Acuate effects of prismatic lenses on reading speed in children with developmental dyslexia

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Abstract

The aim of this study was to examine the acute effect of active prismatic lenses on reading speed of children with developmental dyslexia. Fifteen dyslexic children (10.6 ± 2.1-year-old; 11 girls and 4 boys) performed a silent reading test. After, children were tested for sensorimotor impairments and prism lenses were defined, for each eye, aiming such impairment. Children performed the silent reading test again wearing the prims lenses. Average total reading for each condition was obtained and compared. Results showed that 11 children reduced total reading time when

wearing the prims and a t test showed overall total reading time reduction (pre - 87.8 ± 103.7; post − 56.3 ± 59.4; $p<0.05$). These results suggest that children with dyslexia can take advantage of using prismatic lenses, minimizing sensorimotor impairment, and most importantly improving reading speed.

Introduction

Developmental dyslexia is a neurodevelopmental disorder, described as a specific disorder of language and written language learning. Developmental dyslexia is a pathological reading disorder with no explanatory cause in children of normal intelligence that resists interventions with an impact on schooling (APA, 2013). Resistance to interventions explains why developmental dyslexia is recognized as a disability, related to a disorder of reading automation.

Despite all the controversy, two main theoretical approaches attempt to explain developmental dyslexia. Traditionally, dyslexia has been explained by the phonological theory suggesting a single cognitive deficit in phonological skills (for a review, Snowling *et al.*, 2020), but without indicating a specific causal link responsible for this deficit. Despite of this, indeed specific phonological interventions improve phonological skills but do not transfer such improvement to the reading performance of children with dyslexia (Pennington, 2006; Torgesen & Wagner, 1992). On the other hand, dyslexia has been explained by changes in sensory-motor related approaches suggesting that such deficits in how sensory cues and motor activity integration disrupt the processes of reading automation. As a result, the temporal (Tallal, 1980), the magnocellular (Stein, 2001) and the cerebellar (Nicolson *et al.*, 2001) theories have been suggested.

There is a large literature showing that dyslexia is not solely related to reading and writing. Children with dyslexia also present several changes in tasks such as walking (Moe-Nilssen *et al.*, 2003), isometric force production and control guided by visual feedback (de Freitas *et al.*, 2014), and postural control (Brookes *et al.*, 2010; Patel *et al.*, 2010). A common feature among these tasks is that sensory cues provide a basis for coherent muscle activation considering environmental and task requirements (Barela *et al.*, 2014). This process is not trivial and instead is considerably challenging given that sensory cues are obtained from several sources and are subject to considerable change owing to all the variations that constantly occur in the environment, to continuously modify the coupling strength between the available sensory stimuli and the motor activation to perform even the simplest of daily activities.

The multisensory reweighting mechanism differs in children with developmental dyslexia, as recently shown (Razuk *et al.*, 2020), but despite difficulties in integrating sensory cues into appropriate muscle activation, can improve their performance improvement when sensory cues are enhanced. This has been already observed when improvement in reading was observed due to larger font size and space between letters (Zorzi *et al.*, 2012). Similarly, we showed that children with dyslexia can take advantage of guided eye movements to improve motor tasks, such as postural control (Barela *et al.*, 2020) and more applied force to resolve sensorimotor conflicting (Razuk *et al.*, 2020) in maintain upright stance.

Recently, we have shown the impact of specific interventions on reading speed in children with dyslexia. Virlet and colleagues observed a positive effect of a 9-month proprioceptive intervention, based upon prism glasses, oral neurostimulation, insoles and breathing instructions (Virlet *et al.*, 2024). Similar results were observed by employing a 2.5-month sensorimotor intervention based upon general motor activities with cognitive engagement in which children with dyslexia showed reading, and attentional and self-steam improvements (Barela *et al.*, 2025). A common and important improvement observed in both studies was improvement in eye movement patterns (Barela *et al.*, 2025; Virlet *et al.*, 2024), showing that any improvement in reading due to intervention in children with dyslexia is also related to eye movement pattern change.

Proprioceptive intervention in our previous work (Virlet *et al.*, 2024) is considered a global intervention towards correcting spatial multisensory integration disorders. However, recent preliminary data (Silva *et al.*, 2024) have shown that the use of active prisms might contribute to alleviate reading difficulties in children with dyslexia similarly to the proprioceptive intervention. Our results reassemble some other important preliminary data (Sampaio *et al.*, 2009). Therefore, the goal of this study was to examine the acute effect of active prims on reading speed of children with dyslexia. Our hypothesis is that active prisms will improve reading speed of these children.

Methods

Participants

Fifteen children with dyslexia (10.6 ± 2.1 year-old; 11 girls and 4 boys) participated in this study. Dyslexic children were recruited from local phonological clinicians after they had undergone a complete evaluation and dyslexia screening assessment including neurological, psychological, and phonological capabilities. Non-dyslexic children were recruited from the local community through personal contacts. Children's participation in the present study was conditional upon permission being given by parents, who signed an informed consent form. The local Institutional Ethical Committee reviewed and approved all the procedures employed in the study.

Procedures

Children and parents were invited to visit the laboratory when participants comfortably seated in a regular chair near a table. After a period of adaptation to the laboratory environment, children were asked to read structured texts. In order to read the texts, a chin support was fixated on a table with texts presented in a tablet (iPad 13") placed in front of this structure. Children were asked to place their chin and front head and read the text lines presented in this tablet positioned about 0.5 meter in front of them and at their eye level (Figure 1).

We used six texts taken from children's books for 7- to 10-year-olds, with a controlled random order of presentation. Four lines of text in Portuguese from a children's book were presented on a computer screen in front of each child. The paragraph contained 40 words and 174 characters. The text was 29° wide and 6.4° high, and the average character width was 0.5°. The text was written in black Courier font on a white background. The texts were adapted for children aged 7-9 years. Each child had to read the text silently, and at the end of each reading, the experimenter asked each child a few questions to ensure that they had read and understood the content of the text.

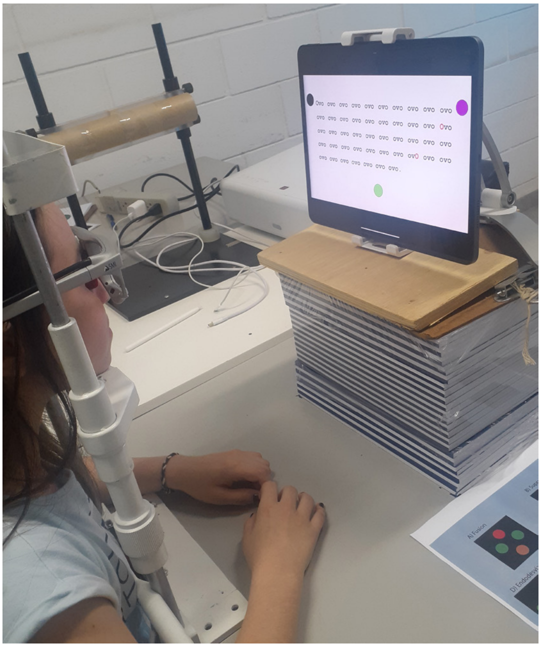

Figure 1. Representative picture showing a child positioned in front of the tablet with the text presented.

After reading the text, children were invited to laid down in a flat surface and their hip rotator muscle tonus was evaluated. Active prisms were employed to obtain hip rotator muscle tonus alignment (Figure 2) aiming to minimize sensorimotor impairments (Virlet *et al.*, 2024). After defining the corrective active prisms, children wore the prisms and read another text, with the same structure that the previous one in the same previous conditions.

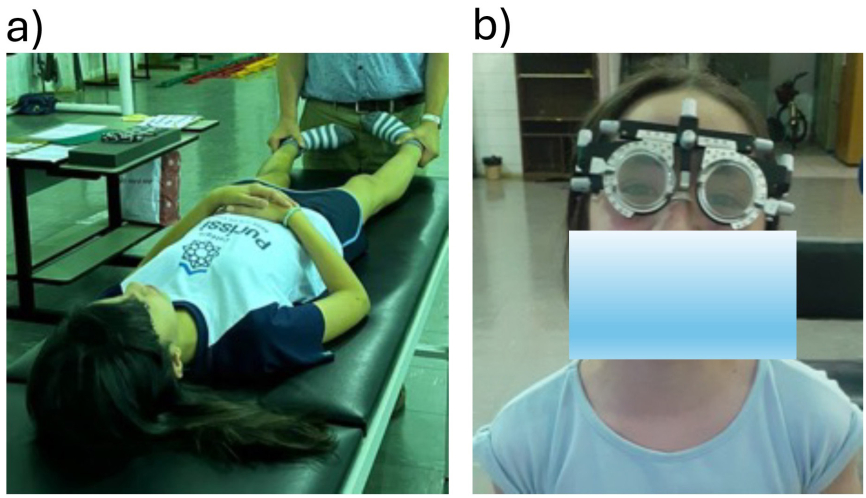

Figure 2. Representative pictures showing a child laying down and being tested regarding the hip rotator muscle tonus (a) and wearing the active prisms (b).

In all cases, total reading time was obtained as the time until the participant started reading the text until the participant had finished reading the text. Finally, total reading time was compared between conditions of without and with prims using a paired t test.

Results

Table 1 depicts the sex, age and total reading time without and with active prisms of all 15 participants. Test t depicted significant difference between reading with and without prism, $t(14)=2.50$, $p=0.02$, Cohn's $d=0.64$, with total reading time reduced from 87.8 to 56.3 seconds.

Table 1. Sex, age and total reading time with no prism and with prism.

Participants	Sex	Age (years)	No Prism (s)	With Prism (s)
1	Female	13.7	17.68	12.63
2	Female	11.6	310.39	147.32
3	Female	7.3	325.51	226.00
4	Male	12.8	24.56	24.23
5	Female	12.0	27.62	24.17
6	Female	9.3	182.17	97.57
7	Female	8.3	129.50	75.61
8	Male	10.4	48.50	40.52
9	Female	10.8	37.00	37.81
10	Male	14.8	29.50	17.10
11	Female	10.3	41.31	44.42
12	Female	11.1	25.50	16.37
13	Male	10.6	30.00	26.67
14	Female	8.7	25.84	25.16
15	Female	7.5	62.51	29.36
Mean		**10.6**	**87.8**	**56.3**
Standard Deviation		**2.18**	**103.72**	**59.49**

Because of the higher variability among children for total reading time, it is important to verify the behavior for each child (Figure 3). In this case, it is possible to identify that 13 children decreased the time when wearing the prism whereas only 2 children slightly increase the time. Moreover, for those who reduced the total reading time, eight children reduced more than 20% the total reading time when wearing the prism compared to with no prism.

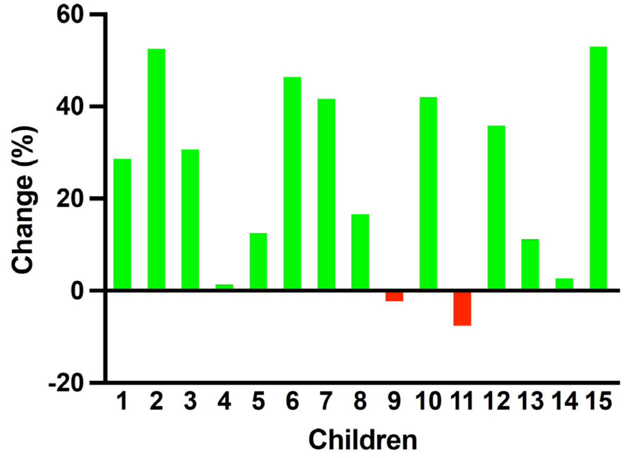

Figure 3. Individual change for each child in the comparison with no prism and with prism. Note: The green color indicates reduction, and the red color indicates increase in the total reading time comparing without and with active prisms.

Discussion

The goal of this study was to examine the acute effect of active prims on reading speed of children with dyslexia, and our hypothesis was that active prisms will improve reading speed of these children. Our results clearly supported this hypothesis as children wearing the active prisms read faster compared to the condition of no active prism. This result is in line with previous results, when reading speed was also improved in children with dyslexia, but advance our knowledge showing that such reading improvement can be observed shortly after wearing the prisms instead of after a few months of intervention.

Right after wearing the active prisms, correcting the unbalance of the hip rotator muscle tonus alignment, children improved reading speed. Besides the statistical group results, most of the children improved reading speed over 20% compared to the condition with no active prisms. Improvement in reading was also recently observed after a 9-month period of intervention aiming to minimize proprioceptive impairments (Virlet *et al.*, 2024). In this study, alignment of the hip rotator was also obtained, but due to active prisms, somatosensory lures acting through the trigeminal nerve, oral stimulation and breathing instructions. Results of this study advances our knowledge showing that solely employing active prisms already is sufficient to improve reading in most of the children with dyslexia who participated in this study.

Proprioceptive dysfunction has been observed in children with dyslexia (Da Cunha & Da Silva, 1986; Quercia *et al.*, 2007) that might be associate with multi-sensory integration disorder of spatial (Quercia *et al.*, 2015) and perceptive components (Quercia *et al.*, 2020) impacting besides reading performance of sensory motor tasks (Barela *et al.*, 2011; de Freitas *et al.*, 2014; Razuk & Barela, 2014). Fortunately, we have showed (Virlet *et al.*, 2024) that appropriate intervention, initially suggested as a global intervention (Quercia *et al.*, 2007), minimizes this multisensory integration disorder and children improve their reading performance. Our results indicate that minimization of this multisensory integration disorder might also be obtained, at least partially, by the active prisms. Moreover, the impact on reading, as results from this study showed, might even occur just after wearing the active prisms. In this study, reading performance was obtained right after adjusting the prism correction, based upon the hip rotator tonus alignment, showing the acute effect of such manipulation, different from results from our previous study when children wore the active prisms, along the other corrections, during 9-month period (Virlet *et al.*, 2024).

Although results from this study are promising, it would be interesting to examine eye movement during reading that unfortunately was not possible in this case. In our previous study, it was observed a clear change in eye movements after the proprioceptive intervention (Virlet *et al.*, 2024) similar to those observed in studies in which reading speed improved in children with dyslexia due to intervention (Barela *et al.*, 2025) or reading conditions (Razuk *et al.*, 2018). Unfortunately, it was not suitable to obtain eye movements with the active prisms during reading, but we could suggest that reading improvement would be related to better eye movement screening the text during reading, but it is an issue that needs further investigation and it is under way.

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