

Revisers' eye movement in reading

O movimento ocular na leitura realizada por revisores de textos

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Abstract: This study aims to investigate the reading processing of professional revisers, comparing their eye movement with subjects who do not work professionally in revision (non-revisers). In the reading and error detection task proposed and performed by 14 revisers and 14 non-revisers, the participants had to read and edit short journalistic texts displayed on a computer, by clicking on the errors and/or inadequacies they found using the mouse. There were two types of errors: a) missing preposition and b) incoherence generated by an incorrect nominal anaphora. In the statistical analysis, when normality was ensured, mixed models were carried out; otherwise, the analysis was carried out by means of non-parametric tests. Considering the eye movement analysis, the general perspective indicates that revisers presented the highest values, meaning they were slower in reading than non-revisers, which occurred concerning the measures of the text, sentence, and local levels. This research contributes to a characterization of reading processes involved in the revision of texts by professional revisers.

Keywords: revision; professional revisers; eye movement; proficiency.

Resumo: Este estudo objetivou investigar o processamento da leitura de profissionais revisores de textos, comparando o movimento ocular destes com o de sujeitos que não trabalham profissionalmente com revisão (não revisores). Na tarefa de leitura e detecção de erros realizada por 14 revisores e 14 não revisores, os participantes deveriam ler e revisar pequenos textos jornalísticos projetados no computador, clicando com o mouse nos erros e/ou inadequações que encontrassem. Havia dois tipos de erros nos estímulos experimentais: a) supressão de preposição e b) incoerência gerada por uma anáfora nominal incorreta. Na análise estatística, quando garantida a normalidade, foram realizados modelos mistos; do contrário, a análise foi realizada por meio de testes não paramétricos. Quanto à análise do movimento ocular, a perspectiva geral foi de que os revisores apresentaram valores mais elevados, o que significa que eles foram mais lentos na leitura do que os não revisores, o que foi identificado nas medidas do nível do texto, da sentença e do trecho alvo. Esta pesquisa contribui para uma caracterização dos processos de leitura envolvidos em tarefas de revisão de textos por revisores profissionais.

Palavras-chave: revisão de textos; revisão profissional; movimento ocular; proficiência.

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1 Introduction

Revision is directly related to the text reading and production process. Therefore, when one rereads a text one has produced, one seeks to assume an exotopic view¹ and check different aspects of the textual structure

¹ The exotopic view is that in which reading is done by using a different gaze from that of the text's producer, a gaze that would stimulate the reading performed by the reader to which the text is intended.

² A *saccade* is a quick, simultaneous movement of both eyes between two phases of fixation in the same direction.

in order to identify possible errors, as well as segments whose interpretation poses difficulty to the reader. However, authors are not always the most suitable readers to revise their own texts, whether for technical reasons, related to the lack of specific knowledge in the language study field (in the case of authors in other areas), or for practical reasons: exotopy may be compromised, given that the text, when read by its own author, loses its unpredictability, which may cause language inadequacies to go unnoticed.

This is the reason for the existence of the professional text reviser, whose occupation is to read texts produced by others in order to identify language inadequacies and propose different corrections or changes.

Despite being an old and important activity, very few studies focus on professional revisers, although there is a perception that this task requires special qualification and demand, particularly regarding reading: “Revisers do not read as other men do, they photograph the word visually; and the texts are reflected in their corrections.” (WAGNER; CUNHA, 2012, p. 12).

Hence, this work aims at investigating how the reading performed by professional text revisers is processed. For such, the eye-tracking investigation method was used. Fixation and saccade² patterns performed by these professionals during revision were checked, as well as whether these patterns are similar to those detected when individuals who are not professional revisers read the same texts. Therefore, this work’s purposes are:

- To investigate eye movement patterns in reading performed by professional text revisers, in an error detection task;
- To compare the eye movement performed by professional text revisers to that of subjects who do not revise texts professionally, in a reading and error detection task;
- To determine if professional text revisers and subjects who do not revise texts professionally perform a reading directed both to the textual surface and to more global text levels.

This study contends that the reading performed by text revisers is less automatic, more controlled and more detailed, which leads to more proficiency in the revision activity.

2 Text revision in a cognitive approach

Heurley (2006) points out three major views of revision from the cognitive standpoint: revision as effective text change; revision as a subprocess of the writing process, aimed at improving the previously written text; and revision as a distinct component of the written production, which would involve a set of subprocesses and procedures implied in the control of writing.

Hayes et al. (1987), in turn, propose a model specifically for revision. The model is divided into processes and knowledge. The first process involved is defining the task, which includes specific issues, such as the reviser's intents, the text traits to be examined, and how the revision is to be conducted. The second process is the evaluation, when the reading objects are selected: understanding, evaluating, or detecting problems. Based on the representation made of the problem, a strategy will be selected, with the possibility for modifying or controlling the revision process in itself, or modifying the text. By modifying the revision process, the reviser may ignore the problem, seek more information to improve the diagnosis, or postpone the action, even when the reviser opts to do more than one reading, one of which directed to a higher level, and another one related to textual surface aspects. By contrast, if the reviser chooses to modify the text, he/she may rewrite it or revise it. In this case, the revision includes those cases in which the reviser corrects inadequacies, preserving the original text as much as possible. An important issue is that revisers may redefine the task as the revision is performed. Thus, the knowledge used, including goals, criteria, and restrictions, is dynamically modified during revision. Revision is related to reading for detecting problems, which, according to the authors, is different, for instance, from reading directed only to understanding.

In 1996, Hayes proposed Hayes and Flower's (1980) writing model be reformulated, with the main purpose of adding important cognitive elements, such as the working memory, as well as to reorganize existing elements to show the relationship between them and more general cognitive processes involved in several types of activities. Revision is therefore seen as a form of text interpretation. The author proposes a new revision model, in which there is a control structure, consisting of a revision task scheme; fundamental processes, including reflection, processing, and text producing; and the resources used, which are the working memory and

the long-term memory. The revision, along with the reflection and text production, is part of the subcomponent of cognitive processes, which, in turn, is part of a greater component. The latter, in addition to cognitive processes, involves an affective/motivational subcomponent, the working memory and the long-term memory. Thus, the author contends that, to understand the revision, one needs to understand not only the process, but also its control structure and the resources involved. The author points out that this set of requirements is acquired with practice, and this may also be inferred from the difference between new and experienced text producers and revisers, as explored by Hayes et al. (1987).

As shown, in these studies' scope, revision no longer plays a secondary role in the writing process, and revision is now seen as an important stage in this process, acting on several levels. Revision has been treated more and more as a control activity, which may operate separately or throughout the writing process.

3 Eye movement and reading

Eyes move in saccades alternating with fixations. While a saccade corresponds to a rapid eye movement to move the focus from one area to the other, a fixation is equivalent to the time spent focusing on a given area. It is possible to determine time and space variables when the eye movement is recorded, as there is a spatial displacement, that is, the point to where the movement is directed, and a temporal displacement, represented by the moment when this movement occurs. In addition, it is known that the type of movement depends heavily on the required information (LAND, 2007, p. 78).

Furthermore, the eye movement does not always occur in a linear manner, as there are situations in which the eye is drawn back to previously focused areas. According to Luegi (2006, p. 23), "Approximately 15% of saccadic movements during reading are regression movements, that is, they go from right to left, towards previous areas of the text, on the same line or a few lines above."

Regressions may be corrections of saccades that are too long and, therefore, the eyes must make a brief return. They may also result from the difficulty in understanding some part of the text. In this case, regressions are usually longer (longer than 10 characters on the same line or towards previous lines) and the behavior regarding the return varies according to the reader's proficiency.

Eye movement recording is used in a wide range of studies on language processing. Many variables may affect the values of fixations and saccades, including whether the reading is done silently or aloud. As there are no specific studies on eye movement during text revision, this section presents studies that address issues associated with the types of errors present in the experimental texts examined in this study, as well as factors taken into account in the analysis performed in this study, such as text rereadings and returns.

As the eye movement is processed in fixations and saccades, words may be skipped between fixations. It is well-known that functional words tend to be skipped, that is, not focused on. According to Rayner, functional words are fixated approximately 35% of the time (RAYNER, 1998, p. 375). This may result from them being more easily identifiable, that is, more predictable based on the context or even to the fact that they are more frequent (STAUB; RAYNER, 2007). The fact that they are short words may also affect their skipping, given that, as the word size increases, the probability of its fixation also increases – 2 to 3-letter words are fixated, in general, 25% of the times (RAYNER, 1998, p. 375).

Hyönä and Nurminen (2006) investigate regressions and, according to their results, readers who tend to direct the returns to parts of the text that are truly informative are able to provide a better summary of what they have read. Thus, there are also aspects related to higher textual levels that interfere in eye movements. Authors researched how competent readers read in order to confirm the classification proposed in a prior study (HYÖNÄ; KAAKINEN; LORCH, 2002) and to determine whether the readers themselves are aware of the reading strategies they use. Three reader patterns were identified: those who process topic structures, who were the minority, followed by the fast linear readers, and, finally, by the slow linear readers, who were the majority. The readers are aware of the time required for reading, whether they are slow or not, as well as whether they return or not to parts of the text; however, they do not have a precise idea of the places to which they comeback. Therefore, there are idiosyncratic differences related to eye movement and to reading, although the instructions provided in the task may affect the patterns. In the case of the research above, the readers were asked to summarize the text, which may have affected how they behaved.

Hyönä and Niemi (1990) investigate a text rereading. The rereading facilitates the process and, thus, all measurements investigated

are reduced, both the number and the time of fixations, as well as the number of returns. The authors also investigate whether the rereading affects the trend to fixate the segments more often with important information. In this sense, the conclusion reached is that the most important parts tend to be fixated more often, but this occurs both in the first reading and in the rereading. However, the rereading facilitates the processing of sentences that are more informative than of those that are not informative. Furthermore, for each successive reading, the average of fixations is longer at the beginning of texts than at the end.

Vauras, Hyönä, and Niemi (1992) investigate the reading of coherent and incoherent texts. In incoherent texts, the sentence order is changed. As their methodology, the authors use the recording of eye movement as well as an off-line measurement, which is an analysis of text rewriting performed by the readers. They conclude that incoherences increase the fixation time as well as the number of returns. Nevertheless, although in coherent texts the increased fixation time results in improved rewriting of the fixated part, the same is not true for incoherent texts.

Luegi (2006) researches the recording of eye movement among European Portuguese readers. The author presents modified sentences intended to create inconsistencies (ungrammaticality or ambiguity) and identifies the readers' reaction. In addition, these manipulations are done in two texts: one in which technical terms are predominant and another whose subject is more common. The author identified that the effect of variables is only visible when dealing with a text with technical vocabulary and sentence manipulation, thus generating inconsistencies. These results are seen both in the number of fixations and in the total reading time. Furthermore, the author determines that readers are quite precise regarding regressions and return specifically to the place where the problems are located.

Alamargot et al. (2006) record the eye movement and the graphomotor execution concomitantly, to investigate the writing process. Although the work focuses on text revision, they identified that the detection of typos can occur in very short times, as can those of a reading fixation. They can even occur in parallel with the graphomotor execution.

Therefore, the recording of eye movement may indicate important aspects of the reading processing. Thus, experimental works demonstrate that both the physiology of vision and the reading processing are determined regarding the eye movement pattern adopted by the subjects.

These studies will support this work's hypothesis that there will be a differentiated reading pattern according to the type of error, as well as to the subjects' experience with text revision.

4 Methodology

4.1 Participants

Subjects who participated in the research were divided into two groups: non-revisers and revisers, each group consisting of 14 subjects. The non-reviser group consisted of college students who did not major in Languages or Communications, as graduation in these two majors is a pre-requisite for investiture in several revision positions and, therefore, these students have a more in-depth qualification in language studies, which sets them apart from a group representing non-reviser subjects. To select the revisers, subjects were required to have worked professionally as revisers, in public agencies, in the private sector, or as freelancers. All revisers were Language majors, one of them was a senior in college, but had been working as a text reviser for three years. Regarding the experience time, 5 of them had worked as revisers for 1 to 4 years; 5 had worked between 5 and 10 years; and 4 had worked for more than 10 years.

4.2 Constructing stimuli

The texts, from the journalistic genre, written specifically for the experiment, consisted of an informative paragraph. The problems found in the experimental texts were of two types:

- missing preposition;
- incoherences generated by an incorrect nominal anaphora.

These types of problems were selected due to the processing cost and represent two different levels: the missing preposition is related to the word and phrase levels; while the incoherence generated by an incorrect nominal anaphora is related to the text level, as readers were expected to perform the integration between the text sentences.

In addition, texts without mistakes and with other types of errors, considered distracters, were inserted. In each experimental session, 20

experimental texts were presented, 10 of which contained a missing preposition, and 10 with incorrect anaphora, which did not include any other errors/inappropriacies whose detection was expected. In addition, 30 other distracter texts were included (8 of which without errors, 2 with one error, 7 with two errors, 9 with three errors, and 4 with four errors).²

In examples 1 and 2 below, two examples of experimental texts are presented, one of which with a missing preposition (presence of two teams' fan clubs) and the other with an incorrect anaphora (American referring to Argentinian).

Example 1 – Experimental text – missing preposition

Após um longo período, o clássico entre Atlético Mineiro e Cruzeiro contará com a presença duas torcidas mineiras. O Cruzeiro será o mandante da partida e vai disponibilizar uma parte dos ingressos para a torcida adversária. O jogo do Campeonato Mineiro será na próxima semana, na inauguração do novo Mineirão, e terá policiamento reforçado.
(After a long period, the classic game between Atlético Mineiro and Cruzeiro will receive the presence two teams' fans from Minas Gerais. Cruzeiro will be the home team and will provide part of the tickets to the opposing fans. The Minas Gerais championship game will take place next week, when the new Mineirão stadium will be opened, and police operation will be reinforced.)

Example 2 – Experimental text – incorrect anaphora

Na noite de ontem, um bebê foi encontrado próximo às margens da Lagoa da Pampulha por um argentino. O bebê estava enrolado em uma manta, e a mãe da criança foi presa horas depois do ocorrido. O americano confirmou em depoimento que a mãe abandonou a criança no local e fugiu logo em seguida.
(Last night, a baby was found close to the margins of the Pampulha Lake by an Argentinian. The baby was wrapped in a blanket, and the baby's mother was arrested hours after the event. The American confirmed in his testimony that the mother abandoned the child at the site and fled right after that.)

² A Latin square distribution, with the reading of the same texts, with or without errors, was not performed, as this would require a higher number of participants, or even a higher number of experimental texts to be read by session, which would render the experiment unfeasible, considering the difficulty in the participation of professional revisers, who had to travel to the experiment site, and considering how tiresome an excessively long the experiment would become.

The experimental texts and the distracters were distributed into 8 topics. In the construction of experimental texts, variables that can affect the results were controlled: 3 sentences; 54 words per text, 18 per sentence; the target words were the 15th and the 16th in the missing preposition text, and the 38th in the incorrect anaphora texts, while the incorrect referent was the 18th word in the text. In the missing preposition text, the word before the preposition had three syllables, and the word after the preposition had 2 syllables, in the Portuguese version. In the texts with the incorrect anaphora, both the referent and the anaphora had 4 syllables, in the Portuguese version.

Specifically regarding the texts with an incorrect anaphora, the informational structure of the texts was also taken into account: the referent (new lexical item introduced in the first sentence text) is not the subject of the sentence, and is accompanied by an indefinite article. Therefore, it is not a focused word. The incorrect anaphora, in turn, is the subject in the third sentence and is accompanied by a definite article, indicating that it was a reference to an item previously introduced in the discourse. Distracter texts were carefully constructed including sentences with a similar syntactic structure, but without an incorrect anaphora, to minimize the possibilities of the participants anticipating the existence of error due to the syntactic structure.

As the frequency of use is quite often related to the fixation time, the Portuguese Bank (PB) corpora, compiled by Tony Sardinha at the Catholic University of São Paulo, was used to control this variable. In general, experimental words are more common in the missing preposition texts than they are in incorrect anaphora texts.

The free program “Coh-Metrix-Port”³, which analyzes several parameters, was used, aimed particularly at offering subsidies to the text readability analysis. The Flesch index is a superficial measure of a text’s readability, which takes into account the average sizes of words and sentences, relating them to the ease of reading. The higher the value obtained, the easier the text processing. Considering this index, the texts in the experiment are classified as very easy, easy or difficult, that is,

³ Available at <www.nilc.icmc.usp.br/coh-metrix-port>. The Coh-Metrix tool was developed at the University of Memphis and calculates text coherence, using different measurements. In Brazil, the Portuguese adaptation was done by researchers at the Interinstitutional Linguistic Center at the University of São Paulo at São Carlos.

corresponding to the grades before higher education. Taking this index into account, as the subjects that participated in the research are at least college students, they should have no problems reading the text.

Since the predictability of words may affect the time focused on them, the predictability of the target word in experimental texts was controlled, by means of a completion test (frame), performed with students majoring in Languages at the Federal University of Minas Gerais (UFMG). For the missing preposition cases, the target word, that is, the one after the preposition, is predictable, since the correct word was used to complete the sentence between 53% and 100% of the times. For incorrect anaphora texts, the target words (the referent and the anaphora) are not predictable, as the chosen words were indicated between 0% and 28% of the times.

Finally, before the start of data collection, a pre-test was conducted with 16 students in the graduate Text Revision program at the Pontific Catholic University of Minas Gerais (PUC-Minas), aimed at checking which errors/inappropriacies would be detected in both experimental and distracter texts. Thus, it was possible to make the last adaptations to the experimental texts, so as to minimize the possibility of the subjects reaching unexpected detections.

4.3 Performing the task

To investigate the reading by professional text revisers, an error detection experiment was performed, using journalistic texts, in which participants were supposed to read the texts provided on a computer screen, clicking on the errors/inappropriacies found using the mouse. The eye tracker, produced by SR Research, model EyeLink 1000, available at the Psycholinguistics Laboratory at UFMG, was used. This is a desktop tracker, that is, the camera and the lights are installed under the computer screen where the stimuli are projected, 40 to 70 cm away from the subject's head. A head stabilizer was used to minimize the subjects' movements and to allow for the recording of the pupillary and corneal reflex. Although the tracker model used allows for binocular recording, only one of the subject's eyes was recorded, which was defined before the start of data collection, allowing for better equipment calibration.

The experiment was conducted at the Psycholinguistics Laboratory at the UFMG School of Languages. The texts were presented on a computer screen, in a random order. First, the instructions were

provided, the equipment was calibrated and the participants underwent a small reading and error detection training using three short texts. Participants were asked to read the text and try to identify the errors and inappropriacies and, when they identified an error/inappropriacy, they should click on them using the mouse. In addition to the eye movement, a chronometric measure was also obtained: the response time. Furthermore, the instructions also stated that the texts were constructed specifically for the research and, therefore, the facts narrated were not necessarily true.

If any participant requested detailed information about the revision activity, the researcher only informed the participant that he/she was expected to behave as if he/she were revising the text, detecting errors and inappropriacies. If the participants asked about the type of errors to be detected, the researcher informed them that he/she could not answer that, emphasizing that they should mark any errors found. Such procedure was adopted in order to determine how the subjects viewed the revision task, based on the types of error detected.

The revision of each text should not take longer than 1 minute/60 seconds, since, if it exceeded this time limit, the program would forward automatically to the subsequent text. A drift correction screen, on which a circle similar to that of calibration was projected at the exact location where the new text would be shown, was placed between texts. As the subject was supposed to focus on this circle so that the researcher could move on to the next text, it was guaranteed that, at the beginning of the reading, the subject would focus his/her gaze on the first word of each text. This avoids variations among texts and subjects regarding when they start reading each text. The background was white and the letters were black, in Times New Roman, size 20, spaced at 3.5. All efforts were made to remove the computer screen brightness, to avoid visual fatigue.

4.4 Data analysis

Different variables were analyzed, at several text levels: sentence, segment, and target. Therefore, the data analysis was based on two angles: the level at which the investigated variable is applied (text, sentence, or segment), and the relation between eye movement and error detection by the subjects.

The variable investigation level has a direct relationship with the type of error investigated: the missing preposition, as it is a local scope error, requires measures that apply to the level of the word or the

phrase, whereas the scope of the incorrect anaphora lies in the integration of parts of the text and, thus, requires measures that correspond to the sentence and text levels.

Furthermore, this work includes both eye movement measurements and the chronometric measurement of the response time. Thus, it was possible to investigate the eye movement as well as the relation between the eye movement and detection. Therefore, the choice was made to use traditional measurements in reading and eye movement studies, as well as to adapt some measurements to this research, combining them with the response time.

Chart 3 – Dependent variables

	Text	Sentences	Segment
Eye movement	<ul style="list-style-type: none"> – Total reading time – Number of fixations on the texts – Average duration of fixations on the texts 	<ul style="list-style-type: none"> – First-pass fixation time on target sentences – Total fixation times on target sentences – Second-pass fixation time on target sentences – Regression-path reading time on target sentences 	<ul style="list-style-type: none"> – First-pass fixation time – Total fixation times on target segment – Number of fixations on the target segment – Regression-path
Eye movement and detection	<ul style="list-style-type: none"> – Total reading time up to detection – Total reading time after detection – Number of fixations up to detection – Number of fixations after detection – Average duration of fixations up to detection – Average duration of fixations after detection 	<ul style="list-style-type: none"> – Total fixation time on target sentences up to detection – Total fixation time on target sentences after detection – Second-pass fixation time in target sentences up to detection – Second-pass fixation time in target sentences after detection 	<ul style="list-style-type: none"> – Total fixation time on the target segment up to detection – Total fixation time on the target segment after detection

In the measurements grouped as “eye movement”, both the texts in which the errors were detected and those in which they were not detected, were taken into account, in order to compare detection to non-detection. In the measurements grouped as “eye movement and detection”, only texts in which the error was detected, as the time of detection (when the participant clicked on the error using the mouse) was used as a divider to analyze each measurement up to and after such a detection: for example, the total reading time up to the error detection and the total reading time after the error detection, measurements that correspond to the total reading time up to the moment when the participant clicks on the error using the mouse and to the total reading time after this moment, until the task is completed.

The total reading time corresponds to the total time the subject took to read and revise each text. The total reading time up to error detection corresponds to the time the subject took to read the text until clicking on the error using the mouse; and the total reading time after detection⁴ corresponds to the time the subject took until he clicked on the error using the mouse until the text revision is completed. The same division applies to the number of fixations on the text up to and after error detection.

The average duration of fixations is equivalent to the ratio between the total reading time, including fixations and saccades, and the number of fixations on the text. Therefore, the average duration of fixations up to error detection corresponds to the ratio between the total reading time up to detection and the number of fixations up to detection. The same logic applies to the average duration of fixations after the error detection.

The first-pass fixation time corresponds to the sum of durations of all fixations performed (whether on the target sentence, at the sentence level, or on the target word, at the local level) until it is abandoned to the left or to the right, as well as during the first reading, that is, it is a measure that indicates the time required when first reading the target.

The total time of fixation on the sentences, however, is equivalent to the sum of all fixations performed on the sentence. This time was also

⁴ Although a significant difference between experimental condition as to the time measurements after error detection, due to the location of each target section (on the first sentence in the case of suppression of the preposition, and on the third sentence for incorrect anaphora), such measurements have been investigated to analyze whether the groups would reread the texts and to verify their engagement in the revision task.

divided into two parts: up to and after error detection, following the same accounting logic described above.

The second-pass fixation time regards the difference between total time of fixation on the sentence and the first-pass fixation time, that is, it is equivalent to the time for return to the sentence after it had been read for the first time. For this measurement, the value up to and after the error detection was also counted.

The last measurement at the sentence level, the regression-path reading time, corresponds to the sum of all fixations performed by the subject from the moment when he/she fixates the target sentence for the first time until the moment he/she fixates on a subsequent part of the text, counting, in addition to the fixations in the target sentences themselves, the possible regressions to previous parts of the text.

The total time of fixation on the target segment is related to the sum of all fixations on it, and the sum of all fixations up to the error detection and after detection was also checked.

The regression-path corresponds to the sum of all fixations performed by the subject from the time he/she fixates the target segment for the first time up to the moment he/she fixates on a subsequent section of the text, counting, in addition to the fixations on the target segment itself, the possible regressions to previous parts of the text.

The independent variables in the eye movement analysis for experimental texts were:

1. Types of errors:

- a. missing preposition
- b. incorrect anaphora

2. Text revision groups:

- a. revisers
- b. non-revisers

3. Detection:

- a. errors detected
- b. errors not detected

The crossing of these variables generates 8 groups:

1. revisers – missing preposition – error detected;
2. non-revisers – missing preposition – error detected;
3. revisers – missing preposition – error not detected;
4. non-revisers – missing preposition – error not detected;
5. revisers – incorrect anaphora – error detected;
6. non-revisers – incorrect anaphora – error detected;
7. revisers – incorrect anaphora – error not detected;
8. non-revisers – incorrect anaphora – error not detected;

First, the data were tabulated and explored descriptively, checking the central tendency measures, such as mean, median, and standard deviation, as well as the visual representation by means of charts, such as boxplot, bar chart, density, and average charts, selected according to the type of variable investigated.

The inferential statistical analysis was then performed, by choosing the most appropriate statistical test based on the analyzed data. The significance level adopted was 95%, therefore, α was defined as 0.05. The program used for statistical analysis was R⁵.

In the variables where the samples adopted a normal distribution, the parametric test was selected. As the experiment was performed with repeated measurements, the defined parametric test was the mixed linear regression model⁶.

In the variables where the samples did not adopt a normal distribution, however, non-parametric tests were selected, namely the Kruskal-Wallis or the Wilcoxon-Mann-Whitney tests, given that these are rank tests and, therefore, knowledge of the sample distribution is required.

5. Results

The revisers detected 191 of the 279 errors, which correspond to 68.5% of the errors. The non-revisers, however, detected 165 of the

⁵ Available at <<https://www.r-project.org/>>.

⁶ This test was also selected, because it enables one to analyze the relation between the variables throughout the task execution, indicating important aspects of the participants' behaviors. This information is not explored in this article, but it is available in Leite (2014).

280 errors, which correspond to 58.9% of the errors. Therefore, revisers were more proficient and detected more errors than did the non-revisers; however, considering only the experimental texts, this difference proved to be statistically insignificant.

The tables provided in this study specify the median values or the “t” or “p” value (depending on the statistical test). Leite (2014) provides more details, such as the number of values considered by variables, the standard deviations, the degrees of freedom and charts. The codes used in all tables provided are as follows:

rev: revisers

nrev: non-revisers

det: error detected

ndet: error not detected

mp: missing preposition

an: incorrect anaphora

N/A: not applicable

* : statistically significant difference

. : marginally significant difference

5.1 Text level

The variables in which statistically significant results were detected are presented below.

In the variables in which the measurements up to and after the error detection were considered, statistically significant results found between the types of errors, that is, when an incorrect anaphora was compared to a missing preposition, were not presented, since these differences were expected due to the composition of texts (in the first case, the error is found in the third sentence, and, in the second text, it is found in the first sentence). Nevertheless, in these cases the revision groups with the same type of error (revisers in anaphora vs. non-revisers in anaphora, and revisers in the missing preposition vs. non-revisers in the missing preposition) were compared.

Table 1 – Summary of the average values of the results obtained in variables at the text level – mixed linear regression models

Measurement	Average		t value	Average		t value	Average		t value
	rev	nrev		an	mp		det	ndet	
total text reading time	35473 ms	27402 ms	*rev>nrev 0.002	32709 ms	30147 ms	*an>sp 0.04	31845 ms	30697 ms	*det>ndet 0.01
number of fixations on the text	134	111	rev>nrev 0.06	129	117	*an>sp 0.002	123	123	-
average duration of fixations on the text	225 ms	205 ms	rev>nrev 0.06	212 ms	218 ms	*sp>an 0.000	218 ms	210 ms	det>ndet 0.05
total reading time after error detection	21590 ms	13812 ms	*rev>nrev 0.001	13323 ms	20696 ms	*sp>an 0.000	N/A	N/A	N/A
average duration of fixations up to error detection	245 ms	222 ms	rev>nrev 0.06	219 ms	243 ms	*sp>an 0.000	N/A	N/A	N/A

Table 2 – Summary of the interaction results obtained in the variables at the text level – mixed linear regression models

Measurement	Variable 1	Variable 2	Average (ms)	Interactions (p value)
Number of fixations in the text	det	mp	104	* an det > mp det (0.003) * an det > an ndet (0.01)
		an	130	
	ndet	mp	113	
		an	112	
Average duration of fixations on the text	det	mp	214	* mp det > an det (0.000) * mp det > an ndet (0.03) * mp det > sp ndet (0.000)
		an	210	
	ndet	mp	198	
		an	207	

Table 3 – Summary of the results obtained at the text level – multiple comparisons of the Wilcoxon-Mann-Whitney test with Bonferroni correction

Measurement	Variable 1	Variable 2	Median	Interactions (p value)
total reading time up to error detection	mp	rev	7469 ms	* rev an > nrev an (0.000)
		nrev	7645 ms	
	an	rev	22301 ms	
		nrev	17094 ms	
number of fixations up to error detection	mp	rev	29	* rev an > nrev an (0.005)
		nrev	34	* nrev mp > rev mp (0.01)
	an	rev	104	
		nrev	81	
average duration of fixations after error detection	mp	rev	276 ms	* rev mp > nrev mp (0.02)
		nrev	265 ms	
	an	rev	377 ms	
		nrev	377 ms	
number of fixations after error detection	mp	rev	81.5	* rev an > nrev an (0.002)
		nrev	56.5	* rev mp > nrev mp (0.000)
	an	rev	38	
		nrev	20	

In comparing the two types of errors, it was determined that the subjects had a longer reading time when the incorrect anaphora was present, which is associated with the number of fixations on the texts, since, also regarding this variable, there was a statistically significant difference between the two conditions, with a higher number of fixations occurring in the texts in which the incorrect anaphora was present. Contrary to this, fixations were longer on average in the texts where the missing preposition was present, which may be also be confirmed by the average duration of fixations up to error detection.

Furthermore, in the interaction among these variables (table 3), the results indicate a difference between the incorrect anaphora detection and the missing preposition detection: while in the incorrect anaphora the higher total reading time is related to the higher number of fixations on the text, in the missing preposition, the detection is related to longer fixations on average. This difference in pattern, therefore, may be related to two different types of reading: a reading towards the surface, with longer fixations, and a reading towards more global levels, with a higher number of fixations on the text.

Regarding the analysis obtained at the text level, the results indicate that revisers, in general, take longer to read the text, and their reading is associated with a higher number of fixations.

In comparing revisers and non-revisers, the first produced higher values for the total reading time and total reading time after error detection (table 1), which indicates that, in addition to taking longer to read the texts, they also maintained the reading longer even after they had detected the error. As to the total reading time up to error detection, in the comparison of revision groups in the same error type, revisers presented higher values than those for non-revisers when the incorrect anaphora was present, but did not exhibit different times regarding the detection of the missing preposition (table 3).

Although there has been a merely marginally significant difference between revisers and non-revisers in terms of the number of fixations on the texts (table 1), upon analyzing this number up to the error detection, in cases of the missing preposition, the number of fixations was higher for the group of non-revisers, whereas in incorrect anaphora it was higher, on average, for the group of revisers. After the error detection, the revisers performed more fixations, regardless of the type of error.

As for the average duration of fixations on the text, there was a marginally significant difference between how the revisers and the non-revisers performed, as also occurred when this variable was analyzed up to the error detection (table 1), with revisers tending to perform longer fixations, on average. There was a statistically significant difference between the groups regarding the average duration of fixations after error detection (table 3).

Therefore, revisers showed a different reading pattern for each type of error: in detecting the missing preposition, the fixations tended to be longer (marginally significant average duration of fixations), and in detecting the incorrect anaphora, the number of fixations was higher.

The total reading time was also longer in the texts in which the error was detected than in those texts in which the subject did not detect the error, and the number of fixations was also higher for those texts; however, this finding may result from the task itself, as, in the texts in which the error was detected, the participant took some time clicking on the error using the mouse.

5.2 Sentence level

Regarding the measurements presented at the sentence level, in the missing preposition cases, only the first sentence, in which the error was located, was taken into account. For incorrect anaphora cases, both the first and the third sentences were analyzed, as they contained the referent and the incorrect anaphora, respectively.

Table 4 – Summary of results obtained from variables at the sentence level – mixed linear regression models

Measurement	Average (ms)		t value	Average (ms)		t value	Average (ms)		t value
	rev	nrev		an	mp		det	ndet	
total fixation time on the first sentence	11274	9227	*rev>nrev 0.02	9971 ms	10527	0.45	10592	9646	*det>ndet 0.000
total fixation time on the third sentence	11050	8240	*rev>nrev 0.009	N/A	N/A	N/A	10756	8655	*det>ndet 0.000
total fixation time on the first sentence up to error detection	9075	8270	*rev>nrev 0.008	9378	8305	0.24	N/A	N/A	N/A
total fixation time on the third sentence up to error detection	6341	4868	0.21	N/A	N/A	N/A	N/A	N/A	N/A

Table 5 – Summary of interaction results obtained from variables at the sentence level – mixed linear regression models

Measurement	Variable 1	Variable 2	Average (ms)	Interactions (p value)
total fixation time on the first sentence up to error detection	mp	rev	8192	* rev an > nrev an (0.03) * rev an > rev sp (0.03)
		nrev	8431	
	an	rev	10522	
		nrev	7981	

Table 6 – Summary of the results obtained at the sentence level – multiple comparisons of the Wilcoxon-Mann-Whitney test with Bonferroni correction

Measurement	Variable 1	Variable 2	Variable 3	Median (ms)	Interactions (p value)
second-pass fixation time on the first sentence	det	mp	rev	2241	* rev an det > nrev an det (0.000) * rev an det > nrev mp det (0.000) * rev an det > rev mp det (0.000) * rev an det > nrev an ndet (0.000) * rev an det > rev an ndet (0.000) * rev an det > nrev mp ndet (0.000) * rev mp det < nrev mp det (0.000) * nrev mp det < nrev an ndet (0.03) * nrev mp det < rev an ndet (0.03) * nrev mp det < rev mp ndet (0.01)
			nrev	182.5	
		an	rev	5076	
			nrev	2088	
	ndet	mp	rev	4274	
			nrev	1846	
		an	rev	1668.5	
			nrev	2092	
first-pass fixation time on the third sentence	an	det	rev	5338	* nrev det > nrev ndet (0.000) * nrev det > rev ndet (0.000) * rev det < nrev ndet (0.006)
			nrev	6181	
		ndet	rev	6072	
			nrev	5739	
second-pass fixation time on the third sentence	an	det	rev	8659	* rev det > nrev det (0.000) * rev det > nrev ndet (0.000) * rev det > rev ndet (0.000) * nrev det > nrev ndet (0.000) * nrev det > rev ndet (0.01)
			nrev	6039	
		ndet	rev	2118.5	
			nrev	1666	
regression-path reading time on the third sentence	an	det	rev	4223.5	* rev det > nrev ndet (0.000) * rev det > rev ndet (0.000) * nrev det > rev ndet (0.002) * nrev det > nrev ndet (0.000)
			nrev	4282	
		ndet	rev	2489.5	
			nrev	2199	
total fixation time on the first sentence after error detection	det	mp	rev	2208.5	* rev an > nrev an (0.001) * rev an < rev sp (0.000) * nrev an < nrev mp (0.000) * nrev an < rev mp (0.000) * rev sp > nrev mp (0.000)
			nrev	525.5	
		an	rev	506.0	
			nrev	0	
total fixation time on the third sentence after error detection	det	an	rev	5232	* rev > nrev (0.000)
			nrev	2933	
second-pass fixation time on the first sentence up to error detection	det	mp	rev	0	* rev an > nrev an (0.02) * rev an > rev mp (0.000) * rev an > nrev mp (0.000) * nrev an > rev mp (0.000) * nrev an > nrev mp (0.000)
			nrev	0	
		an	rev	2904.5	
			nrev	1526	

When the performances of revisers and non-revisers were compared, there was a statistically significant difference as to the total fixation time on the first and third sentences of the text, as to the total fixation time on the first sentence of the text up to the error detection, as well as to the total fixation time on the first and third sentences after error detection. In all of these situations, whether in the cases of incorrect anaphora or the missing preposition, the revisers presented higher values on average than did those obtained for non-revisers. The two groups were also different as to the second-pass fixation time on the first and third sentences, to which revisers took longer to return than did the non-revisers. Revisers also took longer to return to the first sentence up to the detection of the incorrect anaphora (second-pass fixation time up to the error detection) than did the non-revisers. However, neither group presented different results regarding the missing preposition, since, for both groups, the detection of the missing preposition took place on the first reading of the sentence.

5.3 Local level

Within the condition of the missing preposition, only the total fixation time on the target segment, including the 15th and the 16th words of the text, were analyzed. For the condition of incorrect anaphora, however, the total fixation times on the referent and on the anaphora were analyzed separately.

Table 7 – Summary of results obtained from variables at the local level – mixed linear regression models

Measurement	Average		t value	Average		t value	Average		t value
	rev	nrev		an	mp		det	ndet	
number of fixations on the target – mp	10.74	11.74	0.16	N/A	N/A	N/A	11.91	7.68	*det>ndet 0.000
total fixation time in the referent up to error detection	1169 ms	831 ms	*rev>nrev 0.007	N/A	N/A	N/A	N/A	N/A	N/A

Table 8 – Summary of interaction results obtained from variables at the local level – mixed linear regression models

Measurement	Variable 1	Variable 2	Average	Interactions (p value)
number of fixations on the target – mp	det	rev	11	* rev det > rev ndet (0.000) * rev det > nrev ndet (0.000) * nrev det > rev ndet (0.000) * nrev det > rev ndet (0.000)
		nrev	13	
	ndet	rev	8	
		nrev	7	

Table 9 – Summary of the results obtained at the local level – multiple comparisons of the Wilcoxon-Mann-Whitney test with Bonferroni correction

Measurement	Variable 1	Variable 2	Median	Interactions (p value)
total fixation time on the target – mp	det	rev	2980 ms	* nrev det > nrev ndet (0.000)
		nrev	3233 ms	* nrev det > rev ndet (0.000)
	ndet	rev	1072 ms	* rev det > nrev ndet (0.000)
		nrev	1085 ms	
total fixation time on the referent	det	rev	1229 ms	* rev det > nrev det (0.002)
		nrev	726 ms	* nrev det > nrev ndet (0.008)
	ndet	rev	724.5 ms	* rev det > nrev ndet (0.000)
		nrev	497 ms	
total fixation time on the anaphora	det	rev	2092 ms	* rev det > nrev ndet (0.000)
		nrev	1799 ms	* rev det > rev ndet (0.000)
	ndet	rev	669 ms	* nrev det > nrev ndet (0.000)
		nrev	475 ms	
number of fixations on the referent	det	rev	6	* nrev det > nrev ndet (0.003)
		nrev	4	* rev det > nrev ndet (0.000)
	ndet	rev	3	* rev det > rev ndet (0.000)
		nrev	3	
number of fixations on the anaphora	det	rev	8	* nrev det > nrev ndet (0.000)
		nrev	7	* rev det > nrev ndet (0.000)
	ndet	rev	3	* rev det > rev ndet (0.000)
		nrev	2	
total fixation time on the target after error detection – mp	det	rev	675.5 ms	* rev > nrev (0.000)
		nrev	104 ms	
total fixation time on the anaphora after error detection	det	rev	246.5 ms	* rev > nrev (0.000)
		nrev	0 ms	

When the total fixation time on the target segment during the entire text reading was detected, not taking into account the detection time, no statistically significant differences were found between the performances of revisers and non-revisers. Actually, there were statistically significant differences between the texts in which the errors were detected, and those in which the errors were not detected, and, whenever the detection occurred; the total fixation time on the target was longer. This pattern was found in texts with cases of the missing preposition, as well as in those with cases of incorrect anaphora. For this type of error, the difference between the performances of revisers and non-revisers was only identified on the referent, as values were higher for the first. The same results were obtained in the analysis of the number of fixations on the target, but, in this case, the difference between revisers and non-revisers regarding the number of fixations on the referent and on the anaphora was only marginally significant.

Similarly, upon analyzing the total fixation time on the target up to the error detection, that is, the sum of all fixations performed on the target until the participant clicked on the mouse, including the regressions to the word up to that point, a significant difference between the performances of revisers and non-revisers was detected only regarding the referent, given that, in incorrect anaphora cases, the values in general in this case were higher for the performances of revisers. In analyzing the total fixation time on the referent after error detection, that is, after the participants had clicked on the error using the mouse, however, no significant differences between the performances of revisers and non-revisers were detected, as both groups, most of the time, did not return to the referent.

Regarding the incorrect anaphora area, a statistically significant difference was detected between the performances of revisers and non-revisers, as to the total fixation time after the error detection. Therefore, the revisers spent more time fixating the referent to detect the incongruity and possibly attempt to solve it. After the error detection, they returned more times to the anaphora before completing the text reading.

In the missing preposition cases, similarly to what occurred to the total fixation time on the target, no statistically significant differences were found between the performances of revisers and non-revisers as regards the total fixation time on the target up to error detection. The opposite occurred as to the total time of fixation on the target after error detection: revisers obtained higher values than those obtained by the non-revisers, on average.

Therefore, although no significant difference between the performances of revisers and non-revisers was detected when the total fixation time on the target in the text reading was analyzed, this difference did occur when the eye movement was analyzed, taking into account the error detection time. In this case, revisers, in general, obtained higher values than those obtained by non-revisers and, in the texts in which the errors were detected, the total fixation times on the target were higher than in those texts in which the errors were not detected. This variable, therefore, is relevant for the investigation of proficiency in error detection.

6 Final considerations

The results indicated that, in general, the texts in which the incorrect anaphora was present yielded higher values in the investigated measurements, especially at the text level, and even had a longer reading time, related to a higher number of fixations. This result corroborates prior studies in this area, indicating that the processing of errors at levels that require the integration of parts of the text is more difficult. The exception was the average duration of the fixations on the text, as well as the error detection. In this case, the values were higher for texts in which the preposition was suppressed. Since in this measure the interaction between the error type and the detection was significant, it may be stated that the increase in the average duration of the fixations on the text, including in the start, up to error detection, favors the identification of the missing preposition. Considering the location of the errors on the text and their complexity, these differences may result from the global strategies used in the reading at an early or late stage. Hence, it is important that other studies explore this initial finding, including the comparison of a base condition, with and without errors.

The results of this research corroborate Vauras, Hyona, and Niemi's proposal (1992), according to whom incoherences increase both the fixation time and the number of regressions. This research, therefore, confirmed Linguistics data that set the difference between readings directed to levels that are more global and readings directed to levels that are more superficial, also contributing to the characterization of these types of reading, as well as to showing which strategies may be more appropriate for each level. In this sense, an important, though initial, finding is that the detection of the missing preposition is, on

average, favored when longer fixations are performed. Many studies in the area proposed that the reading directed to superficial levels must be different from reading directed to more global levels, although they do not specify how this difference is processed regarding eye movement. The longer duration of fixations appears to be a significant parameter, though other studies are required to confirm this finding, including those with different types or surface errors.

Regarding the differences between those texts in which the error was detected and those in which the error was not detected, the general perspective is that error detection is followed by increased fixation time, at the text, sentence, or local level. At the local level, in the texts in which the error is detected, the total fixation time on the target is higher, which occurs both for the missing preposition and in incorrect anaphora. Such a difference, however, may result from the time required by the participants to click on the text using the mouse.

Finally, regarding the difference between the performances of revisers and non-revisers, the general perspective was that revisers presented higher values for the variables in which a significant difference occurred, which means they were slower in reading than the non-revisers. This occurred at the text, sentence, and local levels.

Thus, this study's results confirmed the initial hypothesis that professional revisers would require a lengthier, less automatic, more detailed, and controlled reading. According to Hayes (2004), with extensive practice, certain edition aspects may become automatic, but not the edition activity as a whole, even for very experienced subjects, a reason why the reading control is an assumption of revision. When Klein and Hoffman (1992) discuss expertise, they emphasize that the differentiated performance of an expert may be identified based on several factors: variability-consistency, accuracy, completeness, and speed. As to speed, the authors highlight that, in some cases, experts may take longer than novices do to complete a task, even when the novices adopt a very fast behavior, on impulse. This research indicates the occurrence of this type of situation.

Professional revisers were also more specific as to the regressions performed. In texts that presented incorrect anaphora, revisers spent a longer total fixation time on the first sentence up to error detection than did the non-revisers, as well as a longer total fixation time on the referent. Since subjects, in general, chose to return to previous parts of the text, when they encountered the incorrect anaphora, the revisers were more

specific and fixated, for a longer period of time, on the part of the text that was actually important for problem-solving, that is, the referent and the sentence containing it. Furthermore, after detecting the incorrect anaphora, the revisers made longer returns to the third sentence of the text, as well as the anaphora itself, which also indicates that they were more specific in this case. According to Hyona and Nurminen (2006), proficient readers tend to direct their regressions to actually informative parts of the text.

Finally, it should be considered that this research specifically investigated error detection, which is one of the revision stages. In addition to this, the corrections must also be performed, but this stage was not investigated by this study, though it deserves to be considered in further studies in the area, including those in which the quality of corrections performed is determined, hence a qualitative investigation. Considering that studies on professional text revision are scarce, especially those with a cognitive approach, this research had an exploratory nature and provided important initial considerations, not only to the study of performances of professional revisers, but also for the study of text revision and reading processes.

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