (CAPD) are reviewed. The causes, pathology and diagnosis of CAPD are also discussed. Recommendations are made for classroom interventions and a case study is presented. CAPDs are complex, heterogeneous disorders involving the process of auditory stimuli within the mechanisms of the central nervous system that can result in profound personal, social and academic consequences. Specificity in diagnosis, support by family members, neuroscience and allied health professionals and educators, and self-management and advocacy are required for children, adolescents and adults to have successful academic and work outcomes.

Introduction
Central auditory processing disorders (CAPD) or auditory processing disorders (APD) are complex communication syndromes related to auditory routing, identification, and sorting of auditory stimuli in the central nervous system so that these data can be correctly interpreted, understood and integrated by the individual. The communication and learning difficulties that ensue from CAPD are often complex and are highly dependent on the setting, context, personality and cognitive abilities of the individual. While the disorder may improve with neurological development through normal growth and development, most individuals live with CAPD throughout their lives. Therefore, a life-long approach with an emphasis on self-management is important (Masters, Stecker, & Katz, 1998). Central auditory processes include: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal resolution, integration and ordering; and auditory performance with degraded or competing sound (Chermak, & Musiek, 1997) and are most simply defined as “what we do with what we hear” or what goes on between the ears (Katz, 1992).

Prevalence
APDs are remarkably common estimated at between 2% to 3% (Chermak & Musiek, 1997) and 7% of the population (Bamiou, Musiek, & Luxon, 2001). It is more common in males than females with a 2:1 ratio. CAPD is often the source of other speech language disorders, dyslexias, learning and behavioural disorders. CAPD is a physical disorder according to the Americans with Disabilities Act (ADA).

Characteristics
There are many cues that an individual may have a CAPD (Schminky & Baran, 1999; Waterloo County Board of Education, 1990). They include:
1. Difficulty hearing in noisy situations
2. Difficulty following long conversations
3. Difficulty hearing conversations on the telephone
4. Difficulty learning a foreign language or challenging vocabulary words
5. Difficulty remembering spoken information (i.e., auditory memory deficits)
6. Difficulty taking notes
7. Difficulty maintaining focus on an activity if other sounds are present; child is easily distracted by other sounds in the environment
8. Difficulty with organizational skills
9. Difficulty following multi-step directions
10. Difficulty in directing, sustaining, or dividing attention
11. Difficulty with reading and/or spelling
12. Difficulty processing nonverbal information (e.g., lack of music appreciation)
13. Easily fatigued
14. Likes TV and other audio stimuli louder than normal
15. Unusually sensitive to sound
16. Memorizes poorly
17. Ignores people if “engrossed”
18. Hyper- or hypoactive behaviour patterns

Causes, pathology and diagnosis
Bamiou and colleagues (2001) noted the central auditory nervous system (CANS) includes all the anatomical and processing mechanisms between the cochlear nucleus in the brainstem to the auditory cortex in the temporal region. The cells in the primary auditory cortex are sensitive to specific frequencies and evidence based on imaging of brain activity related to those snippets of sound that get “stuck in
our heads” suggests that auditory memories are also stored in this area. This area receives direct input from the medial geniculate nucleus of the thalamus. The cortical and subcortical areas responsible for auditory processing are Heschl’s gyrus and the Sylvian Fissure. The left planum temporale is thought to control language processing. In addition to Broca and Wernicke’s areas and interconnections, an area in the parietal lobe, which has been termed Geschwind’s territory, has recently been confirmed through specialized MRI scans, which also functions to connect Broca and Wernicke’s areas and is associated with complex language abilities such as the ability to read and write (Catani, Jones, & ffytche, 2005).

There is no single cause of CAPD. The condition may be genetic, developmental or idiosyncratic, causes that are likely to persist throughout life. Additionally, CAPD may be caused by “trauma, tumours, degenerative disorders, viral infections, surgical compromise, lead poisoning, lack of oxygen and auditory deprivation” (Schminky & Baran, 1999: Strata et al., 2005). It is important to pinpoint the deficits as there is a very heterogeneous presentation to this disorder and management needs to be individualized.

CAPD cannot be tested until children have sufficient maturity to cooperate with auditory testing. This usually occurs around age six or seven. However, hearing deficits can be ruled out before this. Additionally, testing for CAPD should be repeated as the child matures due the inherent plasticity of the developing brain. Other tests that are helpful in diagnosis CAPD include: electrophysiological tests such as evoked auditory potentials that can be compared to age-appropriate norms; behavioural tests in which a message can be understood even with missing elements; auditory discrimination tests, COAT/BOAT, FISH/SHIP; dichotic digit tests (7, 4/3, 8; test of nonverbal auditory signals and patterns; auditory figure-ground problems, or discrimination of auditory stimuli with background noise; and tests of alternating speech perception (Right ear: PU A ZE AP S N SA...Left ear T DO N PLES I T HE CK). An individual should be able to process the whole sentence if the auditory stimuli are alternatively presented to each ear as: PUT A DOZEN APPLES IN THE SACK (American Speech-Language Association, 2005).

Cacace and McFarland (2005) argue that it is imperative to improve the specificity of diagnosis within the area of CAPD through research rather than reliance on expert opinion, and that CAPD should be distinguished from other cognitive, language, attentional and learning disorders. They note that CAPD currently lacks a “gold standard” for assessment and requires further investigation and refinement. Teachers, parents and health professionals all have a role in identifying children with CAPD. Often, children with CAPD have speech, language and academic problems that are apparent in both social and school situations. As part of the diagnostic process, teachers are often asked to complete observational checklists such as the Screening Instrument for Targeting Educational Risk (SIFTER), and parents are asked to complete Fisher’s Auditory Problems Checklist (FAPC).

Co-existing disabilities

While individuals with CAPD may have difficulty maintaining focus or attending to tasks and directions, the problem is with disability rather than with motivation. CAPD is often confused with attention deficit/hyperactivity disorder (ADHD), hearing disorders, social anxiety disorder, oppositional defiant disorders, developmental and cognitive disorders. While these co-morbidities are possible, diagnosis and management of CAPD may resolve or control these other concerns.

Instructional strategies

Bamiou, Campbell, and Sirimanna (2006) noted that interventions related to auditory training can be either “test driven” or “profile driven”. The best instructional strategies specifically address the individual’s assessed deficits. In this case, interventions are prescribed based on test results. However, some general principles can be applied. Profile-driven interventions are suggested based on a CAPD profile or subtype. The two most prevalent classification systems are the Bellis/Ferre model and the Buffalo model.

Interventions strategies include (Patton, n.d.; Whitehead, 1995):

- Using clear, multi-modal communication strategies
- Repetition, reiteration, having the child repeat instructions heard for omissions
- Cue for attention and eye contact
- Modify language: simple, slow, pauses, emphasize key words
- Increase response time
- Blackboard notes
- PowerPoint presentations
- Posters
- Handouts
- Class website
- Practising, pretutoring, and reviewing

Modifying/quieting the environment

- One-to-one instruction
- Small classes
- Carpentry, tennis balls on chair and desk legs
- Structured classrooms
- Individual seating close to teacher/quiet place
- Breaks from listening activities

Auditory training

- Reading
- Pronunciation
- “Earobics”
- Language-building exercises
- Chunking, chaining...

Use of devices/aids

- Computer assisted instruction and note-taking
- Auditory trainers/Assistive listening technologies/FM devices
- Study buddy
- Earplugs

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Teaching self-advocacy
- Build understanding of CAPD
- Helping the child to develop good organizational and study skills
- Self-assertiveness regarding needs for accommodation from teachers and school
- Self-monitoring of learning achievements and needs
- Rest
- Move away from distractions/ask for quiet

**CAPD case study**

Maddy presented for CAPD testing as a 12.5-year-old grade seven student who was having some speech/language difficulties, specifically, mispronouncing multi-syllable words, making some consistent grammatical errors, having difficulty following multi-part instructions, and having fairly indistinct speech that was not always easily understood by others. Maddy had experienced bouts of otitis media as a young child and she had evidenced mild speech delays as a pre-schooler with many consistent baby words such as laylee for telephone and commony for ice cream cone. However, hearing tests were normal prior to beginning school and again at age 12. Maddy was enrolled in a French immersion school from senior kindergarten to grade six.

Behaviourally, Maddy was noted to be a friendly girl who socialized well with her peers. She was described as a follower rather than a leader in social situations, hesitant with new activities, tending to stand at the back of a line and watch what others were doing prior to trying new things herself. Her mother described her as a very intuitive girl who read body language well. She took piano lessons and passed all the Royal Conservatory exams up to grade three. However, she had difficulty with playback and clap-back exercises in practice situations and on tests.

Maddy was described as a highly motivated student whose school results did not commensurate with either her apparent intelligence or effort. She had difficulty following spoken instructions, especially multi-step instructions and frequently required repetition of instructions and information. She was very distracted by background noise, doing much better on the first part of tests than the latter part when some students began moving around the classroom during a test. She found mandatory band practice “shattering”, enjoyed languages but had to work hard to acquire facility in a second language, and she frequently came home from school exhausted and headachy. While very healthy and reporting a good energy level, Maddy was described as a child who required a lot of sleep and “peace and quiet” by her mother. Maddy was born four weeks prematurely, had the cord around her neck and suffered some hypoxia prior to birth. She was delivered by vacuum extraction due to signs of hypoxia during the final stages of labour.

In very noisy environments Maddy often was observed to yawn repeatedly and she reported experiencing panic attacks characterized by heart palpitations, trembling, feeling of choking, nausea, dizziness and fear of “going crazy” from not being able to shut out the sounds. This was exacerbated when she was less able to cope due to tiredness or anxiety. Maddy often would lose focus and daydream or doodle during class or long conversations.

While Maddy’s hearing tested within normal range both at age five and age 12, the latter test suggested auditory processing problems rather than hearing deficits. She was referred to a speech language pathologist for further testing. Tests noted that her performance was below expected levels in all areas in which auditory stimuli were used and this was consistent with observations by parents and teachers. Most notably, Maddy had significant weakness in short-term auditory memory and her ability to process information deteriorated in the presence of competing noise. However, written language and vocabulary were in the high average to above-average range. These findings were consistent with a diagnosis of a central auditory processing disorder. Maddy was relieved to find that there was an explanation for her difficulties with learning and processing information. She had spent years with teachers and others telling her to “pay attention” or “focus” and not be rude by doodling or yawning. In fact, Maddy was delighted when the audiologist told her she must be “absolutely brilliant” to have survived seven years in French immersion despite a CAPD. However, she was very resistant to being singled out in any way with noticeable classroom strategies other than individual test-taking environments.

In grade nine, Maddy’s parents enrolled her in a private school that was willing to accommodate her need for small classes, individual attention and test-taking in a quiet room. She graduated with honours from high school, received a university entrance scholarship, and is currently an undergraduate student in English and International Studies. Maddy continues to need some accommodation for CAPD, especially in terms of writing tests and examinations in a quiet environment. Surprisingly, despite her auditory processing deficits, Maddy continues to study in French and is enrolled in Kiswahili at University and has done well in all courses in her first year of university.

**Summary and conclusion**

It is apparent from the review of the literature and the case study that CAPD is a neurological disorder that has significant impact on personal coping, self-esteem, and social and academic outcomes. CAPD is only fairly newly described and defined in the clinical and scholarly literature. As a result, teachers, neuroscience nurses, and allied health professionals such as audiologists, psychologists and speech language pathologists all have an obligation to become knowledgeable about the condition. They also have a role as part of an interdisciplinary team in screening, diagnosing and assisting individuals to learn to self-manage their auditory deficits in order to achieve academic, social and interpersonal goals.
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Websites of interest
Canadian Association of Neuroscience Nurses – www.cann.ca
Check this site often for updates on information. Reports will be on the website.

Canadian Nurses Association
www.cna-nurses.com

Canadian Congress of Neurological Society
www.ccns.org
Please check out their web-page to learn more about the society to which we belong. CANN is an affiliate of this society.

CCNS publishes the Canadian Journal of Neurological Sciences, which is available on-line.
www.CJNS.org

World Federation of Neuroscience Nurses
www.WFNN.org
All CANN members are automatically members of WFNN.