REVIEW ARTICLE

A Mini Review: Visual and Auditory Perception in Dyslexia

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Keywords
dyslexia, perception, auditory, visual, audio -visual

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Received: 12 August 2020; Accepted: 8 March 2021

Doi: https://doi.org/10.31436/imjm.v20i4

ABSTRACT

Dyslexia is a reading disorder defined as the consequences of sensory impairment which can be quite tricky in diagnosis, as many symptoms of dyslexia tend to overlap with learning disabilities such as Specific Language Impairment (SLI), dysgraphia, dyscalculia, and a few others. However, as research keeps on progressing, a consensus has been made suggesting that dyslexia is commonly attributed to the impairment of auditory and visual perception. This review paper intends to discuss the detailed progression of research focusing on auditory and visual perception among dyslexics.

INTRODUCTION

Dyslexia is an impairment of reading ability described as defects in the development of reading skills.[1] This low literacy among dyslexics is caused by the inability to coordinate visual placement, poor sequencing, and left-right confusion, with all three symptoms arising from neurological impairment or syndromes. [2,3] The etiology of dyslexia is still debated, some say it is caused by impairment of visual, auditory, and even mental development, while others disagree. In 1968, the World Federation of Neurology established an official definition of dyslexia by describing it as "a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin".[4] The difficulty faced by a dyslexic individual emerges in the ability to associate the sound of words (phonemes) with the letters that they see. This is known as a phonological deficit in grapheme -phonemic decoding whereby they struggle with fluent reading and undertake laborious effort. It is even more difficult when the orthographic system has no irregular spelling-to-sound correspondence such as in the English language.[5] However, even though the irregularity of phonemic systems is one of the factors in dyslexia, it has been determined that the impairment of visual-spatial and auditory perception may also interfere with phonological development processing.

Sensory integration and sensory function are the two components needed for the cognitive and executive functions development. Stein (2018) pioneered the study of magnocellular visual impaired function in dyslexia instead of the well-known opinion in phonological weakness. Stein argued that developmental dyslexia is characterised by poor temporal processing which interferes with the sequencing of visual and auditory input and these could be a result of impaired development in the magnocellular cellular pathway in the visual brain system.[3] The magnocellular theory does not only limited to temporal processing deficit, but it eventually affects the cognitive function in processing sensory input as seen in impaired covert shifted attention, attentional shifting, divided attention among

dyslexics in which according to Facoetti et al., (2003), the causal link of deficit in sensory cognitive function is triggered by magnocellular impairments.[6] Another explanation supporting these arguments might be related to dysfunction of rapid neural adaption among dyslexics (see Perrachione et.al, 2016).

The Mechanism of Auditory Perception

The auditory system comprises of the peripheral and nervous systems. The peripheral system is divided into the outer, middle, and inner ear. Each of the parts plays a different function in terms of acoustic amplification. In the outer part, the pinna helps in collecting sound which is then amplified by the auditory canal. Next, the sound passes through the middle ear, where the mismatched impedance of different mediums (air to fluid) takes place. The bone structures of the middle ear, which are the ossicles, malleus, and incus overcome the mismatched impedance by overcoming the air-fluid pressure by boosting the pressure, creating vibration of tympanic membrane allowing transmission of sound via mechanical energy. Overcoming the mismatched impedance is essential, as the transmission of sound energy across mediums reflects back the sound energy, causing the loss of sound intensity.[7] The sound energy then travels along the basilar membrane of the cochlear creating travelling waves, allowing the amplification of sound by the outer hair cell (OHC) and leading to the transduction of electrical signals by the inner hair cell (IHC) of the Organ of Corti.[8] IHC transduces in microseconds, compared to the tens to hundreds of milliseconds relative to photoreceptors and olfactory neurons.[8]

The ability to locate sound localization is a complement factor in betterment of auditory perception, which is being supported and processed by the neurons at cochlea nuclei (CN) at the brainstem and lateral lemniscus (LL) and inferior collicullus (IC) at the midbrain. From there, the signal transduction will be projected to superior colliculi and optic tectum of vision, allowing the visual-audio integration in localizing sound sources.[8]

Figure 1 illustrates the structural basis of the auditory perception pathway starting from the outer part of the ear to the central auditory processing pathway, including the auditory cortex and higher cognitive level. Hearing is basically defined as the ability to perceive sound or acoustic stimuli (Figure 1). Human beings are able to perceive a wide range of sound frequencies (20Hz to 20KHz) and a large dynamic range of intensities (0 to 120dB). Humans perceive the acoustic stimuli with its physical attributes such as pitching and loudness.

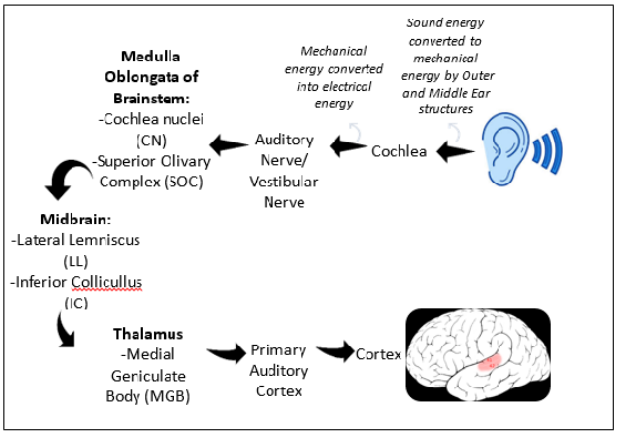

Figure 1: Figure shows the auditory perception pathway. Modified and adapted from Hernández-Zamora and Poblano (2014).[9]

In dyslexia, the mechanism of auditory processing is normally functioning in both peripheral and nervous stage. However, the empirical evidence in associating the development of phonological processing corresponding to visual input of reading had certain changes in the neural brain network compared to normal readers. This was based on the fMRI study by Blau et al., (2009) who found that the adult dyslexic readers had hypoactivation of brain region in letters and speech sound (forms through build-up of phonological knowledge) integration located in superior temporal cortex area. Due to that factor, the dyslexics probably faced difficulty in reading due to this fundamental deficit in processing basic phonological knowledge, hence affecting the grapheme phonemic conversion process that represents audio-visual integration as well. [10]

Auditory Perception Mechanism in Dyslexia

The development of language acquisition is contributed by the well-developed auditory perception in which it provides the ability in distinguishing a variety of physical properties of sound (i.e., pitch, tones, volumes, rhythms).[11] Auditory perception arises from 3 different mechanisms, which are the transduction of sound waves into electrical inputs, noise filtration, and associating sounds into recognisable bytes of memories. It was