

DYSLEXIA, BILINGUALISM AND EDUCATION: INFLUENCE ON READING PROCESSING IN L1 AND L2

Rebecca Reina^{1*}

Marije Soto^{1**}

Jéssica Marques^{1***}

Márcia Reina^{1****}

¹Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

Abstract

Dyslexics are often discouraged from L2 learning; however, it can have beneficial effects. The dual route reading model (Ellis, 1995) proposes reading processing via two distinct routes: the lexical and phonological route. We investigated reading performance in young bilingual dyslexics (aged 8-11) in English and Brazilian Portuguese (BP), checking for transfer of the direct lexical reading strategy, more compatible with the opaque and irregular English orthography as well as dyslexia, thus benefiting reading in BP also. Indeed, dyslexics showed poorer performance on reading pseudowords, but less impairment for frequent words and better performance in English than in BP, with near similar scores compared to controls for sentence reading. This shows that high exposure to English in immersive and student-centered educational contexts may enhance reading even in young bilingual dyslexics.

Keywords: dyslexia; bilingualism; education; reading; orthographic depth.

* Master's degree in Linguistics by UFRJ, graduated in English and Portuguese by UFRJ, MBA in School Management by USP. Researcher on Neuroscience of Language focusing on bilingualism and dyslexia and the impacts of this relation on cognitive skills, reading and writing processes and diagnosis, using experimental paradigms of psycholinguistics and cognitive neuroscience. Address Av. Horácio Macedo, 2151 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, 21941-917, email rebeccareina@letras.ufrj.br. ORCID 0000-0002-8137-5685.

** Works in the field of cognitive neuroscience and language. A constant theme in her research has been lexical processing, involving both the syntactic-semantics and morphosyntax interfaces, in monolingual and in bilinguals. She works mainly with EEG/ERP methodology, at the ACESIN laboratory (UFRJ) but also worked with fMRI (in collaboration with IDOR) during her PhD. In her current research group, she uses experimental paradigms of psycholinguistics and cognitive neuroscience to investigate lexical processing as well as to address the integration of linguistic processing with other cognitive functions, such as executive functions, visual processing, and social and emotional cognition. Address Av. Horácio Macedo, 2151 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, 21941-917, email marijesoto@letras.ufrj.br. ORCID 0000-0003-4232-265X.

*** Graduated in Speech Therapy at UFRJ, postgraduate in neuroscience applied to learning at Federal University of Rio de Janeiro, Master's student in Linguistics at Federal University of Rio de Janeiro. Address Av. Horácio Macedo, 2151 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, 21941-917, jessicamarques@letras.ufrj.br. ORCID 0009-0006-3581-0734.



**** Graduated in Psychology at Veiga de Almeida University, postgraduate in TCC and Neuroscience by PUCRS, postgraduate in Human Resources Management, master in Intellectual Property and Tech Innovation. Address Av. Horácio Macedo, 2151 - Cidade Universitária da Universidade Federal do Rio de Janeiro, Rio de Janeiro - RJ, 21941-917, email mrpsicoaching@gmail.com. ORCID 0000-0003-4470-4002.

Introduction

In Brazil, while bilingualism is becoming a more common phenomenon, the myth that dyslexics can or should never become bilingual is still very much alive. This idea seems to be not only perpetuated by society as whole, but even by therapists and pediatrics. As reported in this study, parents of dyslexic children often face criticism for their choice of putting their children into an immersive English school. This goes against more recent scientific data that point to possible benefits of bilingualism on dyslexics' reading performance and overall cognitive functioning (Vender, Krivochen, Phillips, Saddy & Delfitto, 2021). This scenario underscores the importance of dissemination of the scientific understanding on this subject to a broader audience, as well as the need for further research in a Brazilian context.

Dyslexia¹ is a disorder of neurobiological origin that presents itself as a severe difficulty in learning to read (Shaywitz, 2006) and is associated with a deficit in the association between phonemes and graphemes by learners (Dehaene, 2012). Dyslexics show greater cognitive effort in reading tasks (Lodej, 2016). Depression, anxiety, dyscalculia, and ADHD², which similar to dyslexia is a genetic-neurological condition, are syndromes commonly identified in dyslexics (Lodej, 2016).

In the past, the idea of dyslexics learning a L2 was seen as something undesirable. However, the hypothesis that learning an L2 would bring harm and/or confusion for the dyslexic language learner has been successfully contested by many scientists (Sparks & Ganschow, 1993; Wydell & Butterworth, 1999; Azevedo, 2016, among others). Studies have shown that bilingualism can be beneficial to dyslexics by improving phonological awareness skills, particularly in second language (Ho & Fong, 2005; Lallier, Thierry, Barr, Carreiras & Tainturier, 2018; Hedman, 2012; Azevedo, 2016; van Setten et al., 2017; Vender, Krivochen, Phillips, Saddy & Delfitto, 2019; Vender, Delfitto & Melloni, 2020; Vender, Vernice & Sorace, 2021).

In a language learning context, L1 (first language) and L2³ (second language) reading difficulties are influenced by differences between language orthographic systems. Specific features can be the degree of transparency between sound and grapheme and the different dimensions of granularity in the sound-grapheme relationship. In the context of English (EN, L2) and Brazilian Portuguese (BP, L1), English is considered rather opaque and unpredictable in that sense (Wydell & Kondo, 2003), BP is considered transparent, fine-grained, and mostly regular (Soto, Gomes, França & Manhães, 2018). However, this distinction may affect dyslexics differently from typically developing students.

In a Brazilian school setting, Azevedo (2016) concluded that the bilingual dyslexics in her study engaged in a different reading strategy compared to so-called monolingual dyslexics, due to their experience with more coarse-grained characteristics of the English orthographic system. This is as predicted by the Dual Route Model (Ellis, 1995), which foresees the existence of two cognitive routes for the processing of written words: the Phonological Route or Indirect Route (also

called Non-lexical Route, see Coltheart, Rastle, Perry, Langdon & Ziegler, 2001) and the Lexical or Direct Route. By engaging the Phonological Route, words are segmented into orthographic units that are mapped onto sublexical phonological segments, which form phonological words which subsequently map onto lexical entries. While this route is more compatible with orthographically transparent languages, more opaque orthographic systems may be more compatible with the Lexical Route. This route is often referred to as the direct route, whereby sublexical orthographic information makes direct contact with whole-word orthographic representations, which then provide access to whole-word phonology on the one hand, and higher-level semantic information on the other (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001). Ellis (1995) suggests that there might be a simultaneous transfer of the orthographic analysis to the meaning that is stored in a kind mental orthographic lexicon, as a “mental dictionary”.

Azevedo's (2016) participants were 13–18-year-olds, which leaves open the question of how soon (i.e., at what age) it is possible to see the effect of an elevated level of bilingualism in dyslexics' reading. Another issue is that participants had received their first learning instruction in BP (only one participant received reading instruction in both EN and BP and studied in a full English-immersive environment), and that most participants had learned EN in a non-immersive school with a traditional curricular organization (with English classes for an hour twice a week, for example). In the current study we aim to address how age as well as the language and learning environment in which initial learning instruction takes place may influence dyslexics' performance.

The type of learning environment might be a key factor in dyslexics' success or failure in the mastery of their reading in EN. Studies have shown that more open and flexible teaching methods, such as the Montessori method, as well as high exposure to English in immersive environments, may enhance L2 acquisition, influencing the strategies of dyslexic reading for both languages (Lillard & Else-Quest, 2006; Baccaglini-Frank & Cashin, 2019, among others).

Thus, the current research aims to investigate the reading of dyslexics with an elevated level of exposure to English, hypothesizing that this L2 learning positively affects the reading performance of the dyslexic child both in L1 (PB) and in L2 (EN). We entertain the same assumption put forward by Azevedo (2016), based on the Dual-route model (Ellis, 1995), predicting that the more irregular patterns of grapheme to phoneme correspondence in L2 force the engagement of the direct lexical route, which in turn favors dyslexics by bypassing their weakness in grapheme to phoneme decoding. We propose that is even the case for the reading performance of young dyslexics (8–11 years old) with an elevated level of exposure to and use of English in their daily lives. In order to investigate these claims, dyslexic and control participants engaged in a variety of tasks, such as the reading aloud and writing of frequent, infrequent and pseudowords, in both L1 and L2. We expected tasks that require phonological mapping (such as infrequent and pseudowords) to impact dyslexics disproportionately. However, we expected dyslexics difficulties to be remediated by direct lexical mapping, especially in

sentential context, in which syntactic and semantic information aids lexical prediction. We also tested the hypothesis that underlying cognitive difficulties affect beyond reading and writing by applying a Rapid Naming Task (RAN), which should be especially challenging for the dyslexic group. This paper expands on existing literature and provides new insights into the topic by investigating whether intensive learning of a second language can have a remedial effect on dyslexic children. Moreover, in this study, we pilot two new instruments: a word writing task in EN, as well as a sentence reading task in PB and EN, tailored specifically for research on dyslexia in a Brazilian L2 learning environment. For all reading tests, accuracy and reading times per word frequency and word or sentence length were collected to assess the correlation between effort and accuracy in greater detail.

Dyslexia and reading decoding models.

This study explores the impact of second language (L2) learning on reading performance of bilingual dyslexics. We consider bilingualism as defined by the use of multiple languages or dialects in daily life with varying levels of proficiency (Grosjean & Li, 2013). Dyslexia is described as a specific learning disorder that affects reading by impairing the ability to decode orthographic symbols. All participants in this study were diagnosed with dyslexia, distinguishing their difficulties from broader language impairments. The cognitive processes underlying dyslexia symptoms will be further explained in subsequent sections.

The Granularity and Transparency Hypothesis (henceforth GTH) proposed by Wydell and Butterworth (1999) aims to understand the cognitive process of mapping graphemic symbols to phonological representations in different orthographic systems. According to this hypothesis, spelling can be characterized by two dimensions: transparency and granularity (see also Wydell & Kondo, 2003). The transparency of grapheme to phoneme mapping and the size of phonological units represented by the orthography influence reading acquisition and decoding processes. The orthographic system of Brazilian Portuguese (BP) is considered transparent with fine granularity (Soto, Gomes, França & Manhães, 2018), while English (EN) has an opaque orthographic representation with variable granularity (Butterworth, 1980; 1992). This makes reading in English more irregular and less predictable. Transparent systems, as is the case for BP rely on grapheme-to-phoneme mapping as a decoding strategy, while languages like English may require a separate lexical route to quickly recognize words that do not follow regular spell-sound correspondences (Lodej, 2016), forcing the reader to develop strategies for reading small and large units in parallel.

Consequently, the ease of reading acquisition in L2 may be influenced by its transparency and granularity as well as its distance or approximation of the L1 (Wydell & Butterworth, 1999). Therefore, a dyslexic student's success or failure in first and foreign language learning can be partly attributed to the spelling systems to which each language belongs. The development of multiple granular scaling

strategies is an efficient response to spelling (Wydell & Ijuin, 2018), which is in accordance with the Dual Route Model (Ellis, 1995). Capovilla, Dias and Montiel (2007) report the correspondence of this model in terms of brain circuitry: temporoparietal and occipito-temporal networks are engaged in phonological and lexical mapping, respectively, thus confirming the idea of a dual pathway model of reading, as proposed by Ellis (1995).

Based on the observed difficulties of dyslexics' reading of infrequent or unfamiliar words, Ellis, Flude and Young (1990) argue that dyslexia can be seen as caused by a failure to engage the phonological pathway of reading, which would explain deficits in converting letters into sounds. However, they can succeed in reading familiar and frequent words, which Ellis (1995) suggests is done by recruiting the lexical route. Complementing these ideas, Dehaene (2012) suggests that selective difficulties in recruiting the phonological or lexical route may result in two possible dyslexia types, i.e., phonological/deep dyslexia and superficial dyslexia. Finally, Ellis and Young (1996) also argue that the phonological route is not only important for reading but also for writing, since it involves converting sounds into letters to form written words. People with dyslexia often have trouble spelling words while writing, which can reflect problems establishing the relationship between sounds and letters and as well as the combination of letters that represent them.

Various studies show that dyslexics' brains present hypoactivation in areas associated with phonological processing and phonological awareness during reading or phonological tasks, such as the left posterior temporal cortex and the and the left inferior frontal cortex (Dehaene, 2011; Buchweitz *et al.*, 2018) and in areas engaged in the processing of orthographic forms, such as the Visual Word Form Area (Dehaene, 2012; Azevedo, 2016; Zhou, Xia, Bi, Shu & Han, 2019).

What these studies highlight more generally is that dyslexia seems to affect a wide range of brain areas commonly associated with auditory and visual language processing, which is suggestive of the complexity of the cognitive processes that are influenced by underlying impairments. Aligned with the Dual Route model, the Double-deficit Hypothesis, proposed by Wolf and Bowers in 1999, suggests that dyslexia may be caused by separate impairments in phonological deficits and naming speed processes, which, when combined, lead to severe reading impairment. The hypothesis also suggests that dyslexic individuals may vary in impairments. Rapid Automatized Naming (RAN) is identified as a screening tool for dyslexia, with dyslexic readers typically performing poorly on RAN tasks. As far as we know, there is no adaptation for this task for bilinguals who might face bilingual lexical activation, possibly adding to cognitive load, reflecting increased response times.

Dyslexia and L2 reading.

As mentioned before, some studies indicate that bilingual reading acquisition can be beneficial to dyslexics' reading performance in L1 and L2. Several studies with adults and adolescents showed the effects of language specific reading

decoding strategies (Lallier, Thierry, Barr, Carreiras & Tainturier, 2018; Hedman, 2012), while others reported no beneficial transfer (van Setten et al., 2017).

Studies that approach the bilingual experience as advantageous for bilingual dyslexic children are still not common, although many studies explore additional difficulties dyslexic children might experience while learning an additional language (Ho & Fong, 2005). However, research also makes it clear that although dyslexic children might be more challenged due to their condition, L2 learning does not worsen their condition and may even be beneficial (de Bree, Boerma, Hakvoort, Blom & van den Boer, 2022).

Nonetheless, the influence of L2 reading acquisition might not transfer to all tasks. Vender, Krivochen, Phillips, Saddy and Delfitto (2019) found no difference between bilingual (of a variety of L1 languages and Italian as L2) and monolingual (with Italian as L1) dyslexic children for the task of pseudoword repetition in Italian, suggesting that the underlying cognitive mechanisms involved are not sensitive to reading strategy transfer. Conversely, a study by Vender, Delfitto and Melloni (2020) showed that bilingual dyslexic children with Italian as L2 (mean age 10) performed better on a morphological task than monolingual dyslexics, with Italian as L1, and in some cases even outperforming monolingual non-impaired children. Thus, it seems that some tasks are more sensitive to the metacognitive knowledge that bilinguals acquire, which also benefits dyslexics.

Another study from Vender, Krivochen, Phillips, Saddy and Delfitto (2019), which assessed AGL (artificial grammar learning) in monolingual and bilingual children, with and without dyslexia. Their findings led them to conclude that there is an advantage of bilingualism for dyslexics, once bilingual dyslexics performed better than their monolingual counterparts and, in some conditions, at the level of the two control groups.

In a study comparing word reading outcomes, de Bree, Boerma, Hakvoort, Blom and van den Boer (2022) concluded that performance in bilinguals with developmental language disorder (including dyslexia) is related to the developmental language disorder itself, and not to bilingualism.

Despite studies showing benefits, or at the least, no disadvantages to L2 learning in dyslexic children, there is not yet much research that empirically corroborates the claim that advantages in reading may occur due to the transfer of language specific reading strategies in bilingual dyslexic children. Azevedo's study (2016) *did* show a beneficial effect of L2 (EN) learning on L1 (BP) reading. Based on the Dual Route model, the author attributed this effect to a selective recruitment of the direct lexical route in reading processing by dyslexic bilinguals, which might be better suited to English reading as well as being an effective strategy for dyslexic readers in L1.

Likewise, Vender, Vernice and Sorace (2021), by analyzing the results of several empirical studies, argue that bilingualism does not exacerbate the difficulties of children with developmental disorders, quite the opposite, it can be beneficial for their cognitive, linguistic, and socio-cultural functioning.

We expected to replicate and complement the effects found in Azevedo's (2016) study. Different from the adolescent participants of her study who mostly studied in traditional schools, our younger participants (8 to 11) are enrolled in an immersive teaching environment, which provides an elevated level of exposure to English. The school applies the Montessori methodology, which might be especially beneficial for dyslexics because it has a multisensory approach, individualized instruction, emphasis on creativity and problem-solving activities, and focuses on social and emotional development (Gutek, 2003), all of which is also particularly beneficial for L2 learners (Lillard & Else-Quest, 2006; Nijakowska, 2008, Vender, Vernice & Sorace, 2021).

Objectives and hypotheses

In this study, we aimed to investigate reading strategies in 6 young bilingual dyslexics aged eight to eleven, who are exposed to and use English on a daily level. We measured reading performance on the reading aloud of frequent, infrequent and pseudowords, as well as the silent reading of sentences, in both languages, comparing dyslexics to typical bilingual readers matched for age with the objective of checking for transfer of reading strategies that are more compatible with the deficit, and which may benefit reading in BP. To characterize each of the participants in detail we also applied a pseudoword repetition task, a language proficiency questionnaire, a digit span, IQ and RAN test. The specific age bracket was chosen because it is the age when the initial reading instruction process is supposed to be completed, and it is also the age at which the dyslexic participants tend to receive their diagnosis.

We put forth four specific hypotheses. The first one is that dyslexics are strengthened in the reading processing strategy by the lexical route, which is a strategy more compatible with their deficit, and possibly more adequate to deal with the opacity and irregularity in the granularity of the English spelling system. According to this hypothesis, dyslexics resort to whole word strategies benefiting frequent word reading and spelling. They are expected to perform badly on infrequent and pseudowords, for which control group will do better for being able to successfully apply phonological mapping. Arguing that the lexical route is beneficial for dyslexics, and it is fostered due to exposure to English, the use of this route will be evaluated for better results in EN than in BP, by the two groups. Dyslexics may also struggle more with longer words as shorter words are easier to memorize and map directly. They will also read more slowly, especially when encountering difficult words. Control subjects are expected to have better overall performance in both speed and accuracy. Similar patterns are predicted for the word writing task, although time is not measured for accuracy.

Our second hypothesis is that dyslexics can benefit from contextually supportive information in the reading sentences task. This will be reflected in more errors in the word reading task compared to the control group, but with comparable results in reading sentences, given that direct lexical access strategies

will especially benefit reading when syntactic and semantic contexts allow for lexical prediction. Therefore, we might also expect dyslexics to do better in EN compared to BP.

Our third hypothesis is that even at an early age, possibly dependent on an elevated level of exposure and an open and flexible teaching methodology, the reading performance of dyslexics both in L1 and in L2 is positively affected to different reading strategies (lexical route or the phonological route) postulated by Elis (1996). This may be reflected in good performance on reading and spelling frequent words, or good performance, comparable to control counterparts, on sentence reading.

Our fourth hypothesis is that dyslexics' impairments affect underlying cognitive processes, such that they are expected to perform worse on the RAN test compared to the control group, showing that difficulties extend to other tasks than reading or writing. We also expected varieties in performance according to age and forecasted that this test might have been especially difficult on dyslexic participants due to competition between potential lexical candidates in two languages.

Method

Participants were recruited from a private bilingual school in a Brazilian state capital. The school follows an American and international curriculum that is the IB Programme (International Baccalaureate). This means that the entire school curriculum is taught in English, apart from the BP classes (the participants have 50 minutes of BP class every day). The school offers a transdisciplinary, inquiry-based, student-centered education according to the Montessori method. It is an English immersion environment in which students' reading instruction is in English. The study participants use English extensively in school and sometimes at home and in media consumption.

Dyslexic participants and their control counterparts were matched by age and school year (2 from third grade, two from fourth grade and 2 from sixth grade). Participants are henceforth coded as D1, D2, D3 (D for dyslexic and ADHD) and C1, C2, C3 (C for control). Inclusion criteria were a minimum of 3 years of enrollment and previous diagnosis for dyslexia for the dyslexic participants. Another aspect of this study is that all dyslexics in this study also present ADHD, which may be reflected in a deficit in working memory, particularly on tasks that require attentional control. This co-occurrence is quite common, affecting about three out of ten people with dyslexia (Darkin & Erenberg, 2005); however, it does introduce a new variable to the study. All participants had a diagnosis for both dyslexia and ADHD and were taking medication for this condition during study.

Table 1: Synthesis of the most relevant participants' information in anamnesis.

Participant	D1	C1	D2	C2	D3	C3
Current age (Y-years, M-months)	8y 4m	9y 1m	9y 8m	10y 4m	11y 1m	11y 3m
Age entering school/day-care	3y	5m	5y	4y	2y	2y
Age entering first bilingual school	3y	3y 10m	6y	5y	2y 11m	4y
Age entering current bilingual school	5y	3y 10m	6y	5y	2y 11m	4y
Age of Dyslexia diagnosis	6y	-	6y	-	7y	-
Length (months) and frequency of Speech Therapy	38 months 2x a week	-	26 months 1x a week	-	26 months 2x a week	-
Additional issues	ADHD	-	ADHD	-	ADHD	-
Frequency of Learning Support at school	daily	-	daily	-	daily	-
Frequency of Learning Support out of school	3x a week	-	1x a week	-	-	-

The research team was composed by a neurolinguist, a speech therapist and two psychologists. The tests were divided into five individual 50-minute sessions (totalizing thirty sessions) in which the first one was online; the other sessions were done in person. No session was conducted in groups, each session was individual.

The reading tests were reading aloud twenty-four frequent words, twenty-four infrequent words and twenty-four pseudowords in BP (Rodrigues, 2015) and twenty frequent words, twenty infrequent words and twenty-four pseudowords in EN (Siqueira, 2018), also comparing them for length (long x short, being 4 to 5 letters short and 6 to 9 letters long), average number of errors and reading time; reading speed of thirty sentences in EN and thirty sentences in BP, with equal number of short, medium and longer sentences (developed for this research that will be further validated and published) in a truth value task, for which accuracy and reading time is measured.

We also applied a dictation test of thirty-five frequent words, twenty-five infrequent words and fifteen pseudowords in EN (developed for this research that will be further validated and published), and a dictation test BP (Dias, N. M., & Capovilla, F. C., 2000), for which average number of errors is calculated having twenty-four frequent words, twenty-four infrequent words and twenty-four pseudowords. In this newly developed dictation test we paid attention specifically to cognates (35%), which might reveal if participants are transferring L1 strategies to spelling.

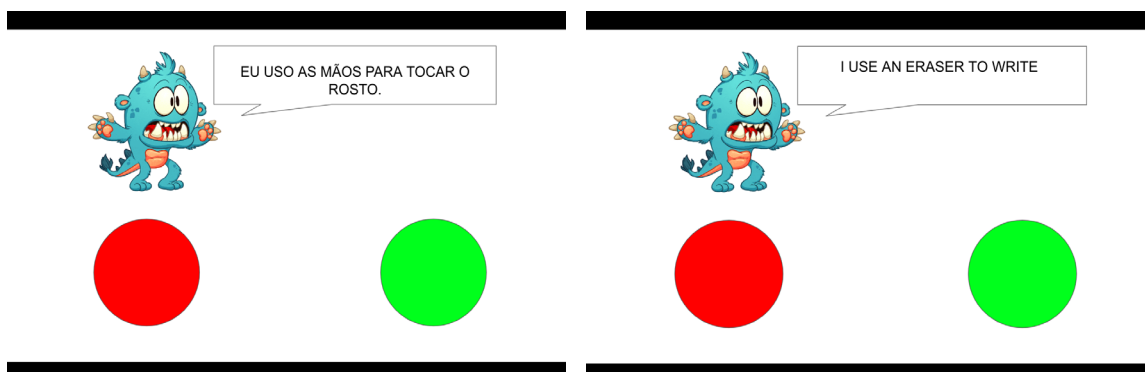
Likewise, we applied RAN: Naming of fifty objects, fifty colors, fifty numbers and fifty letters (Ferreira, Dias, Seabra & Macedo 2003), for which a classification is calculated based on the times they take to complete the task; repetition task of pseudowords (Kessler, 1997), for this task better results were expected from the control group, since dyslexics tend to present impaired phonological working memory (Costa, 2011); Digit SPAN – ITPA and IQ: WASI - Wechsler Abbreviated Intelligence Scale. We also performed an interview with the children's parents in order to get a detailed history on diagnosis, specific difficulties, and therapeutic interventions.

To assess language proficiency, we applied the PVST (Picture Vocabulary Size Test) (Anthony & Nation, 2021), in which accuracy is measured on auditorily presented words for which the participant has to choose the matching pictures among four and a Language Experience and Proficiency Questionnaire, known as QuExPLi (Scholl & Finger, 2013) and a short interview with the participants regarding their use of English.

Among the tests, two were specially developed for this study: the English dictation test and the sentence reading task. All information (stimuli, procedures and results) can be found on the OSF Platform (Open Science Framework): https://osf.io/7fkta/?view_only=807fb531f91a4b8b860ab7d6935a919a. Although most tests were replications in terms of stimuli and procedure, the design for the sentence reading speed test was especially developed for this study. In this test, speed was measured by reading time and truth value judgment (see Image 1). Participants were asked to help an alien that has arrived on Earth to learn about our planet, and they would do so by judging the truth value of the alien's observations, by touching a red (for *false*) or green (for *true*) circle. This test also measures proficiency once participants must understand what is written. The sentences of the test were not translated one to another, each test (BP and EN) having their own sentences. Participants saw thirty sentences for each test. In the BP test, twelve sentences were short, fifteen were medium and three were long. In the EN test, eleven sentences were short, sixteen were medium and three were long. Both tests had sixteen true and fourteen false sentences.

The research was approved by the Research Ethics Committee of IESC - UFRJ (number 55071622.8.0000.5286).

Image 1: First sentences for BP and EN Reading Speed of Sentences tests.



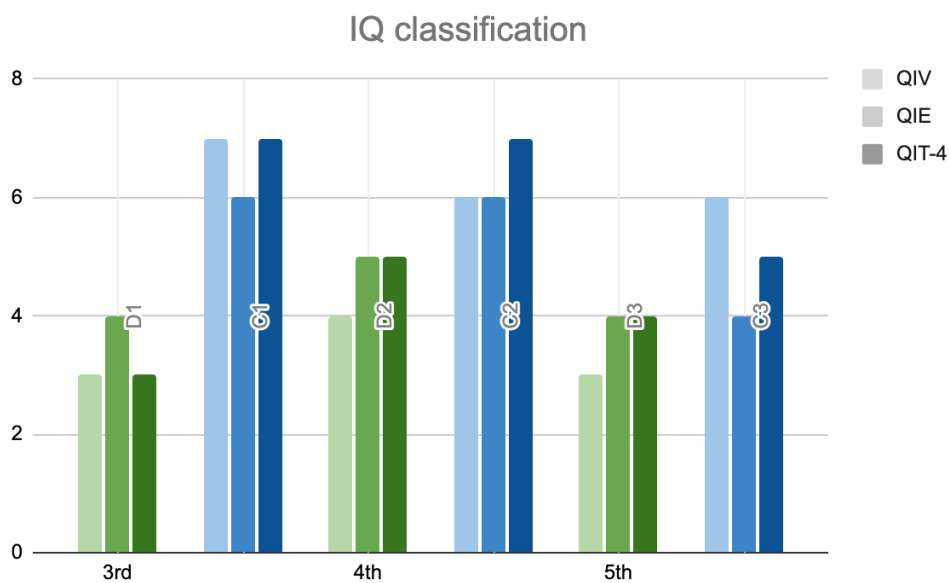
Results

Participants' cognitive profile: anamnesis, IQ, and span test.

The anamnesis showed that all dyslexic participants were diagnosed when they were 6-7 years old, and that they all received learning support at school daily. It also showed that D3 (the oldest) did not receive learning support out of school anymore, whereas D2 did once a week and D1 (the youngest) three times a week.

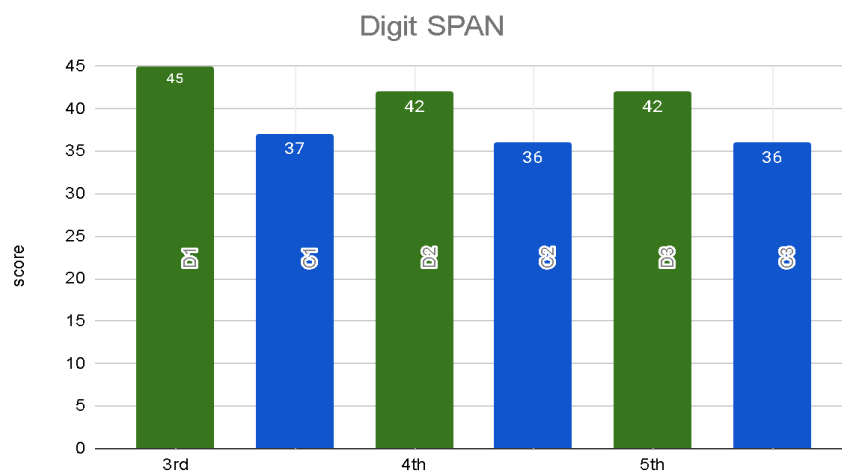
The IQ test is corrected for age and yields a number from zero to seven, ranking from “much lower” (1), to “medium” (4), to “much higher” (7). D1 and D3 ranked between middle lower and medium, possibly due to ADHD (Lopes, 2012), and D2 ranked between medium and upper medium. C1 and C2 controls presented highest scores, between upper and much higher, possibly reflecting giftedness, whereas C3 is closer matched to D3. Other aspects assessed through this questionnaire are available in our OSF project.

Graph 1: IQ classification



The score for the digit span in Portuguese (ITPA) shown in Graph 2 is the scalar score (for raw scores see our OSF project). Better results were achieved consistently by the dyslexic group (see Graph 2). This was not expected since individuals with ADHD tend to present compromised working memory (Kofler, 2020), but perhaps dyslexics' superior performance reflects some compensatory attentional mechanism to remediate their reading difficulties.

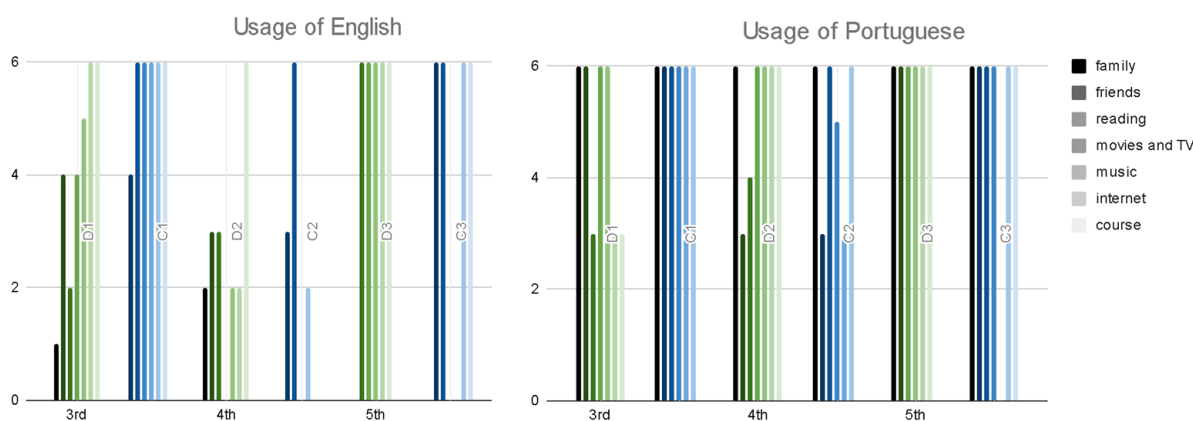
Graph 2: Digit SPAN scores



Participants’ linguistic profile: LEPQ and PVST test

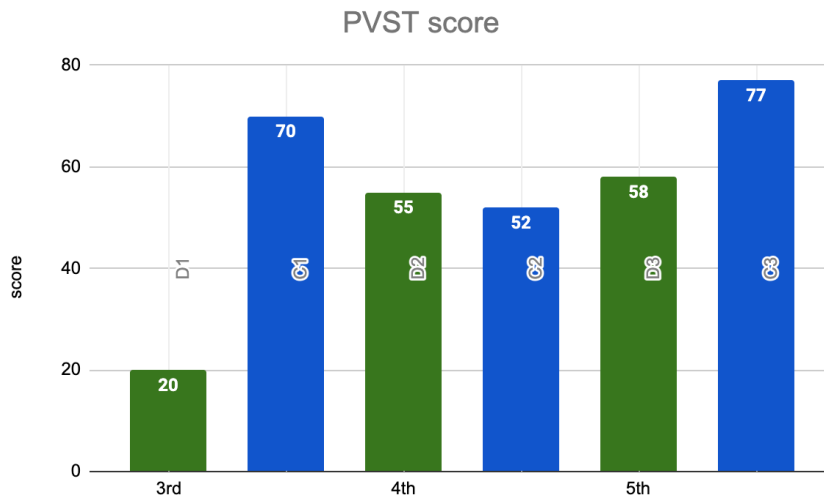
In the Language Experience and Proficiency Questionnaire (Scholl & Finger, 2013), we will highlight here BPxEN exposure for learning. On a scale of 0 to 6 (0= not at all, 3 = a lot, 6 = a lot), overall participants rated music and the internet as most influential, and for other activities the number varies (see Graph 3). For L1, ratings among categories were relatively more balanced. Other aspects assessed through this questionnaire are available at our OSF project.

Graph 3: Usage of English and Portuguese according to QuExPLi.



In the PVST test, which requires auditory word (in small sentences)-picture matching, participants D2, C2 and D3 scored between 52 to and 58 out of 96 (~57%), whereas C1 and C3 scored better, with 70 and 77 (~77%). D1 scored only 20 (see Graph 4). Overall lower scores for dyslexics might be expected due to their learning difficulties associated with dyslexia and ADHD. However, we see a slight improvement with age. D1’s results suffered from distraction, also D1 is not exposed to English outside of school (see more in our OSF project).

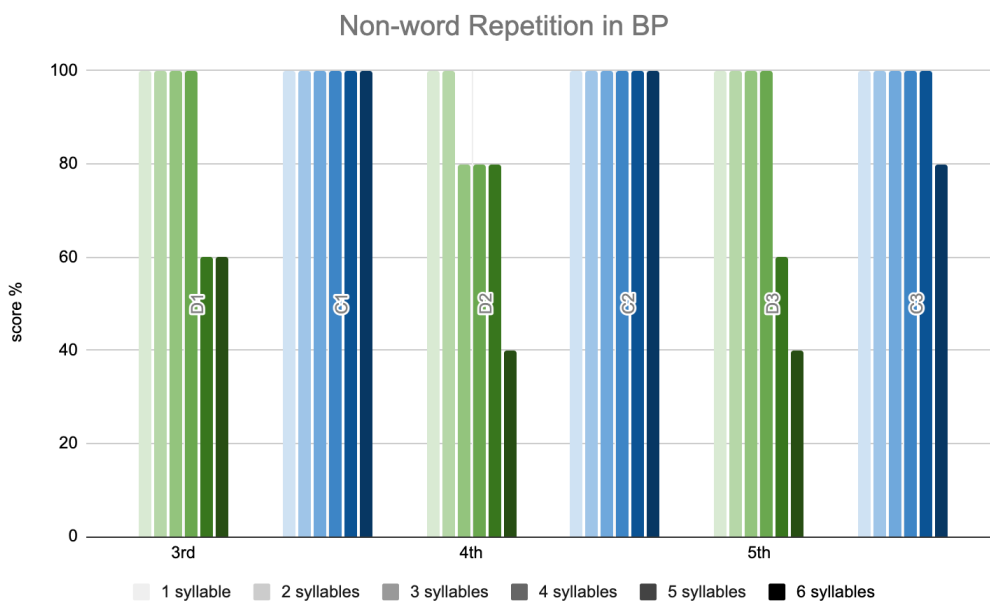
Graph 4: Picture Vocabulary Size Test scores (max. score 96).



Language processing tests: word repetition and RAN test.

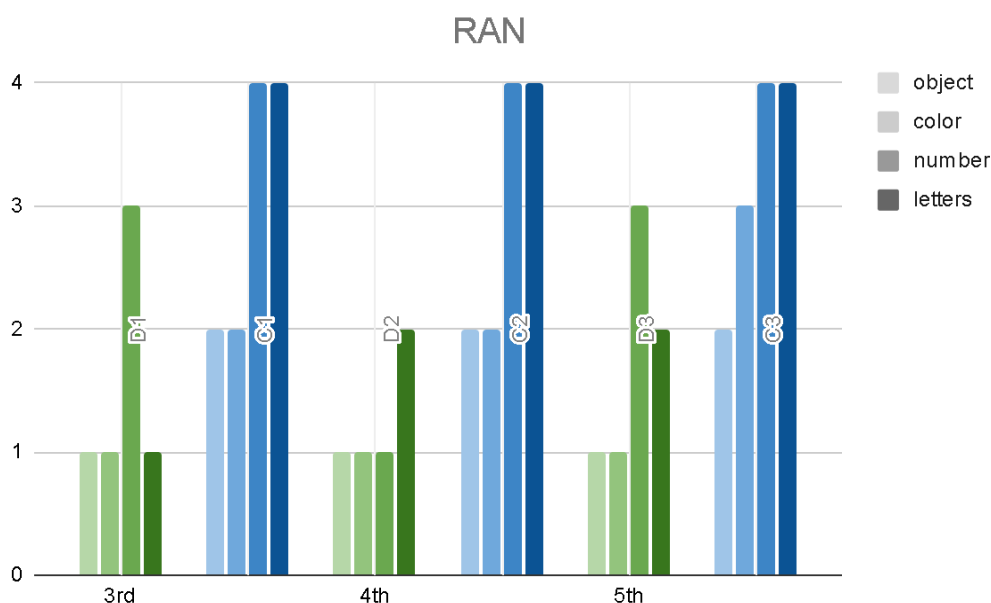
In the BP pseudowords repetition test, the control group had better results than the dyslexic group and this result (see Graph 5) was expected due to supposed impaired phonological working memory in dyslexics (Costa, 2011). Nonetheless, dyslexics showed 80-100% accuracy for words up to 4 syllables and only had relatively poorer results with 5-6 syllable words, which can be explained by their innate difficulty. The results reveal that these dyslexic participants do not have difficulties with their phonological loop for smaller words, but when it comes to a high cognitive load and high cognitive pressure (longer words), performance suffers.

Graph 5: Scores for Pseudowords repetition in BP (in %)



Dyslexics scores for the RAN test were relatively low. In Graph 6, the y axis represents participants' classification, being 1 for relegation/displacement, 2 for light relegation, 3 for a satisfactory performance and 4 for a great performance. The X axis refers to participants' school years. Thus, we see that for object and color naming dyslexics consistently classify the worst (1), for numbers they qualified better (3) but still underperformed compared to controls (4). For the letter category, all controls performed at maximum (4), whilst dyslexics performed at level 1, for D1, or at level 2, for D2 and D3. However, this test was not made for bilinguals and was done in BP. This is important to mention because bilinguals may spend more time in this task due to lexical choice (both inputs, one for each language, may come to mind when facing an item) This might be an even bigger cognitive load for dyslexics in an already taxing task. However, the results confirm expectations that the naming process is a type of weakness in dyslexia as proposed by the double deficit hypothesis (Wolf & Bowers, 1999).

Graph 6: RAN results



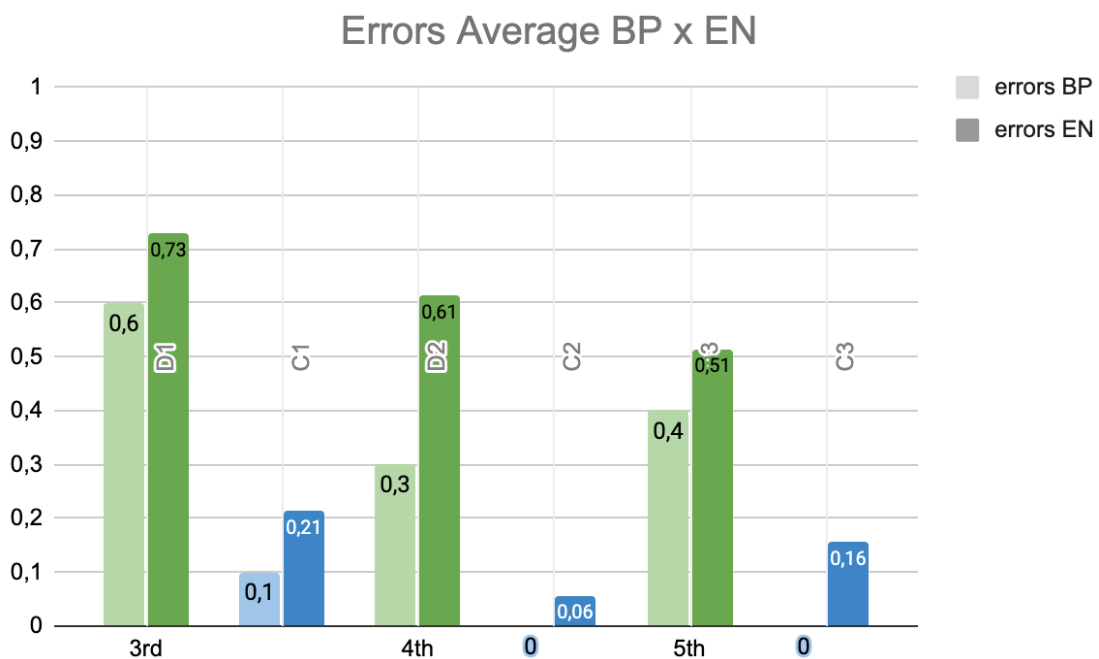
Reading and writing tests in EN and BP

In the dictation tests, better results were expected from older participants once they are less dependent on L1 knowledge since they are more experienced in L2 and the control group. We also expected better results in BP than in EN given that BP is their first language (L1), so this might give them an advantage of lexical and phonological knowledge, especially affecting performance on infrequent words and pseudowords. In the supplementary materials, results for each of the items per category can be accessed in our OSF project, here we report overall average errors per word, comparing BP to English (see Graph 7).

In general, higher error rates for dyslexics reflected more difficulty with infrequent words and pseudowords, except for D3 who seemed to have managed to develop some skill in predicting possible spelling forms in English. Participants scored better (shorter bars) on BP than on EN.

In writing, lexical, and phonological knowledge in L1, likely greater than in L2, seemed to have helped, as we can observe that for all participants, the scores in BP were higher than in EN.

Graph 7: Dictation score BPxEN (average errors per word)



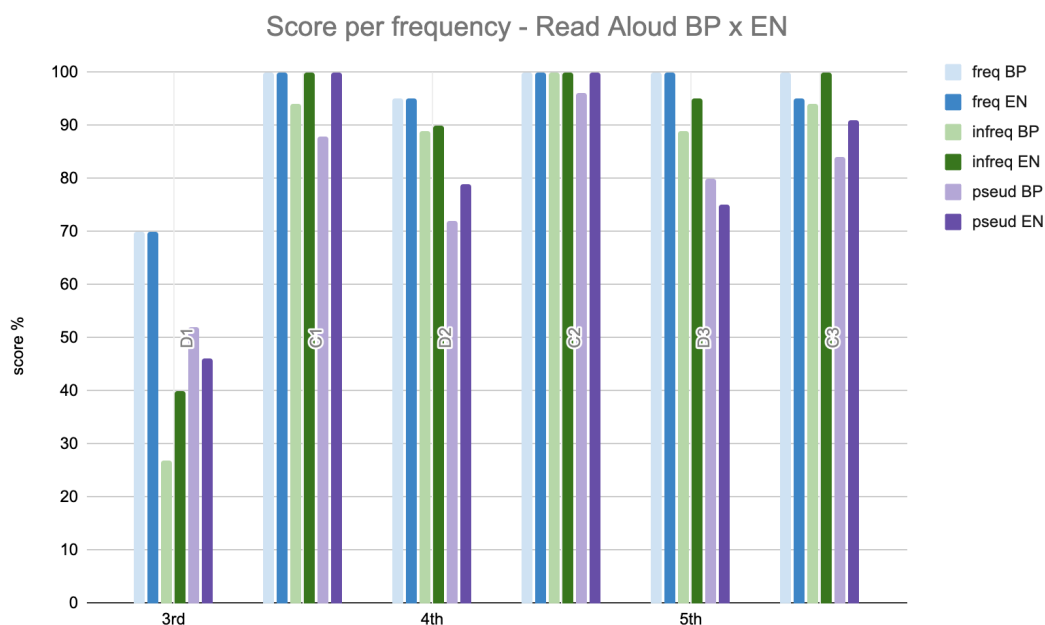
In Graph 8, accuracy scores are shown in %, separately for frequent, infrequent and pseudowords. For frequent words, all participants (D and C) scored equally for both BP and EN, except for C3 who scored slightly better in BP than EN (100% x 90%). For infrequent words, all participants (D and C) scored better in EN than in BP, albeit with exceedingly minor differences, perhaps because reading instruction at their school is in English. In contrast, when it comes to pseudowords, the control group scored better overall, and better in EN than in BP. It seems that the control group improved for English over the years because they may have internalized the sound-orthography patterns. Dyslexics showed mixed results among each other, it seems that they were not able to employ the same strategy as easily as the control group did.

Dyslexics appeared to have had an advantage for English over Portuguese, which was less pronounced when the word is long (see Graph 9). When the word was long, dyslexics presented similar poorer results for EN and BP. This seems to point to the expected lexical effect for short words. The lexical effect predicts that words that are used more frequently tend to be processed more quickly and easily and may be more likely to be retrieved from memory (Baayen, 2001), and in this

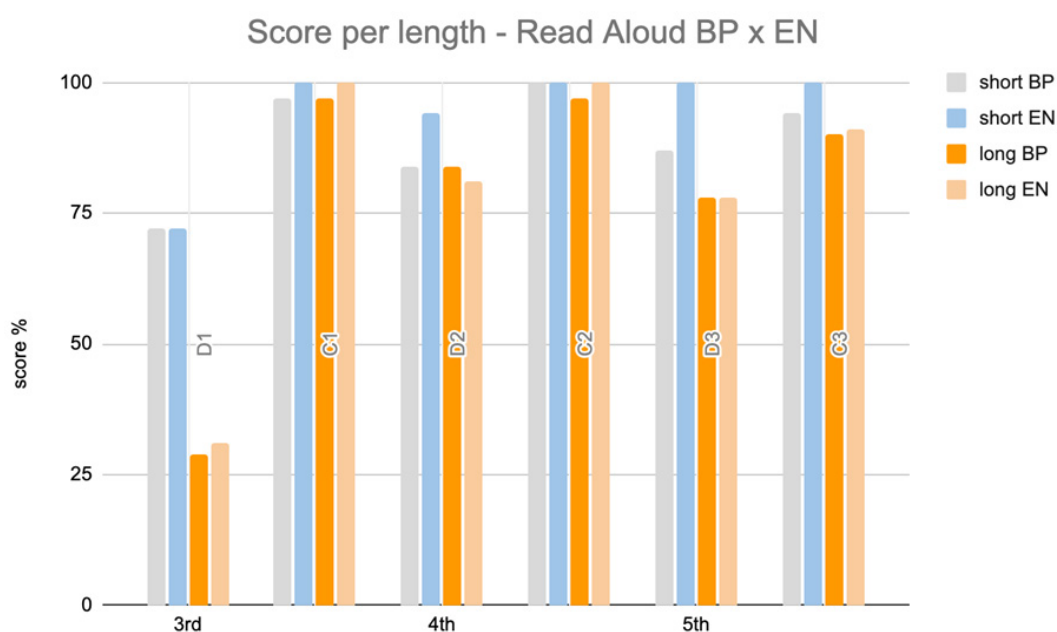
case, we also predict that shorter words' orthographic form is more likely to be accessed and stored in full form.

The results for reading and writing words did not show similar patterns. For reading, the best results occurred in English. The advantage of English was not so prominent in writing as it was in reading, suggesting that the effects of the strategy we seem to see in reading do not apply for the writing process in our study. Indeed, all participants performed better on the BP Dictation test than the EN test.

Graph 8: Read Aloud BPxEN score per frequency (in %).



Graph 9: Read Aloud BPxEN average reading accuracy per length (in %).

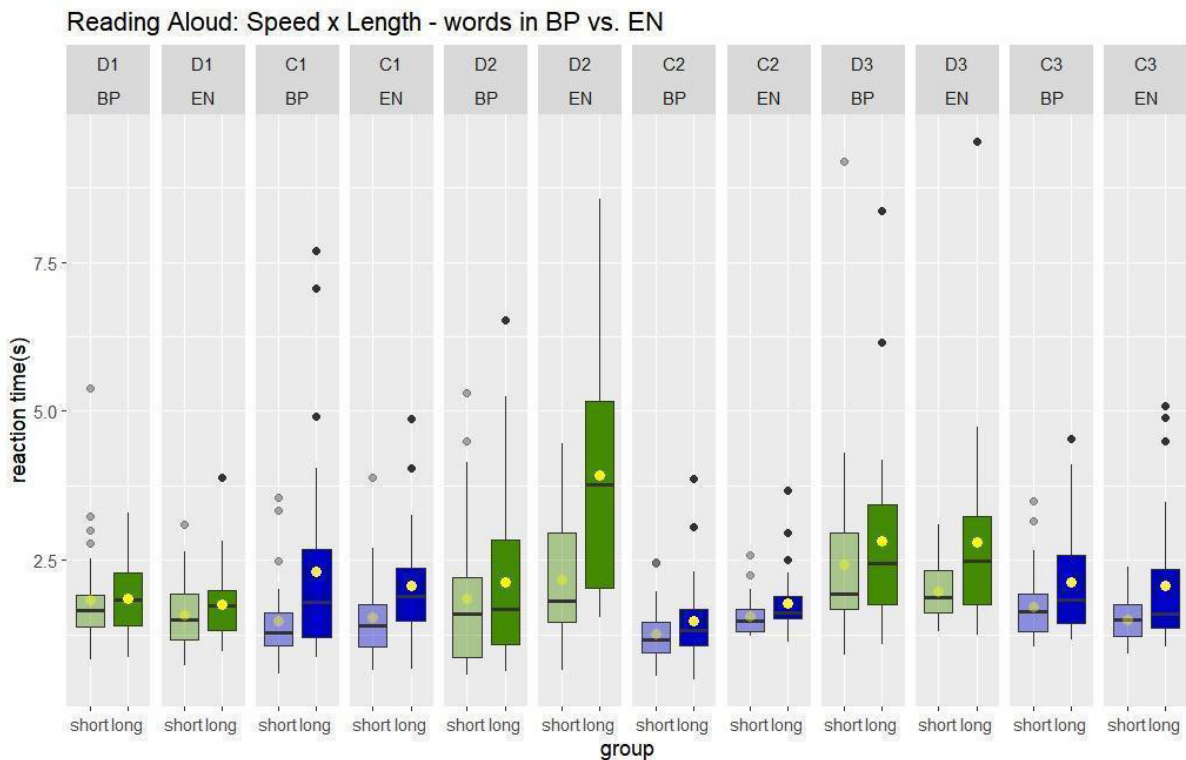


In terms of reading time, overall, dyslexics were slower than controls (see Table 2 and Graph 10), especially on longer words (see Graph 11). Dyslexics D1 and D3 read L2 faster than L1, and so did control C3. D2 read slower overall and presented the most pronounced difference between short and long words. Overall, all participants showed increasingly longer reading times for infrequent and pseudowords, but the difference between these categories varied among participants. We can see that overall higher reading times reflected difficulty and that more time spent on reading did not translate to higher accuracy, especially not for dyslexics.

Table 2: Read Aloud BP x EN average reading time per type of words (in seconds).

Participant	D1		C1		D2		C2		D3		C3	
	BP	EN	BP	EN	BP	EN	BP	EN	BP	EN	BP	EN
Frequent	1.7	1.8	1.4	1.4	1.1	2.3	1.1	1.6	1.9	2.0	1.6	1.5
Infrequent	1.5	2	1.4	1.7	1.5	3.4	1.2	1.6	2.2	2.4	1.9	1.6
pseudoword	2	1.6	2.6	2.1	2.9	3.3	1.6	1.6	3.4	2.6	2.5	2.1

Graph 10: Read Aloud BP x EN average reading time per length.



For the reading speed of sentences test, reading in BP was expected to be more accurate and faster than in EN, sensing that BP might offer some advantage as it is the native language of our participants. A surprising result revealed more

or equal accuracy in EN compared to BP, except for D1 (see Graph 12). Also, we can see in Graph 13, there seemed to have been more fluid reading of EN, with overall similar or faster reading times for EN compared to BP for all participants. Although overall reading times were faster for controls, this difference was very minimal, again except for D1. Overall better performance in EN might be because participants get more training in reading in L2 than in L1 since all classes, except for BP classes, are taught in English. We may also infer that the recruitment of the direct lexical route especially benefited reading in sentences, where syntactic and semantic contexts favored lexical prediction.

It is no coincidence that the difference in performance was greater between the third-grade dyslexic and control participants, once this the age where children will have just finished their reading instruction process in EN. In fact, in Brazil, the third grade is considered to close the cycle of initial reading instruction. The difference between C1 and D1 can be explained by the fact that D1 probably has not completed his reading instruction process due to his innate difficulties, whereas C1 will have already finished it.

This is also clear from the data presented in Table 3, which compared reading times by length of the sentence. D1 is the only participant who showed much slower reading times for longer sentences, in both languages. For the other participants, length produced relatively longer reading times, only for BP, and only for the longest sentences. This again confirms an advantage for EN, when reading occurred in context.

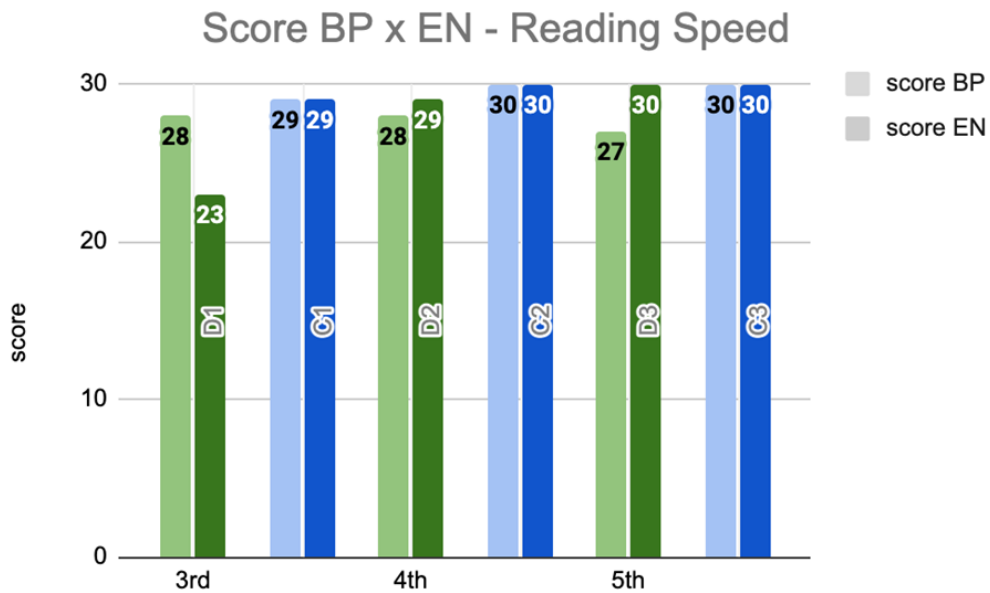
The sentence reading task also measured proficiency, as the reader was not able to rely on guessing the meaning but was required to understand what was written in order to make the truth value judgment. The accuracy results revealed that all participants were proficient enough to complete the task efficiently.

We can see that whereas there was only a relatively slight difference between dyslexic and control participants for the sentence reading task, differences were more pronounced in the reading aloud of words task. Owing to that, we may note some differences between sentence reading and word reading. The sentence reading did not require reading aloud. On the other hand, the word reading task did not require any additional task beyond reading aloud. Therefore, task requirements were different. Reading aloud may add a complicated layer for dyslexic students, who do not display phonetic or articulatory difficulties *per se* but might be hindered by difficulties translating print to sound (although occasionally participants would mouth the words even in the sentence reading task). The task for the sentence reading added another dimension by requiring understanding and decision (true or false); while this dimension may add cognitive load, it is also perhaps a more engaging and motivating task, especially within the context of the experiment which aimed at adding a *gamification* element (by presenting the story and character of the alien). Another aspect is that the sentence test did not control for frequency, presenting mostly frequent words, nor did it present pseudowords, which are typically more challenging for dyslexics. These might be all aspects that have influenced results. Notwithstanding, we suggest that the

better reading in EN displayed in this test may be, at least partly, the result of reading strategies (direct lexical route) favored by EN, which are advantageous for dyslexics, and which have a positive effect on reading in BP also, as reflected in the results for the sentence task which were very close for both languages.

For the word task, it seems that EN reading forced the use of the lexical route and that BP forced the use of the phonological route, which was expressed in inferior performance on infrequent and pseudowords for dyslexics. In the word task there is no semantic or world knowledge context that may aid the participant in predicting lexical content; in the case of an isolated word, especially when it is unfamiliar, decoding seems the only viable option.

Graph 11: Reading Speed Sentences BPxEN accuracy (max. score is 30)



Graph 12: Reading Speed Sentences BPxEN average response time (in seconds)

Reading Speed - reaction time to sentences in BP vs. EN

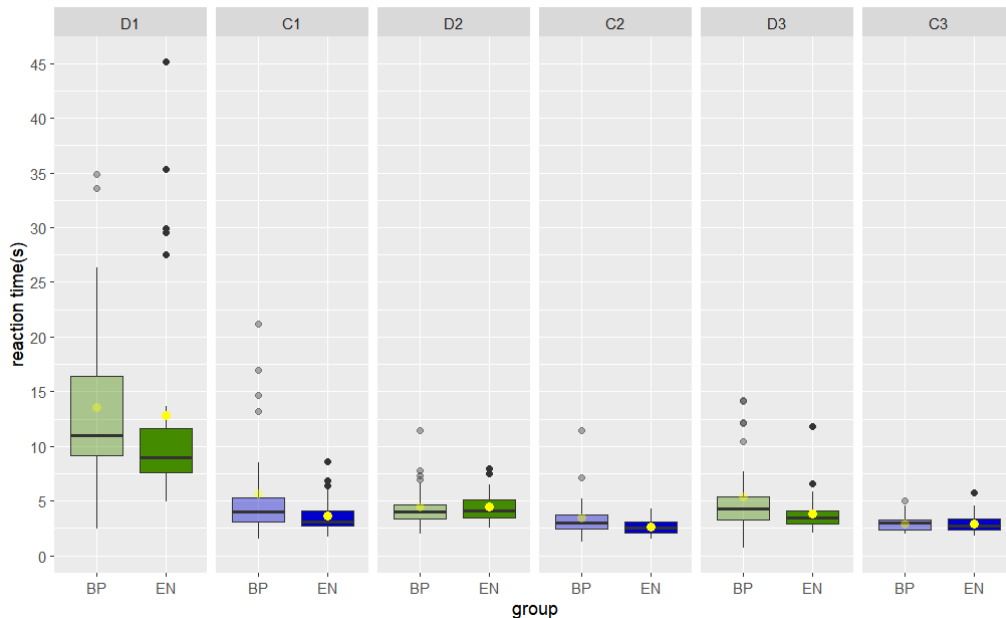


Table 3: Reading Speed Sentences BPxEN average reading time average reading times per length (in seconds)

Participant	D1		C1		D2		C2		D3		C3	
	BP	EN	BP	EN	BP	EN	BP	EN	BP	EN	BP	EN
short	12,4	13,4	5,1	2,8	3,8	4,4	2,5	2,5	4,7	3,5	2,6	2,6
medium	13,5	8,9	4,4	4,2	4,2	3,9	3,7	2,5	5,3	3,4	3,0	2,9
long	16,7	16,7	11,4	4,1	6,7	5	4,8	2,8	7,3	4,7	3,3	3,3

Discussion

Our main hypothesis was that dyslexics benefit in their reading by recruiting the lexical route, favored by the specific characteristics of the English orthographic system, which is a strategy more compatible with their deficit. The expectation that dyslexics would have difficulties with pseudowords due to engaging in the direct route in both languages was confirmed. During this task, dyslexics presented more difficulty and longer reading times with infrequent, and especially pseudowords, compared to the control group, which is compatible with the idea that dyslexics were using the lexical route as a strategy in reading for both languages. Dyslexic participants, when facing an unknown word, replaced it with a similar word based on form; for example, D3 for the pseudoword “nurto” he read “naruto” and D1 read “smile” in the pseudoword “smill”. Additionally, it was common to see D1 reading the beginning and end of the word and guessing the middle or reading the beginning and end of the words and misplacing its parts. This confirms both their specific difficulty with grapheme to phoneme mapping, as well as the hypothesis that they are making use of the lexical route for both L2 (EN) and L1 (BP), meaning that it is a compatible strategy to their reading difficulties.

It seems that dyslexics do not have specific difficulties with EN *per se*, but that their difficulties are increased due to the infrequency of words, which is of course especially true for pseudowords, which are non-existent. The fact that dyslexics performed equally worse when the words were long, also suggests a lexical effect, if we consider that both frequency and word length may favor mental word storage of full form (Baayen, 2001). Whereas control participants were able to transfer predictions based on the regularity of more coarse-grained orthography-sound patterns (as are characteristic for EN), dyslexic participants did not seem able to do so.

Although participants tended to read pseudowords faster in L2 than in L1, this was associated to poor accuracy, meaning that although they were reading faster in L2, they were scoring less in L2 than in L1, with the exception of D2 who read faster in L1 than in L2 and C2 who spent the same time for both.

We expected participants to perhaps benefit from the linguistic competence in L1, given that it is their native language, as well as deriving some advantage from higher predictability due to more transparent grapheme-phoneme correspondence in BP, especially in the case of infrequent and pseudowords. For infrequent words, the opposite was true, while for pseudowords results were mixed. The influence of the language of reading instruction and general school content (in English) seemed to have been greater in the case of infrequent words.

In terms of accuracy, we expected a similar pattern for the word writing task as the word reading task. However, all participants performed better on the BP Dictation test than the EN test, which perhaps indicates that participants do not benefit in an analogous way from reading strategy transfer. Language transparency seemed to have helped, as we can see from the higher scores in BP compared to EN. However, interestingly, for dyslexics, errors made for cognate words showed no benefit of L1 transfer even for nearly identical words (ex. “speshool” for “special”). This shows that for dyslexics transparent mapping did not follow intuitively from L1 phonological knowledge as it did for control participants. Overall, the dictation data seems to confirm that although difficulties in orthography-phonology mapping may at the base of both reading and writing, there are differences between the cognitive processes involved, and it might be that the strategy transfer we see in reading does not occur in writing, or that the dual route model does not make adequate predictions for writing. Perhaps this is because writing requires a two-fold orthography-phonology mapping (when hearing and then writing, and when reading to check for accurate writing) (Herbert, Kearns, Hayes, Bazis & Cooper, 2018).

According to our second hypothesis, we foresaw that dyslexics would show the strongest benefits of L2 reading acquisition in reading sentences compared to reading words. Indeed, we saw that dyslexics and controls behaved very similarly in the sentence reading task. One explanation might be that direct lexical access strategies become increasingly influential in contexts that allow for strong lexical prediction supported by syntactic and semantic context, which led dyslexics to perform not only comparable to their control counterparts, but also slightly better in L2 than in L1. Nonetheless, we must also consider that there were methodological differences between tests, such as the absence of frequency as a factor in the sentence task, as well as the motivation factor in the more engaging sentence reading task. These elements could be explored in future studies.

On the whole, our results partially support the idea that bilingual dyslexics make use of EN reading strategies for BP in accordance with other studies. This confirms models that entertain Dual route models for orthographic processing such as proposed by Ellis (1995), Coltheart, Rastle, Perry, Langdon and Ziegler (2001) and Dehaene (2012). As anticipated by Wydell and Butterworth (1999), specific characteristics of granularity and transparency of orthography to phonology mapping seem to influence the mode of processing, yielding a full form advantage in L2, specifically for dyslexics. The dyslexics in this study appear to present similar underlying cognitive impairments, due to their

shared difficulties with phonological segmentation as required in the reading of pseudowords, for example, but future larger scale studies should be carried out in order to adequately map distinctive performance of different dyslexia types in this specific language learning settings as foreseen by Dehaene (2012).

Our third hypothesis stated that we would see the beneficial effects of the transfer of strategies even in younger participants and our results show that the dyslexic participants show similar results to control's performance in some tasks (i.e., in the reading aloud pseudowords task, reading time was close and dyslexic participants were applying a whole-word reading strategy, based on the word form), meaning that even at young age, participants recruit direct mapping. We see in the sentence reading task, especially for D2 and D3, that differences in performance between dyslexics and controls was minimal. The fact that D1 has not caught up (yet), might reflect that it takes beginning dyslexic readers longer to achieve similar outcomes compared to their typically reading peers, as would be expected. Older participants achieve better scores in most of the tests.

In terms of levels of dyslexia and ADHD, D1 presents the most severe impairments. This might be due to his age, given that he has undergone therapeutic intervention for a relatively shorter period of time. It might be that his profile persists in its gravity. Therefore, it is somewhat complicated to tease apart to what extent his relatively lower performance is due to his age or his individual difficulties.

Finally, we predicted that the RAN test would confirm the complexities of underlying impairments in agreement with the Double Deficits proposed by Wolf and Bowers (1999). For the RAN task we observed that dyslexics performed consistently poorly for all categories; the distance between controls and dyslexics was for letters, thus confirming predictions made by the double deficit hypothesis (Wolf & Bowers, 1999). The fact that the task does not control for effects of bilingual activation may have augmented the contrast, since this task is not designed for bilinguals. The development of such adaptation could be the topic of future studies.

Studies have shown that dyslexics can benefit from multisensory and practical learning activities, which may be less common in a traditional classroom (Guimarães & Silva, 2013). An immersive L2 learning environment may propose just such a context by emphasizing language acquisition through social interaction and a transdisciplinary approach. In that sense, we may speculate that the Montessori method seems to have improved participants' proficiency and task performance, and that the effects we observed are partly due to the specifics of this environment.

Thus, the results expand and complement the results of Azevedo (2016) by showing that comparable results can be found even in young bilingual participants, especially when they are subject to an elevated level of exposure to EN through immersive teaching and a more open and flexible methodology influence reading performance in BP. The newly introduced instruments contributed to a more exact and detailed characterization of participants' performance. For example,

the time measures for the reading aloud of words per frequency, as well as the speed and accuracy of reading sentences allowed us to conclude that there was no effort-accuracy trade-off for word reading (i.e., longer times did not lead to more accuracy), and that effort spent on reading sentences was very similar among the (older) dyslexics and the control group. However, future studies are required in order to norm these tests adequately.

In the end, the myth turned out to be persistent: the idea of a dyslexic learning a second language is still a taboo. Most of the parents of the participants in this study were told not to place their dyslexic children in a bilingual school. The general lack of interest of other schools to participate in the study is also telling in that sense. This highlights the importance of the study's contribution, to the demystification of this misconception by fostering scientific dissemination and provoking interest. In a small way, the study has brought scientific research and school together, through meetings and lectures with teachers and parents, which will hopefully snowball into a greater understanding of the issues outside of academia.

Final Considerations

It is beneficial for dyslexic students to achieve higher levels of bilingualism at an early age in the context of an opaque orthographic system, such as is the case for English (L2) and Brazilian Portuguese (L1). In this sense, this study has achieved its goal of advocating and expanding immersive bilingual education for children with dyslexia, highlighting the importance of the learning method.

Although our findings for reading align well with existing models such as the Dual Route model (Ellis, 1995; Coltheart, Rastle, Perry, Langdon & Ziegler, 2001; Dehaene, 2012), when it comes to writing, our findings seem to challenge this model once better results were achieved in L1 (more transparent, hence foreseeing the use of the phonological route) than L2 (opaquer, hence foreseeing the lexical route). Future studies are required, detailing cognitive routines involved in writing more clearly, in order to investigate bilingual dyslexic writing.

Due to the specificity of the inclusion criteria of this study (dyslexia diagnosis at an early age, enrolled in a bilingual school), it is hard to find a vast number of participants. We tried to remedy this methodological weakness with a broad spectrum of tests, but we must concede that this limits the kind of conclusions and generalizations which can be taken from this research. Other studies faced the same reality. For example, Azevedo's (2016) study had twelve participants in total. In Brazil, bilingualism is growing, nonetheless dyslexic students and their parents are still often discouraged from enrolling in English courses or an immersive English school. This further limits the possibility of finding participants for this kind of study. Therefore, it is fundamental that studies are conducted, even with few participants, which one by one will add up to a broader understanding. Furthermore, we are aware that in this study data is retrieved from an extremely specific group of participants of an extremely specific reality with its own cultural and socio-economic context. Yet, we believe all pieces of data and information

are relevant when it comes to the topic of this research. Little by little, we might put together the pieces of a larger puzzle, in order to reach deeper knowledge on the framework of dyslexia, the inclusion of dyslexic students in various contexts of L2 learning and a demystification of alleged obstacles in L2 learning.

As mentioned, we sensed that the taboo surrounding dyslexics and L2 learning are still prevalent. Indeed, we encourage the production of booklets for schools and teachers about dyslexia and bilingualism, given that there is a lack of hands-on material on the subject. This material should not only offer didactic tips based on findings in the literature, but also steer away from framing dyslexia L2 learning solely as problematic, and instead inform on the potential benefits of this experience. Additionally, we feel there is room for investigation when it comes to the therapeutic intervention in cases of dyslexia. Speech therapists tend to focus on the Phonological Route strengthening; however, our results show the importance of bolstering rapid naming mechanisms and the potential for alternative reading strategies.

Acknowledgements

We thank the professionals of our team and the partner school of this study that have shown great commitment to the dissemination of science.

Notes

1. The DMS-5 (Diagnostic and Statistical Manual of Mental Disorders) includes dyslexia as a specific learning disorder, characterized by impairment in reading, in the speed of word recognition and in the decoding process, which may or may not be related to comprehension difficulties.
2. According to the American Psychiatric Association (2013), Attention Deficit Hyperactivity Disorder (ADHD) is the most common neuropsychiatric disorder in childhood and is included among the most prevalent chronic diseases among school children. ADHD is a condition that affects people's behavior. Symptoms include inattention and hyperactivity. People with ADHD can seem restless, may have trouble concentrating and may act on impulse.
3. Within the scope of this article, we are referring to L2 as the additional language learned in a formal learning context.

References

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. Arlington, VA: American Psychiatric Publishing.
- Anthony, L., & Nation, I. S. P. (2021). Picture Vocabulary Size Test (Version 1.2.3) [Computer Software]. Tokyo, Japan: Waseda University. Available from <http://www.laurenceanthony.net/software/pvst>.
- Azevedo, A. F. (2016). Cérebro, Leitura e Dislexia: Um Estudo Experimental Sobre a Leitura e as Bases Neurais da Dislexia Em Monolíngues e Aprendizes de Inglês Como L2, Com o Uso de Ressonância Magnética Funcional. (Doctoral dissertation, Pontifícia Universidade Católica do Rio Grande do Sul (PUC-RS)).
- Baayen, R. H. (2001). *Word frequency distributions* (Vol. 39). Springer Science & Business Media.

- Baccaglioni-Frank, A., & Cashin, A. (2019). Montessori education and dyslexia: A literature review. *International Journal of Special Education*, 34(2), 35-49.
- Buchweitz, A., Costa, A., Toazza, R., de Moraes, A., Cara, V., Esper, N. ... Franco, A. (2018). Decoupling of the Occipitotemporal Cortex and the Brain's Default-Mode Network in Dyslexia and a Role for the Cingulate Cortex in Good Readers: A Brain Imaging Study of Brazilian Children. *Developmental Neuropsychology*, 44(1), 146-157.
- Butterworth, B. (1980). Evidence from linguistic analysis for cognitive modularity. In M. P. Friedman, J. P. Das, & N. O'Connor (Eds.), *Intelligence and Learning* (pp. 83-107). New York: Plenum Press.
- Capovilla, F. C., Dias, N. M., & Montiel, J. M. (2007). *Avaliação cognitiva de leitura e escrita: fundamentos para a prática neuropsicológica*. Vol. 1-3. São Paulo: Memnon.
- Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, 108(1), 204.
- Costa, C. L. (2011). Dificuldades de leitura e memória de trabalho: Um estudo correlacional (master's thesis, Universidade de Brasília).
- De Bree, E. H., Boerma, T., Hakvoort, B., Blom, E., & Van Den Boer, M. (2022). Word reading in monolingual and bilingual children with developmental language disorder. *Learning and Individual Differences*, 98, 102185. <https://doi.org/10.1016/j.lindif.2022.102185>.
- Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends in cognitive sciences*, 15(6), 254-262. <https://doi.org/10.1016/j.tics.2011.04.003>
- Dehaene, S. (2012). *Os neurônios da leitura: Como a ciência explica a nossa capacidade de ler*.
- Dias, N. M., & Capovilla, F. C. (2013). *Avaliação neuropsicológica cognitiva: leitura, escrita e aritmética*. São Paulo: Memnon.
- Ellis, A. W., Flude, B. M., & Young, A. W. (1990). "Neglect dyslexia" and the early visual processing of letters in the right hemisphere. *Cognitive Neuropsychology*, 7(1), 21-40.
- Ellis, A. W. (1995). *Leitura, escrita e dislexia: Uma análise cognitiva*.
- Ellis, A. W., & Young, A. W. (1996). Connectionist models of cognitive neuropsychology: The simulation of reading aloud, writing, and the recognition of words. *Cognitive Neuropsychology*, 13(5), 671-696.
- Ferreira, J. A. T., Dias, N. M., Seabra, A. G., & Macedo, E. C. (2003). Performance of proficient reading students in the rapid automatized naming test (RAN). *Psicologia: Teoria e Pesquisa*, 19(1), 69-76.
- Guimarães, A. M. L., & da Silva, A. C. A. (2013). Difficulties and possibilities of the inclusion of dyslexic students in physical education classes. *Revista Brasileira de Ciência e Movimento*, 21(4), 102-113.
- Gutek, G. (2003). *Maria Montessori: Contributions to Educational Psychology*. In Zimmerman, B. J., & Schunk, D. H. (Eds.), *Educational psychology: A century of contributions* (pp. 323-345). Mahwah, N.J.: L. Erlbaum Associates.
- Grosjean, F., & Li, P. (2013). *The psycholinguistics of bilingualism*. Wiley-Blackwell.
- Hedman, C. (2012). Profiling dyslexia in bilingual adolescents. *International Journal of Speech-Language Pathology*, 14(6), 529-542. DOI: 10.3109/17549507.2012.693201

- Hebert, M., Kearns, D. M., Hayes, J. B., Bazis, P., & Cooper, S. (2018). Why Children With Dyslexia Struggle With Writing and How to Help Them. *Language, Speech, and Hearing Services in Schools*, 49(4), 843-863. https://doi.org/10.1044/2018_LSHSS-DYSLC-18-0024. PMID: 30458545; PMCID: PMC6430506.
- Ho, C. S.-H., & Fong, K.-M. (2005). Do Chinese Dyslexic Children Have Difficulties Learning English as a Second Language? *Journal of Psycholinguistic Research*, 34(6), 603-618. <https://doi.org/10.1007/s10936-005-9166-1>
- Kessler, B. (1997). Repetition of pseudowords by children with specific language impairment: Delayed phonological processing or general processing difficulty? *Journal of Speech, Language, and Hearing Research*, 40(1), 193-206. doi: 10.1044/jslhr.4001.193
- Kofler, M. J. (2020). Working memory in attention-deficit/hyperactivity disorder: A selective meta-analytic review of central executive and storage/rehearsal processes. *Psychological Bulletin*, 146(2), 103-139. doi: 10.1037/bul0000214
- Lallier, M., Thierry, G., Barr, P., Carreiras, M., & Tainturier, M.-J. (2018). Learning to Read Bilingually Modulates the Manifestations of Dyslexia in Adults. *Scientific Studies of Reading*, 22(4), 335-349. <https://doi.org/10.1080/10888438.2018.1447942>
- Lillard, A. S., & Else-Quest, N. (2006). Evaluating Montessori education. *Science*, 313(5795), 1893-1894.
- Lodej, M. (2016). *Dyslexia in first and foreign language learning, a cross-linguistic approach*. University of Vienna.
- Nijakowska, J. (2008). An experiment with direct multisensory instruction in teaching word reading and spelling to Polish dyslexic learners of English. Language learners with special needs: an international perspective. *Language Learners with Special Needs*, 130-157.
- Rodrigues, J. C., Nobre, A. P., Gauer, G., & Salles, J. F. (2015). Construção da tarefa de leitura de palavras e pseudopalavras (TLPP) e desempenho de leitores proficientes. *Temas em Psicologia*, 23(2), 413-29. <http://dx.doi.org/10.9788/TP2015.2-13>
- Scholl, A., & Finger, E. (2013). The development and validation of the Questionnaire for the Assessment of a Speaker's Experience and Proficiency (QuExPLi) in non-native varieties of English. *International Journal of Applied Linguistics*, 23(2), 189-214. doi: 10.1111/j.1473-4192.2012.00322.x
- Shaywitz, S. (2006). *Entendendo a Dislexia. Um novo e completo programa para todos os níveis de problemas de leitura*. Porto Alegre: Artmed.
- Siqueira, E. C. G. (2018). O uso das rotas de leitura no bilinguismo e sua relação com a profundidade ortográfica e a proficiência nas línguas. *Revista do GELNE*, 20(1), 27-45.
- Soto, M., Gomes, J. N., França, A. I., & Manhães, A. G. (2018). Neurophysiology of grapheme decoding: The N170 as a predictive and descriptive tool. *Revista da Abralín*, 17(1), 402-433.
- Sparks, R., & Ganschow, L. (1993). The impact of native language learning problems on foreign language learning: case study illustrations of the linguistic coding deficit hypothesis. *The Modern Language Journal*, 77(1), 58-74.
- Van Setten, E. R. H., Tops, W., Hakvoort, B. E., van der Leij, A., Maurits, N. M., & Maassen, B. A. M. (2017). L1 and L2 reading skills in Dutch adolescents with a familial risk of dyslexia. *PeerJ*, 5, e3895. <https://doi.org/10.7717/peerj.3895>
- Vender, M., Krivochen, D. G., Phillips, B., Saddy, D., & Delfitto, D. (2019). Implicit Learning, Bilingualism, and Dyslexia: Insights From a Study Assessing AGL With a Modified Simon Task. *Frontiers in Psychology*, 10. <https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01647>.

- Vender, M., Delfitto, D., & Melloni, C. (2020). How do bilingual dyslexic and typically developing children perform in nonword repetition? Evidence from a study on Italian L2 children. *Bilingualism: Language and Cognition*, 23(4), 884-896. doi:10.1017/S1366728919000828
- Vender, M., Vernice, M. & Sorace, A. (2021). Supporting bilingualism in vulnerable populations. *Sustainability (Switzerland)*, vol. 13, no. 24, 13830. <https://doi.org/10.3390/su132413830>
- Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for developmental dyslexias. *Journal of Educational Psychology*, 91(3), 415-438.
- Wydell, T. N., & Butterworth, B. (1999). A case study of an English-Japanese bilingual with monolingual dyslexia. *Cognition*, 70, 273-305.
- Wydell, T. N., & Kondo, T. (2003). Phonological deficit and the reliance on orthographic approximation for reading: a follow-up study on an English-Japanese bilingual with monolingual dyslexia. *Journal of Research in Reading*, 26(1), 33-48.
- Wydell, T. N., & Ijuin, M. (2018). A reading model from the perspective of Japanese orthography: connectionist approach to the hypothesis of granularity and transparency. *Journal of Learning Disabilities*, 51(5), 490-498.
- Torgesen, J. K. (2005). Recent discoveries from research on remedial interventions for children with dyslexia. In H. L. Swanson, K. R. Harris, & S. Graham (Eds.), *Handbook of learning disabilities* (pp. 345-364). New York: Guilford Press.
- Zhou, W., Xia, Z., Bi, Y., Shu, H., & Han, Z. (2019). Reduced neural activity in the VWFA during Chinese character recognition in dyslexic children. *Developmental Cognitive Neuroscience*, 40, 100714. doi: 10.1016/j.dcn.2019.100714.

Recebido em: 29/06/2023

Aceito em: 31/08/2023