Research in Developmental Disabilities 83 (2018) 1–7

Contents lists available at ScienceDirect

Research in Developmental Disabilities

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

Effect of colored filters on reading capabilities in dyslexic children

Milena Razuk[a,b,*], Faustine Perrin-Fievez[a], Christophe Loic Gerard[d], Hugo Peyre[a,d], José Angelo Barela[b,c], Maria Pia Bucci[a]

[a] UMR 1141 Inserm - Paris Diderot University, Robert Debré Hospital, Paris, France
[b] Institute of Physical Activity and Sport Sciences, Cruzeiro do Sul University, São Paulo, São Paulo, Brazil
[c] Institute of Biosciences, São Paulo State University, Rio Claro, São Paulo, Brazil
[d] Child and Adolescent Psychiatry Department, Robert Debré Hospital, Paris, France

ARTICLE INFO

Number of reviews completed is 1

Keywords:
Children with dyslexia
Eye movement
Fixation
Reading
Colored filters

ABSTRACT

Aim: The aim of the present study was to examine the effects of colored filters on reading performance and eye movement control in children with and without dyslexia.
Methods: Eighteen children with dyslexia and 18 children without dyslexia were seated on a chair with their heads stabilized by a forehead and chin support. The children read different texts under the following three filter conditions: no filter, yellow filter, and green filter. The children's eye movements were recorded with a Mobile EyeBrain Tracker. Reading total time, duration of fixation between two successive saccades, pro-saccades amplitude and number of pro- and retro-saccades were obtained.
Results: Children with dyslexia read the fastest and had the shortest fixation time in the green filter condition compared with the other conditions. Furthermore, children with dyslexia showed the shortest fixation time in the green filter condition with respect to the other conditions.
Conclusions: Taken together, these results suggested that the green filter improved reading performance in children with dyslexia because the filter most likely facilitated cortical activity and decreased visual distortions.

1. Introduction

Dyslexia seriously affects the academic development of children because most academic activities require reading and writing during the learning process. The results of a study conducted in the 1990s suggested that children at that time were spending up to 60% of their time reading and writing (McHale & Cermak, 1992). Although, no recent data have been collected on the time currently spent reading and writing, the percentage is expected to be even higher. As a result, the prevalence of visual stress is higher in individuals with dyslexia than in individuals without dyslexia (Singleton & Henderson, 2007; Singleton & Trotter, 2005).

To minimize and prevent visual stress, the use of colored filters have been beneficial for children with dyslexia (Denton & Meindl, 2016), autism (Ludlow, Wilkins, & Heaton, 2006; Ritchie, Della Sala, & McIntosh, 2011), and attention deficit/hyperactivity disorder (Iovino, Fletcher, Breitmeyer, & Foorman, 1998). In general, these children have frequently used colored filters during the school day and at home for remediation of reading difficulties (Denton & Meindl, 2016; Henderson, Tsogka, & Snowling, 2013).

The symptoms of sensory visual stress include feelings of eyestrain and excessive brightness and various perceptual distortions, such as fading, blurring, flickering, and movement of parts of the visual stimulus (Wilkins, 2002). Wilkins (2002) has suggested that

* Corresponding author at: Institute of Physical Activity and Sport Sciences, Cruzeiro do Sul University, Rua Galvão Bueno, 868, Liberdade, 01506-000, São Paulo, SP, Brazil.
E-mail address: milena.razuk@gmail.com (M. Razuk).

https://doi.org/10.1016/j.ridd.2018.07.006
Received 12 July 2017; Received in revised form 3 July 2018; Accepted 12 July 2018
0891-4222/

people with abnormal visual cortices are hypersensitive to coarse high-contrast stripes, such as lines of black text on a white background, which cause distortions and apparent text motion. Because colored filters are thought to minimize these distortions and apparent text motion, they are considered useful as assistive technology for people with learning disabilities (Hall, Ray, Harries, & Stein, 2013; Henderson et al., 2013). In 1983, Irlen was the first to patent a set of colored-filter lenses, which are also known as overlays, for treatment purposes, and she suggested that the beneficial colors might differ according to each child's needs. However, the use of colored-filtered spectacles to reduce the effects of visual stress on reading is controversial, and the scientific community remains skeptical about their benefits. For instance, Ritchie et al. (2011) tested the efficacy of the use of Irlen-colored overlays on reading difficulties in 60 children with ages ranging from 7 to 12 years in three different conditions: using an overlay with a prescribed color, using an overlay with no prescribed color, and using no overlay. They reported that using the Irlen-colored overlays did not have any immediate effects on the reading performances of the children with reading difficulties. Thus, the benefits of colored filters are debatable.

Despite this controversy, a candidate brain structure for understanding the relationship between colored filters and reading is the magnocellular system (Chase, Ashourzadeh, Kelly, Monfette, & Kinsey, 2003). Indeed, Stein (2001) and Stein and Walsh (1997) have suggested that magnocellular system malfunction is responsible for the behavioral reading deficits. The magnocellular theory, which has recently been reformulated as a general temporal processing deficit in dyslexia (Goswami, 2011; Lehongre, Ramus, Villiermet, Schwartz, & Giraud, 2011; Pammer, 2013; Tallal, 1980; Vidyasagar, 2013), suggests that individuals with dyslexia have specific deficits in the processing of rapid visual and auditory stimuli (McLean, Stuart, Coltheart, & Castles, 2011).

Although the magnocellular pathway is not involved in color vision, it receives input from the three types of cones that are sensitive to different wavelengths of light and that are therefore referred to as short (S; blue color), medium (M; green color), and long (L; red color) wavelength cones. Reading is compromised in red-light (long wavelength) environments compared to green-light (medium wavelength) environments because the red light inhibits the activity of the magnocellular system (Chase et al., 2003). Ray, Fowler, and Stein, (2005) have suggested that individuals with reading performance deficits might benefit not only from reduced S-cone input but also from compensation by the M- and L-cone inputs (Ray et al., 2005). Individuals with reading performance deficits are thought to have a strong overlap of L-cone input to the surrounds of M cells, which changes M- and L-cone functioning (Stromeyer et al., 2000).

Henderson et al. (2013) investigated the effects of the use of colored filters during reading in undergraduate students with and without dyslexia and found that both groups read more words per minute with colored filters than without. Moreover, the group with dyslexia showed marginally larger gains in its reading rate with the filters on than their non-dyslexic peers did. Ray et al. (2005) have shown that reading improved significantly after a yellow filter was used for three months compared with the use of no filter in children with reading difficulties. Those authors considered colored filters an effective intervention for delayed readers, and they suggested that the yellow color increased input to the magnocellular system by selectively stimulating both L- and M-cones (Hall et al., 2013). In contrast, Denton and Meindl (2016) did not find any significant improvements in reading from the use of colored filters in three individuals with dyslexia (a 7-, 11-, and 32-year-old).

Kim, Seo, and Ha, (2015) investigated sentence reading before and after the use of color filters using functional magnetic resonance imaging (fMRI) in patients with Meares-Irlen syndrome. The results showed that 80% of the patients selected a blue filter, and their reading speed improved over 20% after using it. Moreover, the fMRI showed significant regions of activation in the left middle and superior temporal cortices during sentence reading with filters compared to sentence reading without filters. These regions are involved in comprehension and, more specifically, semantic and syntactic integration (Friederici, Rüschemeyer, Hahne, & Fiebach, 2003; Vandenberghe, Nobre, & Price, 2002). Thus, despite the controversy, the use of filters seems to change activation in cortical structures related to the reading process.

One major problem with the studies of the use of colored filters during reading is the lack of standardization of the procedures used. The procedures used to investigate reading performance with and without a filter must be strictly controlled with methods, such as maintaining the same environmental organization and/or experimental setup; preventing any noise and/or distractions; randomizing the trials with and without filters; and, most importantly, presenting different texts in each condition to prevent learning effects. Finally, it is important to record eye movements during the reading with filters in order to obtain objective data on eye movement and reveal any potential mechanisms underlying the reading improvements.

Studies have shown that reading performance was improved in yellow and blue filter conditions (Kim et al., 2015; Ray et al., 2005), however, there is no study in the literature that has investigated the intermediate of the color spectrum wavelengths between yellow and blue, for example, green color filter. Therefore, the aim of the present study was to examine the effects of colored filters on reading performance and eye movement control in children with and without dyslexia.

2. Materials and methods

2.1. Subjects

Eighteen children with dyslexia (mean age 9.8 ± 1.2 years) and 18 age-matched children without dyslexia (mean age 9.8 ± 1.3 years) with no reading difficulties participated in this study. The children with dyslexia were recruited from the Child and Adolescent Psychiatry Department of Robert Debré Hopital (Paris, France) where they were referred for a complete dyslexia evaluation and extensive examinations, including neurological/psychological and phonological capability assessments. For each child, the L2MA battery was used to evaluate the time required to read a text, their comprehension of the text, and their ability to read words and pseudo words (Chevrie-Muller et al., 1997). The L2MA, which is a standard test that was developed by the Centre de Psychologie