Language disorders associated with central auditory processing dysfunction

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Presented By

Abeer Khalifa AL Haifi

MB.Bch in Medicine

Under Supervision of

Dr. Zoher El Hoshy

Professor of Otorhinolaryngology

ENT Department Faculty of Medicine, Cairo University

Dr. Hossam El Dessouky

Assistant Professor of Phoniatrics Faculty of Medicine, Cairo University

Dr. Sahar Saad Shohdi

Assistant Professor of Phoniatrics Faculty of Medicine, Cairo University

Cairo University

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Content

List of Abbreviations

APD	*Auditory processing disorders*
CAPD	*Central auditory processing disorders*
ADHD	*Attention deficit hyperactive disorders*
SLI	*Specific language impairment*
SRD	*Specific reading disorders*
ILD	*Inter-aural level difference*
ITD	*Inter-aural time difference*
TFM	*Tolerance fading memory*
ERP	*Event related brain potential*
MMN	*Mismatch negativity*
AEA	*Auditory efferent activity*
CAEP	*Cortical auditory evoked response*
RMS	*Root-mean-square*
LP	*Learning problem*
EEG	*Electroencephalographic*
SNR	*Signal-to-noise ratio*
LLI	*Language learning impairment*

Abstract

Central auditory processing disorders (CAPD)can be described as difficulty in processing auditory information while peripheral hearing sensitivity and intellectual ability are unimpaired. Many studies were done to find any relation between central auditory processing dysfunction and language disorders such as in: autism, selective mutism, attention deficit hyperactive disorder, specific language impairment, dyslexia and learning problems. There is a major role of screening for (CAPD) in children with language disorders to use specific line of assessment to diagnose (CAPD). According to their results the intervention strategies will start by three major categories, namely environmental modifications, compensatory strategies and auditory training programs. However, further research is needed to understand the entity of language disorders associated with central auditory dysfunction and the relation between them to find the most effective intervention for individual cases.

Key Words:

Auditory Processing disorders- Central auditory Processing disorders .

Introduction

Children and adults with auditory processing disorders (APD) have problems comprehending speech. The concept of auditory processing disorders APD is often difficult for parents, educators and other professionals to understand. This is because individuals with auditory processing disorders have normal hearing but parts of the brain which analyze and interpret the sensory information from the ears do not function appropriately ***(Boon, 2007)***

Central auditory processing is often described as "what you do with what you hear" or the brain's ability to process what the ear detects **(ASHA, *1996).*** People know that we hear with our ears, but we should all remember that it is our brain that makes use of the information we hear. If the brain is unable to correctly process what is said, the message is lost or misunderstood ***(Pillow, 2003).*** Thus, differences between hearing and listening need to be clarified. Hearing is a physiological process involving the detection of sound. Listening on the other hand, involves an active attentional process (perceptual cognitive) based on binaural hearing. It develops later in childhood and is influenced by extrinsic and intrinsic factors e.g. noise, fatigue, anxiety, motivation and interest, speed of processing ***(Boon 2007).***

Central auditory processes are not attention, memory, cognition or long-term language representation but the auditory system mechanisms and means responsible for sound localization and lateralization, auditory discrimination and pattern recognition, temporal aspects of auditions and auditory performance decrements with competing and degraded acoustic signals. These processes apply to non verbal as well as verbal signals and affect many areas of daily activity including speech, language and social functioning ***(ASHA, 1996)***

Central auditory processing is a multidimensional task requiring intact auditory abilities such as closure, figure ground, cognition or selective attention**.** Professionals interested in communication disorders have worked to understand central auditory processing disorders and the possible relationship to language, reading and learning problems. It is difficult to detect which of these disorders are the primary and which are the secondary. These relationships become more complicated when other disorders, such as attention deficit disorder and low intelligence level are present ***(Keith, 1999).***

There is much controversy about the extent to which auditory processing deficits are important in the genesis of language disorders, particularly specific language impairment (SLI) and dyslexia (or specific reading disability –SRD). ***Rosen (2003)*** found that some but not all auditory skills are impaired, on average, in groups of SLT/SRD listeners. Typically only a minority of SLI/SRD listeners exhibits any auditory deficits and there is little or no relationships between the severity of the auditory and language deficits in SLI/SRD groups.

Auditory sensory processing is a crucial underpinning of the development of social cognition, a function which is compromised in variable degree in patients with pervasive developmental disorders (PDD) ***(Seri et al., 2006).*** It has been postulated that autistic children who have abnormalities in auditory information processing may be unable to engage jointly in attention with speakers –a skill that can be regarded as pivotal in autism ***(Charman, 2003)***.

Till now the role of CAPD in development of language disorders is not fully understood and still not well documented.

Aim of the work

The aim of this work is to review the literature regarding language disorders associated with central auditory processing dysfunction and study the impact of this dysfunction on the disease process and study different screening methods available to pick up suspected cases and thus be able to direct or modify the treatment plan.

Anatomy and neurophysiology

The ears are paired sensory organs comprising the auditory system, involved in the detection of sound, and the vestibular system, involved with maintaining body balance/ equilibrium. The ear is divided anatomically and functionally into three regions: the external ear, the middle ear, and the inner ear. All three regions are involved in hearing. Only the inner ear functions in the vestibular system.

The external ear serves to protect the tympanic membrane, as well to collect and direct sound waves through the ear canal to the eardrum. The canal is about 1¼ inches long, it contains modified sweat glands that secrete cerumen. Too much cerumen can block sound transmission.

The middle ear, separated from the external ear by the eardrum, is an air-filled cavity (**tympanic cavity**) carved out of the temporal bone. It connects to the throat/nasopharynx via the **Eustachian tube.** This ear-throat connection makes the ear susceptible to infection (otitis media). The eustachian tube functions to equalize air pressure on both sides of the eardrum. Normally the walls of the tube are collapsed. Swallowing and chewing actions open the tube to allow air in or out, as needed for equalization. Equalizing air pressure ensures that the eardrum vibrates maximally when struck by sound waves.

Adjoining the eardrum are three linked, movable bones called "**ossicles**," which convert the sound waves striking the eardrum into mechanical vibrations. The smallest bones in the human body, the ossicles are named for their shape. The hammer (**malleus**) joins the inside of the eardrum. The anvil (**incus**), the middle bone, connects to the hammer and to the stirrup (**stapes**). The base of the stirrup, the footplate, fills the **oval window** which leads to the inner ear

The inner ear consists of a maze of fluid-filled tubes, running through the temporal bone of the skull. The **bony** tubes, the *bony labyrinth*, are filled with a fluid called **perilymph**. Within this bony labyrinth is a second series of delicate cellular tubes, called the *membranous labyrinth*, filled with the fluid called **endolymph**. This membranous labyrinth contains the actual hearing cells, the *hair cells of the organ of Corti*. There are three major sections of the bony labyrinth:

1. The front portion is the snail-shaped **cochlea**, which functions in hearing.
2. The rear part, the **semicircular canals**, helps maintain balance.
3. Interconnecting the cochlea and the semicircular canals is the **vestibule**, containing the sense organs responsible for balance, the *utricle* and *saccule*.

The inner ear has two membrane-covered outlets into the air-filled middle ear - the **oval window** and the **round window**. The oval window sits immediately behind the stapes, the third middle ear bone, and begins vibrating when "struck" by the stapes. This sets the fluid of the inner ear sloshing back and forth. The round window serves as a pressure valve, bulging outward as fluid pressure rises in the inner ear. Nerve impulses generated in the inner ear travel along the vestibulocochlear nerve (cranial nerve VIII), which leads to the brain. This is actually two nerves, somewhat joined together, the cochlear nerve for hearing and the vestibular nerve for equilibrium ***(PATTS, 2001).***

The cochlea processes sounds (including speech sounds) by frequency, intensity, and duration. Each of these parameters contains information that is necessary for understanding speech, including phonetics and prosody. Subcortical auditory processing further refines this information, coding for frequency bands, onset and termination, sound source, frequency modulation, and intensity modulation. Therefore, when speech information reaches the cerebral cortex, it is already sophisticated ***(Webster, 1995)***.

Katz (1978) reported that the central auditory nervous system begins at the ponto-medullary junction of the brainstem where the auditory nerve fibers terminate. The afferent auditory pathways continue through the pons and midbrain to the thalamic level. Along this route, called the lateral lemniscus, many tracts are reprojected to the cerebellum and reticular formation. The most superiorly located group of brain stem nuclei, the medial geniculate, located at the thalamic level, project fibers to the primary auditory reception area of the cortex (Brodmann's area 41). From this point there are many auditory connections either directly or indirectly to various areas in each hemisphere; however the majority of the auditory sensitive fibers are in the inferior parietal or posterior half of the superior part of the temporal lobe. There is also an abundance of auditory fibers in the posterior half of the corpus callosum; an area often overlooked as part of the central auditory nervous system ***(Pandya et al.,1981)***

Information needed for speech perception enters the primary auditory cortex via the sublenticular internal capsule. Primary auditory cortex (Brodmann's areas 41 and 42) comprises the transverse gyri of Heschl. From primary auditory cortex, short association fibers project to area 22, which comprises the posterior two-thirds of the superior temporal gyrus and the planum temporale. In most people, the left area 22 is larger than the right; this asymmetry correlates with the fact that in most people left area 22 is necessary for speech comprehension. The arcuate fasciculus carries information from area 22 to the area triangularis (areas 44 and 45) and the prefrontal cortex. Along this pathway, the arcuate fasciculus interacts with the angular (area 39) and supramarginal (area 40) gyri. The left area triangularis is needed for proper expressive speech in all right-handed people and in most left-handed people ***(Webster, 1995)***.

The information extracted from different peripheral sensory receptors converges at various levels within the central nervous system. Perceptual processing relies on the integration of these multiple sensory inputs. In speech perception, an observer's final percept is determined by the ability to combine the visual images produced by the lip and mouth movements and the acoustic characteristics associated with them ***(MacDonald & McGurk, 1978).***

Although multisensory integration is crucial for the interpretation of our sensory environment, little is known about the neural mechanism underlying audiovisual speech integration ***(Joassin et al; 2004)***

It was originally suggested that information originating from different sensory modalities is treated independently at the early stages of the perceptual process, converging within high-level cortical structures in feedforward fashion ***(Massaro, 1998).*** Recent evidence, however, clearly shows that multisensory integration occurs at much lower levels of the cortical hierarchy ***(Fox & Schroeder, 2005).*** For example, audio-visual interactions can take place as early as 40 ms after stimulus onset in sensory-specific areas such as the auditory cortex ***(Molholm et al; 2002)*** and responses in the primary visual cortex can be altered by sound ***(Watkins et al; 2006).*** Notably, the timing of these interactions precludes feedback influences from high-level integration areas. Multisensory interactions are known to occur in subcortical structures such as the superior colliculus ***(Meredith & Stien, 1983).*** This midbrain structure receives visual, auditory and somatosensory inputs in order to create unified spatial percepts and spatiotopy at this level has been verified ***(DuBois & Cohen, 2000).***

It has been established that before reaching the deep layers of the superior colliculus, auditory signals necessarily pass mainly through the ipsilateral inferior colliculus ***(Winer & Shreiner, 2005).*** Similarly to the superior colliculus, multisensory interactions have been shown to occur in the inferior colliculus ***(Groh et al; 2001).*** In addition to being an essential relay in auditory processing, the inferior colliculus has the most diverse connections of any of the auditory structures in the central auditory nervous system ***(Winer & Shreiner, 2005).*** The inferior colliculus receives auditory input mainly from the contralateral ear ***(Oliver et al; 1997),*** in addition to receiving visual ***(Mascetti & Strozzi, 1988)*** and somatosensory inputs ***(Paloff & Usunoff, 1992).***

Theories of speech perception

Various theories have been advanced to explain speech perception. These theories include the psychoacoustic theory, the direct realist theory, the motor theory, and native language magnet theory. Each theory is more conceptual than mechanical and is consistent with certain experimental data. However, none is proven and none is fully explains speech perception.

The *psychoacoustic theory* assumes that the spectral and temporal characteristics of the speech signal are the sources of speech information. This information is processed by the auditory system (bottom-up) with the help of cognitive (cerebral) processes (top-down). Speech information is processed similarly to the way non speech auditory information is processed by both humans and nonhuman mammals.

The *direct realist theory* assumes that the articulatory gestures - the positions and movements of the vocal tract, including lips and tongue, during speech - are the sources of speech information. These articulatory gestures are perceived not only by their spectral and temporal acoustic cues but also by vision, and, if one touches the lips, also by tactile cues. The