Research in Developmental Disabilities 80 (2018) 112–130

Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Subjective and objective evaluation of visual functions in dyslexic children with visual perceptual deficiency—Before and after ten-weeks of perceptual training

Ka-Yan Leung*, Henry Ho-Lung Chan, Mei-Po Leung

School of Optometry, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong Special Administrative Region

ARTICLE INFO

Keywords:
Perception
Visual evoked potential
Dyslexia
Visual perceptual deficiency
Visual perceptual skills
Perceptual training

ABSTRACT

Aims: This pilot study investigated perceptual and electrophysiological characteristics of dyslexic children, and evaluated the immediate and prolonged effect of visual perceptual training on these characteristics in these children.

Methods and procedures: Seven dyslexic children and seven controls aged 7–8 years were recruited and completed this study. All dyslexic children completed 10-weeks of visual perceptual training. The visual perceptual skills were assessed and binocular visual evoked potentials (VEP) were recorded with two different pattern stimulations initially (Baseline), 3 months after the first assessment (Evaluation I) and 6 months after first assessment (Evaluation II).

Outcomes and results: A significant reduction ($p = 0.021$) in VEP amplitudes in the dyslexic subjects in response to 15 Hz reversal frequency at 15% contrast stimulation was found, compared with controls, prior to perceptual training. A significant correlation ($p = 0.005$) was found between the VEP amplitude with 15 Hz reversal frequency and the total score of Test of Visual Perceptual Skills (non-motor) – revised (TVPS-R). After training, dyslexic subjects scored higher in some of the visual perceptual tasks and these improvements persisted for 3 months. However, the VEP amplitude in the dyslexics showed no significant change after perceptual training.

What this paper adds

The paper suggested that dyslexic children have abnormalities in the visual pathway. The visual perceptual performance, after training, was found to be improved and this effect lasted for at least 3 months. However, no corresponding activity change was shown in the VEP after training.

1. Introduction

Dyslexia, according to the World Health Organization (1993), is a specific disorder in reading and writing, despite normal intelligence, adequate education resources and normal visual acuity. The prevalence of dyslexia is 9.7–12.6% in Hong Kong (Chan, Ho, Tsang, Lee, & Chung, 2007) while that in United State is 5–12% (Katusic, Colligan, Barbaresi, Schaid, & Jacobsen, 2001) depending on the inclusion criteria. The common presentations of dyslexic children include omissions, substitutions, distortions, or additions of words or parts of words (World Health Organization, 1993). They may also have long hesitations or "loss of place" in text, inaccurate phrasing and poor comprehension skills (World Health Organization, 1993). Dyslexics suffer from visual perceptual

* Corresponding author at: A034, School of Optometry, The Hong Kong Polytechnic University, Hung Hom, Hong Kong Special Administrative Region.
E-mail address: daisy.ky.leung@polyu.edu.hk (K.-Y. Leung).

https://doi.org/10.1016/j.ridd.2018.06.008
Received 13 April 2017; Received in revised form 18 June 2018; Accepted 19 June 2018
0891-4222/

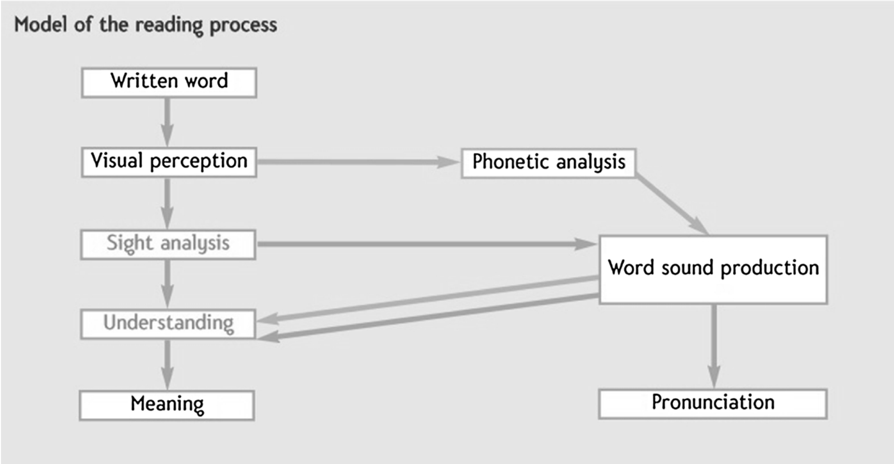

Fig. 1. Different pathways for reading process.

problems which can contribute to their disorder in reading and writing (Ho, Chan, Tsang, & Lee, 2002). It was suggested to determine if any visual dysfunction is contributing to the learning difficulties (Allen, Evans, & Wilkins, 2009). Evans (2004) illustrated the pathways of reading process shown in Fig. 1: When we read, we have to recognize simple words firstly by sight analysis, then followed by phonetic analysis, which is a process to break down complicated words into sound components. Some dyslexics have deficit in one of these two pathways (Evans, 2004). Both pathways start with visual perception and all forms of reading start with visual perception (Evans, 2004), hence visual perceptual deficiency may contribute to the learning difficulties in dyslexics. Visual perception involves visual skills for organizing and extracting visual information from the environment, and the ability to integrate this information with that from other sensory modalities and with that from higher cognitive functions (Scheiman & Rouse, 1994). Good visual perception is essential in most school activities such as writing, reading, copying and remembering letters or words. It has been reported that 75% to 90% of classroom learning is vision-related (Carol, 2005). Therefore, any disorder in visual perception can greatly hinder learning and academic performance in school.

Our visual system has complementary pathways, the magnocellular pathway (M-pathway), parvocellular pathway (P-pathway) and koniocellular pathway (K pathway), which have different physiological characteristics but with a degree of cross-talk (Merigan & Maunsell, 1993). The M-pathway substrate is the large ganglion cells, which are widely distributed across the retina, and whose axons pass to the ventral lateral geniculate nucleus (LGN); information is then transmitted to the visual cortex. It responds to low contrast stimuli with high temporal frequencies and low spatial frequencies. The M-pathway is responsible for perceiving rapidly flickering or moving stimuli. The P-pathway substrate is cells mainly at the fovea, and whose axons pass to the dorsal LGN; information is then transmitted to the visual cortex. It responds to high contrast stimuli with low to moderate temporal frequencies and high spatial frequencies. The P-pathway is responsible for perceiving colour and fine detail (Merigan & Maunsell, 1993). The K-pathway is the least studied, K cells are very small and form six thin layers in the LCN, not much is known of their receptive field properties (Martinovic, 2016; Sherman, 2009). K pathway was through to response to blue/yellow chromatic stimuli; in addition, it contributes to motion processing as K-cells project directly to motion-sensitive cortical area (MT/V5). (Martinovic, 2016; Sherman, 2009) It has been suggested that 70–75% of dyslexics have a disorder in the M-pathway (Lovegrove, 1993; Lovegrove, Martin, & Slaghuis, 1986). A histological study has shown a significantly smaller size of magnocellular cells in the brains of dyslexics, but no significant difference in the size of parvocellular cells, when these cells are compared with those of controls (Livingstone, Rosen, Drislane, & Galaburda, 1991). Many studies have suggested abnormality in the M-pathway at the level of the primary visual cortex (V1) or earlier in dyslexics (Greatrex & Drasdo, 1995; Maddock, Richardson, & Stein, 1992; Khaliq, Anjana, & Vaney, 2009; Kubová, Kuba, Peregrin, & Nováková, 1996; Romani et al., 2001; Schulte-Körne, Bartling, Deimel, & Remschmidt, 2004; Wang, Bi, Gao, & Wydell, 2010; Kobayashi et al., 2014). Several studies have shown reduced sensitivity and/or increased latency to pattern visual evoked potentials (VEP) stimuli with lower spatial frequencies and/or higher temporal frequencies in dyslexics compared with normal readers (Livingstone et al., 1991; Greatrex & Drasdo, 1995; Maddock et al., 1992; Kobayashi et al., 2014). Motion VEP studies have provided further evidence to support the suggestion of a disorder of the M-pathway in dyslexics. Longer latency (Kubová et al., 1996) and lower amplitude in P100 and P200 components (Schulte-Körne et al., 2004) have been found in dyslexic subjects. Schulte-Körne et al. (2004) have examined dyslexic and controls with a motion-onset VEP at three different velocities (2, 8, and 16 deg/s). They have found lower amplitude in P100 and P200 components in dyslexic subjects, and the differences in amplitude between the dyslexics and the controls were more significant with motion-onset VEP at higher velocity.

Perceptual learning is a process of learning to improve the selection of information available in the world that is relevant to the task (Gibson, 1969). Perceptual training can be used to improve the perceptual performance of an individual, which may allow that individual to be more responsive to educational instruction (Gersten et al., 1975; Rosen, 1966) and may enhance reading performance in dyslexia (Meng, Lin, Wang, Jiang, & Song, 2014). Gori and Facoetti (2014) suggested that perceptual learning selectively improves visual abilities and brings performance improvement through training on tasks not involving reading letters or letter