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THE MAGNOCELLULAR THEORY OF DYSLEXIA: AN OVERVIEW, SUB-CATEGORIES AND APPLICATION IN TEACHING

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Abstract:
Worldwide, the acquisition of competent reading skills is recognised as one of the fundamental aspects in education since reading forms the basis of all academic learning. Notwithstanding this, the number of learners who do not perform well at school due to low reading levels seems to be increasing over the years in most African countries. A significant number of these is diagnosed to be dyslexic. In view of this, several researchers have taken great strides to develop theories that define dyslexia. However, none of these has managed to give an inclusive and convincing argument that is relevant in all contexts. This article therefore, focuses on the magnocellular theory in its attempt to combine the hypotheses of all major theories of dyslexia in explaining the experiences encountered by affected learners. An overview of this theory and its application in the teaching and learning process is examined as the discussion unfolds.

Keywords: application, dyslexia, magnocellular theory, reading, teaching

1. Introduction

Dyslexia is a type of a specific learning disability in which a learner's reading potential is below that of the age mates despite being exposed to adequate educational tuition (Kamala, 2014). Learners with dyslexia often experience reading challenges that differ from one to another. This depends on the type of dyslexia that an individual has and its severity. Dyslexia can either be developmental or acquired. Developmental dyslexia is caused by biological anomalies while acquired dyslexia emanates from brain damage that would have occurred after the initial acquisition of reading skills (Woollams, 2014).

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The subcategories of developmental dyslexia include auditory, visual and mixed dyslexia. Dulude (2012) cites peripheral and central dyslexia as the two main types of acquired dyslexia. Detailed knowledge of the aetiology, types, signs and symptoms of this learning disability assists in designing and providing suitable intervention.

2. An overview of the magnocellular theory of dyslexia

The magnocellular theory is a combined theory that seeks to integrate all the findings of the visual, auditory, phonological and the cerebellar hypothesis in explaining dyslexia. Proponents of the magnocellular theory contend that dyslexia is caused by a neurological impairment in the magno cells of the brain thalamus, an area which is responsible for the processing of visual and auditory stimuli (Kranich & Lupfer, 2014). This means that, when the magnocellular cells are dysfunctional, information received either through the sense of sight or hearing might not be accurately interpreted, leading to a distortion of its meaning. Benasich and Fitch (2012) further observe that, the magnocellular dysfunction may also influence the development of tactile problems found in some dyslexic learners. In other instances, all sensory modalities might be impaired.

2.1 The sub-categories of the magnocellular theory

This section outlines the sub-categories of the magnocellular theory. An attempt to describe how they are linked to it is given before briefly highlighting some of their limitations in explaining dyslexia.

2.2 The visual processing theory

This theory reflects the oldest and most popular hypothesis of dyslexia. The first proponent of the visual processing theory was Orton (1925) who maintained that, dyslexics “see" letters and words in reverse, for example; |p| for |q|, |d for b, |was| for |saw|, |ton| for |not| (Ritchey & Goeke, 2006). In view of this, Orton reasoned that images of letters are stored in both halves of the brain, but those in the right hemisphere are mirror images of those found in the opposite hemisphere. He thought that letter and word reversals in reading and writing are due to delayed lateral dominance, which resulted in the failure to suppress the "reversed" letter images in the non-dominant hemisphere. The net result was that some individuals with dyslexia see letters and words in reverse (Clark, Boutros & Mendez, 2010).

A common characteristic of the visual and the magnocellular theory is that they both explain visual difficulties experienced by some dyslexic learners as emanating from poor development of the magnocellular system, an area of the brain that is sensitive to visual motion (Shery *et al.*, 2011). This system connects the eye retina to the occipital and parietal lobes of the brain thereby allowing information brought in by the eye to be processed by the necessary areas of the brain. Stein (2018) contends that, the magnocellular system also helps to keep the two eyes fixated to converge on each word

during the process of reading. This further means that, a deficit in the magnocellular pathway leads to problems in visual processing, and, via the posterior parietal cortex, to abnormal binocular control and unstable perceptions of print.

2.3 The auditory processing theory

The claim of the auditory theory is that dyslexia may be caused by defects in the left auditory cortex (Fostick & Ram-sur, 2012). This is the part of the brain's temporal lobe responsible for sound naming, identification and temporal processing. Affected individuals may show poor performance on several auditory tasks, including frequency discrimination and temporal order judgment. They also tend to mishear words, substitute similar-sounding words for the actual auditory target and have difficulties with sound-blending or spelling (Prestes & Feitosa, 2016). Other experiences include having flat or monotonic speech when reading and receptive language deficits that encompass semantics and syntax. A phonological deficit in some learners with dyslexia is secondary to a more basic auditory impairment (Richardson, Thomson, Scott & Goswami, 2004). This means that, poor processing of auditory information is the direct cause of phonological deficits that may further result in retarded reading. The relationship between the magno-cellular and auditory theory is that, some proponents of the latter view dyslexia as a result of mild auditory magno-cellular impairment (Richardson et al, 2004). This means that, any slight deficit in the magnocellular pathway linked to audition may eventually lead to dyslexia.

2.4 The phonological deficit theory

According to the phonological deficit theory, dyslexics have a specific sound manipulation impairment, which affects their auditory memory, word recall, and sound association skills when processing speech (Caylak, 2010; Press, 2012). The theory contends that competence in reading an alphabetic system requires effective learning of the grapheme- phoneme correspondence and if sounds are poorly represented, stored or retrieved, the mastery of grapheme-phoneme correspondence is affected accordingly (Caylak, 2010).

As such, the phonological theory reveals a straight forward link between a cognitive deficit and the behavioral problem of concern. At the neurological level, it is usually assumed that the origin of the disorder is a congenital dysfunction of left-hemisphere of the brain areas underlying phonological representations, or connecting between phonological and orthographic representations (Prestes & Feitosa, 2016). The evidence of dyslexia in certain individuals is poor performance on tasks that require competence in phonological awareness, phonics, vocabulary, fluency and reading comprehension (Ramus, Marshall, Rosen & Heather, 2013). Poor verbal short-term memory and slow automatic naming in some dyslexics also points to a more basic phonological deficit, perhaps having to do with the quality of phonological representations, or their access and retrieval (Press, 2012).

2.5 The cerebellar theory

The cerebellar theory is primarily based on the observation that some learners with dyslexia show a variety of motor problems caused by a cerebellar impairment (Nicolson, Fawcett & Dean, 2001). These can be depicted in overall clumsiness, poor manual dexterity, balance and coordination. Stein (2018) describes the cerebellum as a large brain mass that is responsible for the acquisition of motor skills necessary for balance and co-ordination. Also, the role of the cerebellum in automatisation cannot be over emphasised (Clark, Boutros & Mendez, 2010). Rapid Automatised Naming (RAN) denotes one's ability to quickly identify visuals, such as numerals, letters, colours and objects. Swanson, Harris and Graham (2013) relates RAN to a combination of phonological, orthographic and processing skills which represent a similar microcosm of cognitive tasks that are involved in reading development. Since RAN has a strong correlation with reading proficiency it means that, associated skills can be considered in the assessment of learners with a reading disability. On a different note, some dyslexic learners' handwriting can be directly linked to a cerebellar dysfunction hypothesis as this skill requires precise timing and co-ordination of diverse muscle groups' (D' Angelo & Casali, 2013).

Ramus (2004), observes that the relationship that exists between the magnocellular and the cerebellar theory is that a generalised dysfunction of magno-cells does not only affect sensory pathways but also spreads to the posterior parietal cortex and the cerebellum. This encompasses all the known cognitive, sensory, and motor manifestations of dyslexia. In view of this, Clark et al. (2010) posit that, when the dyslexic's cerebellum is mildly impaired, often due to dysfunctional magno-cells, this does not only affect their automatisation skill but also their formation of words using the tongue and facial muscles. This results to poor articulation of words. Affected learners often read slowly, with effort and less fluency. It is, moreover, postulated that, retarded or dysfunctional articulation would further lead to deficient phonological representations.

2.6 A critique of the sub-categories of the magnocellular theory

The magnocellular theory, unique in its ability to account for all manifestations of dyslexia, is attractive. However, like all the other theories it has some limitations that are mostly depicted in its subcategories (Ramus, 2004). One line of criticism emphasises its several failures to replicate findings of visual deficits in some learners with dyslexia and inconsistencies between assumptions and results established after an investigation (Kranich & Lupfer, 2014). The visual aspect of the magno-cellular theory also does not explain the contribution of other mechanisms involved in reading, although it acknowledges the existence of auditory and phonological problems in some learners affected (Caylak, 2010).

Another line of criticism is failure of the auditory processing theory to account for the existence of auditory deficits in some learners with dyslexia. This means that some investigations have established an intact rapid auditory processing ability in

affected individuals (Stein, 2018). Other studies however, do find auditory impairments in a sub-group ranging from a few isolated persons to about half of the population under study (Richardson *et al.,* 2004). Another limitation posed by this theory is that it does not account for the visual or automatic reading contribution to reading. Nonetheless, it can be applauded for attempting to show the link between audition, phonological awareness and production of speech.

Furthermore, the major weakness of the phonological theory is that it focuses more on the relationship between letter symbols and sounds but fails to account for the existence of sensory and motor impairments in some learners with this learning disability. Proponents of this theory tend to dismiss these disorders based on the conviction that there are not basic features of dyslexia. This means that, while they consider the co-existence of motor impairments with phonological deficits as potential signs of dyslexia, they do not perceive them as playing a causal role in the existence of this reading disorder (Ramus *et al.,* 2013).

This study argues that the cerebellar theory fails to account for sensory disorders found in some learners with dyslexia. While this hypothesis puts emphasis on motor impairment, it does not specify the proportion of dyslexics that are affected by motor problems. Kronbichler *et al* (2002), observe that studies previously conducted have had varying results with some failing to establish any while others identifying them in a subgroup of affected persons. Ramus et al. (2013), further clarify that motor dysfunction is normally found in dyslexic learners who also have attention-deficit hyperactivity disorder (ADHD).

3. Application of the magno-cellular theory in teaching

The magnocellular theory as a unit of key theories of dyslexia substantiates that the reading challenges experienced by individuals affected differ from one to the other hence the need to conduct a detailed assessment procedure before giving any intervention. The following section discusses strategies that may be employed to improve visual, auditory, phonological processing of information and automatic reading potential in specific groups of learners with dyslexia. The final section will focus on multi-sensory teaching as the ultimate proposal of the magno-cellular theory.

3.1 Visual Processing of Information

To counter the visual processing difficulties faced by some dyslexics, teachers must consider the adoption of strategies that can improve visual perception of information. In view of this, Autrey and DeMuth (2012) suggest that educational tasks that may improve visual discrimination of objects utilise grouping, sorting and matching activities. For learners to understand differences that exist in objects, an awareness of their distinct features which include shape, size and colour is paramount, hence the usefulness of various media in the teaching process cannot be disputed. Marshall (2008) substantiates that, in the actual representation of reading matter, learners may be

guided through an analysis of how letters and words are formed and arranged to develop meaningful phrases. Furthermore, individuals with visual closure deficits may need to be afforded an opportunity to read new words or content, repeatedly, until mastery has been attained (Moustafa & Ghani, 2016). After a while, the same work may be presented with missing elements, for learners to complete as expected. Use of previously learnt knowledge as a base for mastering more complex content is also important because it does not only aid the memory of some dyslexic learners but further makes learning of new content easier. In this case, it implies using words already learnt to decode new ones (Press, 2012).

3.2 Auditory Processing of Information

To meet the needs of dyslexic learners with auditory processing deficits, the significance of providing a least-restrictive learning environment that can enhance higher-order listening cannot be over-emphasised (Tallal, 2012). Furthermore, speech-sound training for those with difficulties in decoding information must be afforded by credible role models or teachers so that accurate demonstrations are presented (Moustafa & Ghani, 2016). Educational activities that improve symbol-sound association may also be helpful to dyslexics who experience sound blending problems or confusion with similar-sounding words. In addition, Mather and Wendling (2012) emphasise the importance of teaching intonation during oral reading to learners who have flat, monotonic speech or have difficulties with rhythm. For those who demonstrate semantic difficulties, such as poor use and understanding of antonyms, categorizations, synonyms or homonyms, the teacher should directly teach these language aspects after identifying the individual needs. Above all, the adoption of teaching strategies that enhance auditory comprehension and memory, such as chunking, verbal chaining, mnemonics, rehearsal, paraphrasing and summarising may be beneficial to affected learners.

3.3 Phonological processing of information

In meeting the needs of dyslexics with phonological processing difficulties, orthographic mastery must be stressed. Through this, words are processed as a unit rather than their individual component sounds to yield meaning. One significant aspect in this process is guiding learners towards phonologic mastery. In view of this, Birsh (2011) emphasises that, phonological awareness leads to the ability to look 'inside' words for syllables, rhymes, and individual sounds. This implies that, learners with dyslexia should be taught how to segment, blend, and manipulate syllables and sounds for effective reading. The phonics must also be taught through an explicit phonics instruction. This is an organised programme in which letter-sound correspondences are taught systematically (Berninger & Wolf, 2009). Also, in teaching decoding skills, the relevance of a systematic explicit instruction of linguistic awareness which encompasses phonological, orthographic, morphological awareness and phonics skills cannot be disputed.

3.4 Automatic word recognition and fluency training

To meet the needs of learners with dyslexia who have poor automatic word recognition and fluency, Berninger and Wolf (2009), state that the development of accuracy in letter-sound associations, is necessary. Affected learners may then be guided through the development of automaticity in single words then a combination of patterns may follow (Trezek & Hancock, 2013). Another strategy is giving reading tasks that match the reading potentials of learners. These should be carefully selected, so that the learner is not frustrated by being exposed to material that is too difficult for his capabilities. Chunking of text is also another way of improving automatic reading. This involves the breaking down of information into manageable units. Through this process, slow readers can focus on a reading task for a longer period before the introduction of more complex reading skills. Bexkens *et al.* (2014) also contend that dyslexics typically need more time to name the RAN items compared to their peers irrespective of the orthographic complexity of one's language. However, multiple readings of text may subsequently influence improvements in reading speed, accuracy, comprehension and expression, hence all these are categorised as aspects of automatisation.

3.5 Multi-sensory teaching

The magno-cellular theory, ultimately proposes the adoption of multi-sensory approaches in teaching learners with dyslexia. This involves making clear links amongst the visual, auditory, kinaesthetic and tactile senses (Marogna, 2012). Visual pathways rely on the sense of sight, the auditory on hearing while kinaesthetic hinges on feelings and touch (Moats & Dakin, 2008). The visual method focuses on assisting learners to identify and differentiate letters and words while in the auditory method, there are trained to identify the auditory sounds and gradually match letters with specific sounds. Furthermore, in using the sense of touch, learners are assisted to use their hands to mould or write certain symbols or letters (Moustafa & Ghani, 2016). This implies that, learners with dyslexia can learn better by remembering the letters if they see, produce, pronounce, and write them. It can therefore, be concluded that multi-sensory teaching builds on learners' strong sensory channels while developing the weaker ones.

3.6 Presentation of learning content

The strategies and techniques employed in delivering content to learners with dyslexia determine its level of mastery. Vaughn et al. (2012) suggest that the concepts taught must be systematically presented and this implies breaking down complex skills into smaller, manageable units of learning. Birsh (2011) further suggests the adoption of cumulative instruction in which the aspects of a new lesson are developed from learners' knowledge or concepts previously learnt. Presentation of content must also be explicit. This means that the teacher must ensure the provision of detailed explanations and demonstrations in the process of teaching and learning (Moats & Dakin, 2008; Vaughn *et al.,* 2012). Use of relevant media may also improve the effectiveness of

illustrations availed. In addition, the presented content must meet the specific needs of learners. This relates to individualised instruction. Above all, lessons delivered must be learner-centred. Kasim (2014) contends that, this approach acknowledges the teacher as a facilitator of learning and values every learner's voice as central to the entire learning process. This strategy also improves learner motivation, peer interaction, confidence, responsibility and active participation while reducing disruptive behaviour.

4. Conclusion

The magnocellular theory offers one of the best approaches in the education and inclusion of learners with dyslexia because through its sub-categories, the nature and causes of this learning disability are explained in detail. Variations and types of dyslexia are also exposed. The challenges faced, diverse needs and potentials of learners affected are consequently deliberated upon. This creates fertile ground for educators and other service providers to design and implement relevant intervention strategies.

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