EYE MOVEMENTS IN ORAL READING BY PRIMARY-SCHOOL STUDENTS: THE RELEVANCE OF PUNCTUATION MARKS

Movimientos oculares en la lectura oral de estudiantes de primaria: la relevancia de los signos de puntuación

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ABSTRACT

This study aims to explore the relevance of punctuation marks during oral reading. To achieve this objective, we compared eye movement metrics of two groups of 5th-year students, classified based on the Reading Fluency variable. The fluent reading group (FL) consisted of 27 participants, while 31 participants were in the poor reading fluent group (PF). All participants read three types of text: a simple text with punctuation, a complex text with punctuation and a simple text without punctuation. By analyzing the fixations and saccades, the data suggest that the complexity of the text influences the eye-tracking metrics of the PF group, but not the FL group. On the other hand, the presence of punctuation influence the reading behavior of the FL group, but not the PF group. These findings highlight the influence of punctuation and textual complexity on the dynamics of oral reading and offer valuable insights into how reading fluency is related to text comprehention.
Keywords: oral reading, eye movements, punctuation marks.

RESUMEN

Este estudio tiene como objetivo explorar la relevancia de los signos de puntuación durante la lectura oral. Para lograr este objetivo, comparamos métricas de movimiento ocular de dos grupos de estudiantes de 5º año, clasificados en función de la variable Fluidez Lectora. El grupo de lectura fluida (FL) estuvo formado por 27 participantes, mientras que 31 participantes estaban en el grupo de lectura fluida deficiente (PF). Todos los participantes leyeron tres tipos de texto: un texto simple con puntuación, un texto complejo con puntuación y un texto simple sin puntuación. Al analizar las fijaciones y movimientos sacádicos, los datos sugieren que la complejidad del texto influye en las métricas de seguimiento ocular del grupo PF, pero no en el grupo FL. Por otro lado, la presencia de puntuación influye en la conducta lectora del grupo FL, pero no del grupo PF. Estos hallazgos resaltan la influencia de la puntuación y la complejidad textual en la dinámica de la lectura oral y ofrecen información valiosa sobre cómo la fluidez lectora se relaciona con la comprensión del texto.
Palabras clave: lectura oral, movimientos oculares, signos de puntuación.

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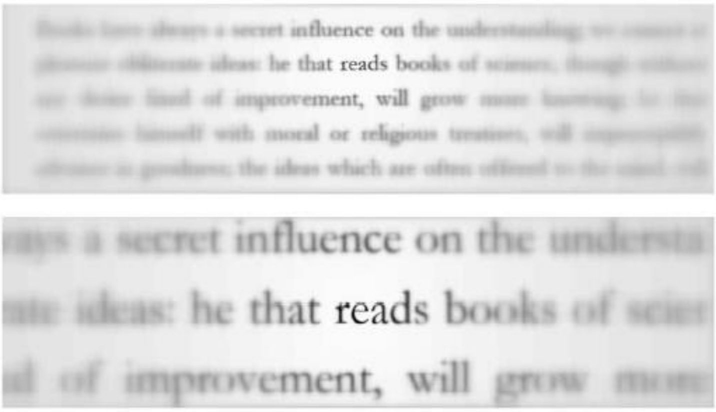
DOI: https://doi.org/10.15517/rk.v48i3.62716

Recepción: 1/12/2023 *Aceptación: 18/4/2024*

1. Introduction

During reading, our eyes are always moving and, due to the narrowness of the fovea area, these movements are ceaseless, resulting in small eye movements to bring the words of a text to this area, for example. Although the accuracy of visual information is limited to the area of the fovea, it is known that the eye begins the process of identifying a word even before the eyes fixate it (Rayner, 1998), meaning that information from the parafoveal area is very important during reading. Figure 1 illustrates the fixation under the word "reads" during the reading of a text, in other words, the clearest word represents the foveal area, while the other words, the imprecise ones, represent the parafoveal area.

Figure 1.
Text reading - foveal and parafoveal region



Source: Dehaene (2012, p. 28).

Taking into consideration these characteristics of the visual field, during the processing of eye movements in oral reading and their interaction with punctuation marks in writing, readers pause in syntactically strategic places for the integration of information; this processing intensifies when there is punctuation, causing an increase in reading times at syntactic or discursive boundaries (Hirotani et al., 2006). Such an event has been called a "wrap-up" and is indicative of mental processes of updating an interpretation that is still in progress but needs to be completed (Rayner, 1998). Hirotani et al. (2006) state that "Readers clearly exploit punctuation and use it to guide their eye movements in ways parallel to those in which listeners use intonation" (p. 439). Thus, evidence is compiled that punctuation interferes with eye behavior during reading.

Based on this evidence, this paper was designed, which focuses on the processing of punctuation marks during oral reading by 5th-grade students, taking into consideration textual complexity and reading fluency.

2. Eye Movements in Reading

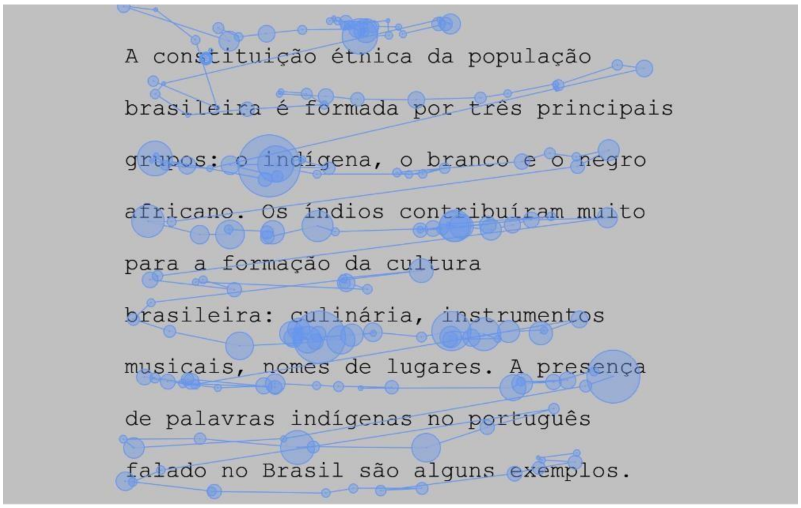
In this section, we will present some eye aspects during reading and their implications for processing, especially in young readers. The eye movements highlighted here are fixations and saccades.

2.1 Fixations

Fixations represent the moment in which the eyes pause slightly under a certain area for processing. The number of fixations is related to the difficulty in processing information (Forster, 2017), meaning that the more fixations made on a given word, the greater the difficulty in processing said word (Rayner, 2014). The variables analyzed in reading studies that consider fixations are: location, quantity and duration of fixations.

The fixations made during the reading are counted in milliseconds (ms): the larger the circle, the longer the fixation duration. Figure 2 shows the fixations graphically in blue circles using the BeGaze software.

Figure 2.
Fixations and saccades displayed by the BeGaze software



Source: the authors.

Studies (Just & Carpenter, 1987; Rayner & Duffy, 1986) have concluded that content words are fixated 85% of the time, while functional words are fixated only 35% of the time. Furthermore, according to these studies, this is due to the length of functional words, which tend to be short, that is, the longer the word, the more likely it is to be fixated. In practical terms, a word with 2-3 letters can be fixated around 25% of the time, while a word with 8 letters is more likely to be fixated, and even re-fixated. Also, keywords for comprehension receive more fixations from fluent readers, which allows them to process more quickly. In some cases, some words do not receive fixations during processing, which is known as the "word skipping" phenomenon, because the word is "skipped" by means of a longer saccade.

It is known that in terms of perceptual area, beginner readers display smaller letter spaces to the right of fixation, around 12 spaces, when compared to adult readers, who display 14-15 spaces. The size of the perceptual area also varies according to the difficulty of the text in both age groups (Rayner & Duffy, 1986).

When it comes to identifying words, the time needed to identify a word is shorter when the eyes initially fixate on the middle of the word, an event known as Optimal Viewing Position (OVP). For Rayner (1978), the first landing position is classified as Preferred Viewing Location (PVL). It is therefore considered that the OVP is the optimal position in terms of word perception, while the PVL represents the actual position of the fixation when reading a word in the sentence (LIU & LI, 2013).

2.2 Saccades

Rayner (2014) defines saccades, or saccadic movements, as the rapid eye movements from one fixation to the next while scanning and processing information. Examples of saccades are shown as blue lines in Figure 2. Their length represents the amplitude of the saccadic movements, that is, the distance from saccade start to end point.

In reading, saccades generally last from 20 to 40 milliseconds and span, on average, 7 to 9 letters, though typically within the range from 1 to 18 letters (Rayner, 2014). Aspects commonly analyzed in these movements are duration, location and amplitude of the movements.

The saccades can be progressive or regressive. When reading Portuguese, where you move to the right, the progressive will be the one made most of the time. Regressive saccades are movements made in the opposite direction to reading; in the case of Portuguese, from right to left. According to Rayner (2014) regressions are linked to comprehension difficulties.

Regressions occur 10 to 15% of the time during reading (Rayner, 2014; Macedo, 2007). For Macedo (2007), it serves as a way of checking whether a word has been skipped or not understood. Many regressions are only a few letters long and can mean that the reader has made a very long saccade, making them need to go back to that information in order to process it; on the other hand, a short regressive saccade can occur to solve a processing problem in the word that is being fixated in the act of regression, for example, in the resumption of one of the syllables of an unknown or very long word.

When compared to fluent adult readers, children usually make shorter saccades, as well as longer fixations, and around 25% of their eye movements consist of regressions, which Blythe and Joseph (2011) believe explains why reading is slower in this group.

3. Eye Movements in Oral Reading

Eye movements have distinct characteristics that depend on the type of reading. When reading aloud, for example, even if you are only following a text that another person is reading aloud with your eyes, the average duration of fixations is longer than when reading silently. This is due to the tendency for the eyes to be ahead of the voice. In a study carried out by Lévy-Schoen (1981), occurrences of refixations on a word were observed, almost as if the eyes were still. The intention of the readers, who were following oral reading, was not to go too far ahead of the heard reading.

In general, what is known about oral reading and eye movements is that articulation in oralization operates more slowly than cognitive processes. As a result of this time difference, readers usually look at and process a word in the text that is two to three words to the right of what they are pronouncing (Inhoff et al., 2011): “Given that the eyes are ahead of the voice in oral reading, readers may only need to process the fixated word, and words to the right of that might be irrelevant” (p. 635).

Huey (1968) suggests a fairly simple relationship between silent and oral reading modes; for him, oral reading processes can be considered essentially the same as silent reading processes, with only the addition of articulatory demands. However, studies that have examined eye movements in oral and silent reading in-depth indicate that eye movements in both modes are strongly correlated (Anderson & Swanson, 1937; Søvik et al., 2000).

For Rayner et al. (2012), examining the demand on tasks in the parafoveal region and analyzing the reading systems that capture information from this region during oral reading can make important contributions to understanding oral and silent reading processes. The authors investigated the role of parafoveal information in oral reading compared to silent reading. Intrigued by the possibility of parafoveal information masking the delay in silent reading, the authors examined whether the availability of parafoveal information affected oral reading. To this end, the authors monitored the eye movements of participants reading sentences silently and orally under conditions in which parafoveal information was sometimes available and sometimes not. The results indicate that parafoveal information contributes directly to a reduction in fixation duration during both oral and silent reading. On the other hand, the "number of fixations" in a sentence was reduced when parafoveal information was available during silent reading, which was not the case during oral reading. In other words, the data indicates that the availability of parafoveal information only helps silent reading. The authors offer three explanations for this: firstly, following the results of another study on the phonological representation of words in working memory[1] during sentence reading (Inhoff, et al., 2004), the available resources for parafoveal processing are depleted as the phonological working memory is required more, since words need to be stored in memory until they are articulated. The second explanation is related to the phonological representations stored in working memory for articulation, which could interfere with more recently activated phonological representations and thus reduce the benefit of parafoveal information during reading. The third explanation is that parafoveal information is treated similarly in the two reading modes, but readers do not make use of this information to program fixation location during oral reading.

[1] The working memory implies the temporary storage and manipulation of information that is considered necessary for a wide range of complex cognitive activities (Baddeley, 2003).

4. Eye Movements and Punctuation Marks

The pause effect related to punctuation marks in reading has typically been attributed to unfinished interpretive processing and the updating of discourse representation, according to Rayner et al. (2012).

Aiming to further understand when and why closure effects occur, Hirotani et al. (2006) investigated the effects of punctuation in clauses and sentences. For the authors, punctuation marks are linked to the permanence hypothesis, through which the deceleration at the end of clauses is seen as strategic. The authors explain that readers, in order to avoid returning to the beginning of the clause, remain at the end of the clause until they have processed all the events contained therein, and then move on to the next clause. This hypothesis is called "dwell-time". This hypothesis characterizes longer eye fixation durations at the end of sentences. According to the authors, when we compare the number of regressions within a clause and at the end of it, especially when there is a punctuation mark at the end of the clause, this hypothesis predicts that readers make fewer regressions at the end of sentences than within the clause. Thus, characterizing reading eye movements in relation to punctuation marks and their importance for sentence organization and, consequently, textual comprehension.

Analyzing the impact on eye patterns when reading texts in Spanish, where the use of commas is mandatory, Angele et al. (2024) organized an experiment with sentences with or without mandatory commas. The data shows that even when commas are mandatory, their effect is primarily to shift when processing takes place rather than to facilitate processing overall. This because:

> There was a local increase in the go-past time for the pre-comma region when commas were presented, which was balanced out by shorter first-pass and second-pass times on the subsequent regions. In global sentence reading time, there was no evidence for an advantage of presenting commas. (Angele et al., 2024, p.1)

So far, there has been a discussion about eye movements in reading, especially in oral reading, and finally, there has been a relationship between some characteristics of eye movements and the presence of textual punctuation marks. From this, the questions arise: what is the influence of punctuation marks during oral reading? Does textual complexity play a role in differentiating these characteristics? And what are the differences in reading processing between individuals with different reading fluencies? In order to answer these questions, in the following sections we present an investigation into the processing of eye movements during oral reading by elementary school students, taking into account textual complexity (simple text, complex text, with or without punctuation marks) and reading fluency (poor reading fluent group and fluent group).

5. Sample

The sample for this study consisted of 58 fifth grade students from public schools in the city of Ponta Grossa, Paraná, Brazil. Using the Multidimensional Scale for the Assessment of Expressive Reading[2] (Vansiler, 2015; Picanço & Vansiler, 2014) the participants were divided into two groups: the fluent reading group (FL) and the poor reading fluent group (PF), as shown in Table 1.

This scale assesses oral reading in the following dimensions: intonation and emphasis, phrasing, and fluidity of rhythm. Depending on the reading performance, the reader receives scores from 0 to 4, with 0 referring to the lowest score. Based on the average between the dimensions, the reader's level of fluency in oral expressiveness is measured: non-fluent (PF) and fluent (FL).

Table 1.
Mean and SD of Reading Score per Group

Fluency-Group	boys	girls	Total
FL	14	13	27
PF	09	22	31
Total	23	35	58

Source: Vansiler (2021, p. 102).

The project was submitted to the ethics committee of Plataforma Brasil and was approved under #2.757.810, CAAE: 86296517.8.1001.0018 on 05/06/2018.

[2] "Escala Multidimensional para avaliação da leitura expressiva". Portuguese version available.

6. Space Characterization and Technical Specifications

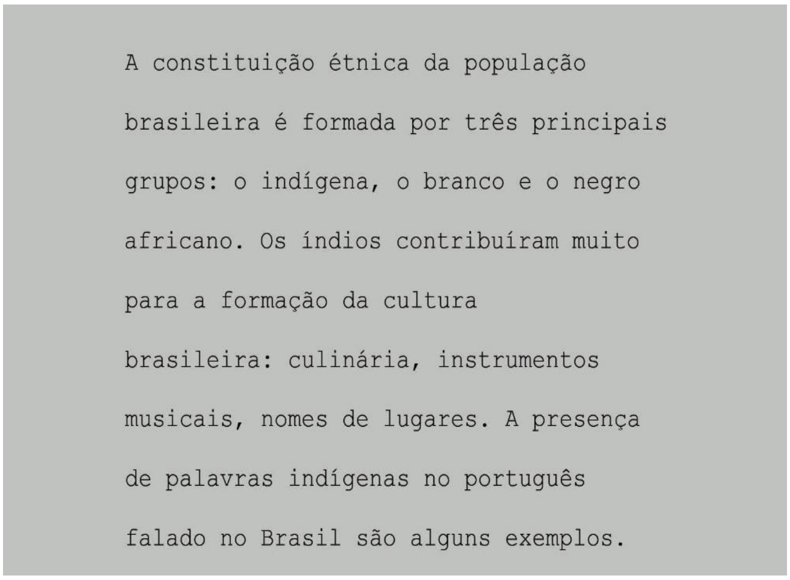
The data was collected at the Visual Processing Laboratory (LabPV), located at UTFPR in Ponta Grossa, Brazil. The RED 500 device from German manufacturer SMI detected eye movements while the participants read the texts. The device is sensitive enough to register any binocular movement every 2 milliseconds and has an accuracy of 0.4. It consists of an infrared set, a projection screen and a notebook on which there is SMI software for recording eye movements, setting up the experiment and processing the data. The infrared is located below the monitor and is positioned at a distance of 60 to 80 cm from the participant. Before the participant began the collection, the height of the table was adjusted so that the participant was in a comfortable position during the experiment. Calibration was carried out with 5 points with a limit of 0.5º on the x and y axes. For each deviation found above this limit, the calibrations were repeated and validated in order to continue with the experiment.

7. Description and Application of the Instrument

The data was collected individually in a quiet room at the LabPV. Each participant sat in front of the monitor with the tracker attached, resting the upper front of their head on a support to reduce sudden movements during the experiment and read aloud, that is, orally. The collection instrument consists of three texts which vary according to textual complexity and the presence or absence of punctuation marks.

Text 1 (Figure 3) corresponded to a complex 49-word school text, the content of which features sentence inversion, less frequent words in the Portuguese language and is highly informative, but the vocabulary is accessible at a school level. The punctuation marks are visible in the text.

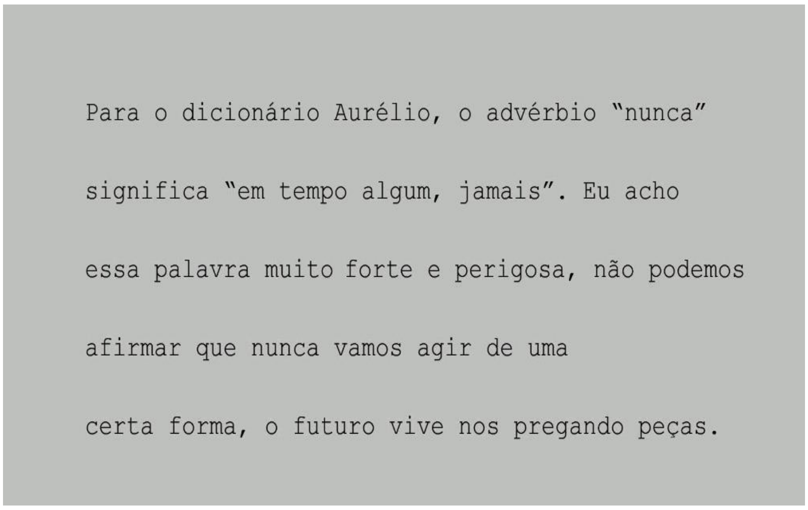
Figure 3.
Screen of the Experiment Center with the Text "Matrizes culturais do Brasil"
(Complex Condition with Punctuation).


A constituição étnica da população
brasileira é formada por três principais
grupos: o indígena, o branco e o negro
africano. Os índios contribuíram muito
para a formação da cultura
brasileira: culinária, instrumentos
musicais, nomes de lugares. A presença
de palavras indígenas no português
falado no Brasil são alguns exemplos.

Source: elaborated by the authors.

Text 2 is composed of a 37-word non-complex school text and also has semantic content accessible to the level of the students, punctuated according to the norms of the written Portuguese language. Figure 4 shows the screen with the text.

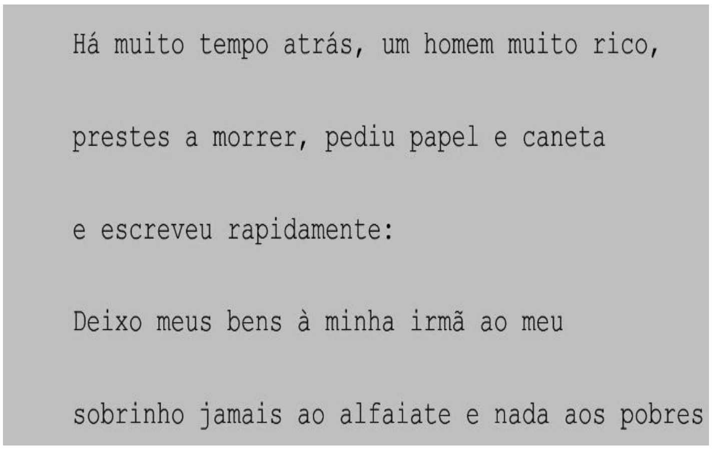
Figure 4.
Screen of the Experiment Center with the Text "Nunca, nuncaquinha" (Easy Condition with Punctuation)


Para o dicionário Aurélio, o advérbio "nunca"
significa "em tempo algum, jamais". Eu acho
essa palavra muito forte e perigosa, não podemos
afirmar que nunca vamos agir de uma
certa forma, o futuro vive nos pregando peças.

Source: elaborated by the authors.

Text 3 is also a non-complex text with 34 words, but part of the text has no punctuation marks. Figure 5 shows the image of stimulus-text 3.[3]

Figure 5.
Screen of the Experiment Center with the Text "A herança" (Easy Condition without Punctuation)



Source: elaborated by the authors.

Questions were asked at the end of each text to ensure that the students were reading carefully. However, these questions and answers were not taken into account when analyzing the data.

8. Analysis of the eye movement data

Considering the three stimuli, quantitative analyses were carried out to check: a) Number of Fixations (NF) and the b) Number of Saccades (NS). To find out whether or not the two eye-tracking metric mentioned followed a normal distribution, the Shapiro-Wilk test was used, according to which, a distribution is considered normal if the value of the parameter p obtained from the test is greater than 0.05. Table 2 displays the test result for the three stimuli considered.

[3] Text commonly used in the classroom to work on punctuation marks. For an example of how to work in class, see: https://brainly.com.br/tarefa/8181984

Table 2.
Classification of Normality of Eye-Tracking Metric Distribution

Stimulus (S)	Number of fixations (NF)	Number of saccades (NS)
S1 - PF	Normal	Normal
S1 - FL	Non-normal	Non-normal
S2 - PF	Normal	Non-normal
S2 - FL	Normal	Non-normal
S3 - PF	Normal	Normal
S3 - FL	Normal	Non-normal

Source: elaborated by the authors.

To compare the distribution of eye-tracking metrics for each stimulus and for each group, we used the Mann-Whiteney statistical test. The Mann-Whitney test is a non-parametric test used to compare two independent samples and determine whether there is a significant difference between them. It is considered the non-parametric equivalent to the t test; however, it does not require the data to be normal.

When the Mann-Whitney U test is applied to two independent samples, one of the results is the U parameter, which indicates the magnitude of the difference between the two samples. A high U value suggests that one of the samples tends to have higher values than the other, while a low U value suggests the opposite. In addition to the U parameter, the test provides the p-value, which indicates the probability of observing a difference between the samples. If the p-value is less than a certain pre-defined significance level (e.g. 0.05), the null hypothesis that there is no difference between the samples is rejected.

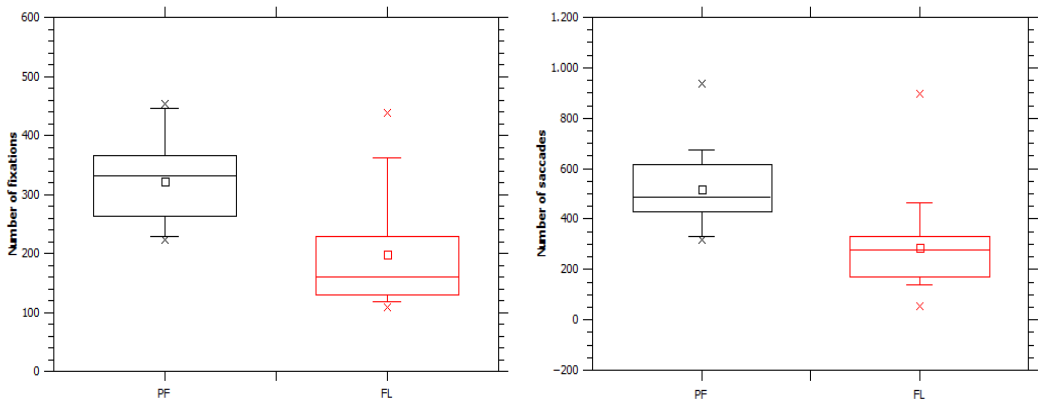
With the Mann-Whitney test it is also possible to calculate the z-score and the effect size r. The z-score corresponds to the normalized value of U. It indicates how many standard deviations the U value is away from the mean. A high Z-score (in absolute value) indicates that the difference between samples is greater than would be expected by chance. In turn, the effect size r indicates the magnitude of the difference between the samples. It is obtained by dividing the z-score by the square root of the total number of observations. Knowing these parameters provides a comprehensive view of the difference between the two samples and whether this difference is statistically significant.

The results of applying the Mann-Whitney test as well as the box-plot of the eye-tracking metrics are described below and are presented by stimulus, comparing the two fluency groups and the three stimuli.

8.1 Analysis of Stimulus 1: Complex Condition with Punctuation

In Figure 6, we present the boxplot for the two eye-tracking metrics we've been discussing, the number of fixations and the number of saccades. As we can observe, the PF group demonstrated a higher number of fixations and saccades compared to the FL group. Considering the mean and median of fixations, the PF group had 306.2 and 332 fixations, respectively, while the FL group had 197.5 and 159 fixations. Regarding saccades, the mean and median of the PF group were, respectively, 517.2 and 488, while that of the FL group was 285.6 and 277.

Figure 6.
Boxplot of NF and NS by Group FL and PF for Stimulus 1



Source: elaborated by the authors.

In order to verify whether this difference between the behavior of the ocular variables of the two groups is significant, the Mann-Whitney Test was employed. The Table 3 displays the test result obtained for the two metrics considered. Since the U value is high and the p value < 0.05, it can be stated that there is a significant difference between the groups.

Table 3.
Result of the Mann-Whitney test in relation to eye-tracking metrics for stimulus 1

Eye-tracking metrics	U (PF)	U(FL)	p	z	r
Number of fixations	87	417	9.09E-05	3.742	0.557
Number of saccades	44.5	435.5	2.15E-06	4.596	0.693

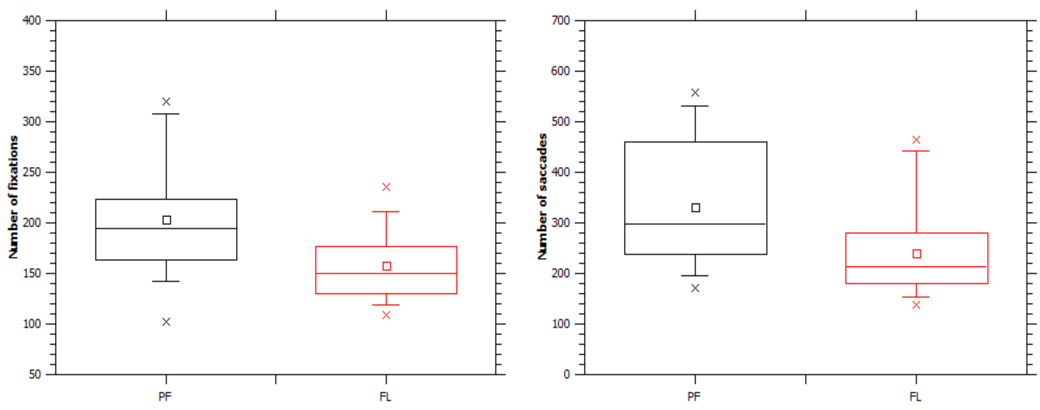
Source: elaborated by the authors.

Looking at Figure 6 and Table 3, the PF and FL groups differ significantly, with the FL group having lower averages in all ocular variables in stimulus 1. As this stimulus corresponds to a complex text, the result indicates that textual complexity directly interferes with eye behavior during oral reading, causing participants with low fluency to need to make more saccades and more fixations. Therefore, ocular variables could be used as parameters to classify reading fluency when the stimulus involves textual complexity.

8.2 Analysis of Stimulus 2: Easy Condition with Punctuation

Figure 7 shows the boxplot of the fixations and saccades of stimulus 02 for each fluency group. Also in this stimulus, the PF group exhibited a higher number of fixations and saccades than the FL group. Regarding the number of fixations, the first had a mean and median equal to 202.9 and 195, respectively, while the second, 157.4 and 150. Also, in relation to the saccades, the mean and median of the PF group (332.1 and 297) performed a slightly higher than the FL group (240.8 and 212).

Figure 7.
Boxplot of NF, NS for FL and PF in Stimulus 2



Source: elaborated by the authors.

As with stimulus 1, the Mann-Whitney Test was employed and the results (high U and p value < 0.05) suggest that there is a significant difference between the groups. Table 4 displays the test result obtained for each of the test parameters.

Table 4.
Results Of the Mann-Whitney Test in Relation to Eye-Tracking Metrics for Stimulus 2

Eye-tracking metrics	U (PF)	U(FL)	p	z	r
Number of fixations	120,5	455.5	2.86E-04	3.44	0.497
Number of saccades	148	428	2.01E-03	2.877	0.415

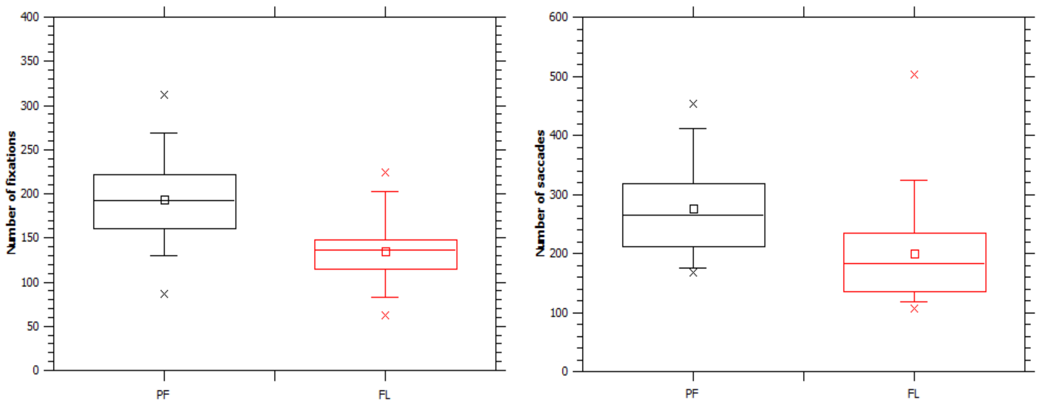
Source: elaborated by the authors.

The results of the eye movements were also statistically different between the fluency groups in stimulus 2, which involved a non-complex text. Participants in the fluent group made significantly fewer fixations and saccades, meaning that the performance of low-fluency readers was once again lower, even though this stimulus was made up of a non-complex text.

8.3 Analysis of Stimulus 3: Easy Condition without Punctuation

The behavior observed in the previous texts for the number of fixations of the PF groups was also observed in text 3. The figure 8 shows the boxplot containing the mean and median measurements of the ocular variables observed in stimulus 3 for each fluency group.

Figure 8.
Boxplot of NF and NS for FL and PF in Stimulus 3



Source: elaborated by the authors.

Also in stimulus 3, the number of fixations and saccades in the PF group were higher than in the FL group. While the mean and median number of fixations for the first were, respectively, 193.2 and 192, for the second they were 134.8 and 136. Regarding saccades, the mean and median were respectively 276.5 and 264 for the PF group, and 200.5 and 183.5 for the FL group. Table 5 shows the result of the statistical test for the ocular variables in stimulus 3.

Table 5.
Result of the Mann-Whitney Test in Relation to Eye-Tracking Metrics for Stimulus 3.

Eye-tracking metrics	U (PF)	U(FL)	p	z	r
Number of fixations	133	673	7.86E-06	4.318	0.571
Number of saccades	179.5	626.5	1.76E-04	3.573	0.473

Source: elaborated by the authors.

As in the previous stimuli, also here the mean of the eye magnitudes investigated was lower for the FL group compared to the PF group. However, for this stimulus the difference between the means was smaller than in the previous stimuli, even so the difference between the groups was statistically significant.

8.4 Analysis of Stimulus 1 X Stimulus 2

After comparing the eye-tracking metrics in relation to the groups, they were also compared in relation to the stimulus. Table 6 displays the result of applying the Mann-Whitney Test comparing the number of fixation and number of saccades in the complex text with punctuation (S1) with those in the easy text with punctuation (S2).

Table 6.
Results of the Mann-Whitney Test for Each Group Comparing Stimuli 1 and 2

Eye-tracking metrics	U (S1)	U(S2)	p	z	r
Number of fixations (PF)	60.5	443.5	6.92E-06	4.346	0.647
Number of fixations (FL)	232.5	343.5	1.28E-01	1.135	0.163
Number of saccades (PF)	81.5	422.5	5.47E-05	3.869	0.577
Number of saccades (FL)	241.5	334.5	1.71E-01	0.949	0.137

Source: elaborated by the authors.

As the p values obtained for the PF group were lower than 0.05 for both eye-tracking metrics, it can be concluded that there is a significant difference between the group's behavior in relation to the complex text with punctuation and the simple text with punctuation. On the other hand, p values greater than 0.05 obtained for the FL group reveal that there is no significant difference for fixations and saccades in this group. These results suggest that the complexity of the text influences the eye-tracking metrics of the PF group, but not the FL group, which may have implications for reading comprehension and cognitive processing. However, more research is needed to explore these relationships in different contexts and populations.

8.5 Analysis of Stimulus 2 X Stimulus 3

The PF and FL groups were also analyzed separately in relation to stimuli 2 and 3, which refer to simple texts with and without punctuation, respectively. Table 7 displays the result of applying the Mann-Whitney Test, comparing the number of fixation as well as the number of saccades in relation to two simple texts, one with punctuation and the other without.

Table 7.
Results of the Mann-Whitney test for each group comparing stimuli 2 and 3

Eye-tracking metrics	U (S1)	U(S2)	p	z	r
Number of fixations (PF)	342.5	401.5	3.11E-01	0.492	0.066
Number of fixations (FL)	199.5	424.5	1.48E-02	2.175	0.308
Number of saccades (PF)	276.5	467.5	5.34E-02	1.613	0.217
Number of saccades (FL)	212.5	183.5	2.92E-02	1.893	0.268

Source: Elaborated by the authors.

Unlike what was observed in relation to complexity, analysis of the data in table 07 reveals some interesting observations about the influence of punctuation on reading, especially when we consider semantics. Semantics is heavily influenced by punctuation. Punctuation helps define the structure and meaning of sentences, indicating where pauses should occur and how different parts of the sentence relate to each other.

In the case of the FL group, we observed significant differences in the number of fixations and the number of saccades between simple texts with and without punctuation. This suggests that the presence of punctuation, which contributes to the semantics of the text, can influence the reading behavior of this group. Punctuation can help guide the reader through the text, making it easier to understand the sentence structure and therefore the overall comprehension of the text.

On the other hand, for the PF group, we did not observe significant differences between fixations or saccades for simple texts with and without punctuation. This may indicate that, for this group, the punctuation has a lesser impact on reading. Perhaps these readers are more focused on the meaning of each word in the text and less on the meaning of the sentence or paragraph.

These findings highlight the importance of punctuation and semantics in reading and understanding text. However, they also show that the influence of the punctuation can vary depending on the reader, possibly due to differences in reading skills, experience, or reading strategies.

9. Discussion

The results of the ocular data analysis presented in the previous section show that the low fluency group had higher values for all eye-tracking metrics than the fluent group for all stimuli. This corroborates the findings of Forster (2017) and Rayner (2014) that the number of fixations is related to difficulty in processing information. These findings suggest that readers with lower fluency may spend more time fixating on words and make more saccades, or quick eye movements, as they read. This could be because they are spending more time processing the information in the text, which could be due to a variety of factors such as lower reading speed, less familiarity with the language, or more difficulty understanding the content.

It's also interesting to note that these patterns were observed across all stimuli, suggesting that these differences in eye-tracking metrics are not just due to the complexity or difficulty of specific texts, but are likely reflective of broader differences in reading ability or strategy between the two groups. However, when comparing the values that differentiate the groups from each other, it can be seen that textual complexity directly interfered with the scores: in the complex text, the PF participants were much more distant from the ocular behavior of the FLs. And this need is more evident in the FP participants.

The textual and typographical characteristics also influenced the eye movements of the two fluency groups: although both stimuli 1 and 2 were composed of informative text, the first text contained formal language and the second colloquial. As colloquial language is simpler, this made it easier to understand the text in stimulus 2, reducing the difference in means between the PF and FL groups.

In the text without punctuation marks, which is stimulus 3, the difference between the values of the two groups in the ocular aspects is much smaller. It can be understood from these results that the text without punctuation was difficult to understand for both groups, even though it was a simple text. The participants had to choose where to pause, giving their own interpretation to the text. Depending on where the pause was (often marked by a punctuation mark), the nephew and the tailor would receive an inheritance or not. Deciding on one interpretation or another required more fixations in both groups, corroborating the findings of Rayner et al. (2006) that "eye movements are sensitive to global text difficulty" (p. 251). In native Spanish fluent readers, when they reading texts without commas, they had fewer fixations, and according to the authors, skilled readers could easily analyze the syntactic structure and semantic relationships in a sentence, even in the absence of commas, at least for syntactically simple sentences (Angele et al., 2024).

Considering the discussion so far, the data shows that the presence of punctuation marks in texts during oral reading is of utmost importance, even surpassing the level of reading fluency and textual complexity. In the two previous stimuli, where the difference was textual complexity, the fluency groups also differed significantly.

10. Final considerations

In order to find out the relevance of punctuation marks during oral reading, this research analyzed ocular aspects (number of fixations, number of saccades) during oral reading of 58 fifth grade students from a school in Brazil, taking into account the reading fluency variable (fluent group and low fluent group) and textual complexity (simple text with punctuation, complex text with punctuation and simple text without punctuation).

In response to the questions that motivated this work –such as: a) what role do punctuation marks play during reading?–, we can see that the punctuation marks during oral reading in the context studied here played a role in textual organization for both fluency groups, since in the text without punctuation, the two fluency groups showed closer eye movements, even so the difference between the groups was statistically significant. Regarding the second question –b) Does textual complexity play a role in differentiating these characteristics?–, it was possible to observe that the fluency groups differed significantly in their eye behavior from a complex text to a simple one, with the fluent group showing lower averages; finally, in relation to the third question –c) What about reading fluency, what are the differences in reading processing?–, it is noteworthy that the low fluency group had the highest averages in all the stimuli and in all the ocular variables.

From continuous writing to the addition of punctuation marks in a text, our brain has adapted synaptic areas for the evolution of its species that guarantee it will pass on to future generations one of its greatest inventions: writing. There is no doubt that there is a place in the brain for the processing of writing. Just as there is no doubt that a reader's brain has different physical and chemical characteristics to a non-reader's brain. Skills with printed material (we're even broadening the concept of reading here, because everything that is printed is processed: reading the world, reading impressions, reading expressions, etc.) are acquired as the reader enters and is introduced to the world of writing.

It is necessary to stimulate the skills of memory, oralization, expressiveness, knowledge of the world and many others related to the ability to read, in order to guarantee the best performance from students. Developing this skill means ensuring that these citizens are actively included in society.

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