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SEÇÃO: TEMÁTICA LIVRE

Pre-reading activities may reduce processing demands in working memory: A quasi-experimental correlational study with EFL Brazilian students (learners)

As atividades de pré-leitura podem reduzir as demandas de processamento na memória de trabalho: Um estudo quase-experimental correlacional com estudantes (aprendizes) brasileiros de inglês como língua estrangeira

Las actividades previas a la lectura pueden reducir las demandas de procesamiento en la memoria de trabajo: Un estudio correlacional cuasiexperimental con estudiantes (aprendices) brasileños de inglés como lengua extranjera

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Abstract: Reading research has found that pre-reading activities positively affect comprehension, which might also act as a tool to reduce the processing demands in working memory (ROSCIOLI; TOMITCH, 2022). The present study investigated whether there was a correlation between pre-intermediate and advanced Brazilian EFL students' working memory capacity as measured by the Reading Span Test and their results obtained in comprehension tests after receiving treatment with two pre-reading activities: Contextual Redefinition and Graphic Organizer (MOORE; READENCE; RICKELMAN, 1999). The former focused on building vocabulary, whereas the latter targeted the organizational pattern of the text. There were two dependent measures: written free recall and comprehension questions. We hypothesized that the treatments would change the correlations between readers' working memory capacity and task performance. Specifically, we expected the correlations between reading span and comprehension to be smaller in the treatment conditions compared to the control. The findings reveal that the activities can affect reading comprehension differently depending on students' proficiency. The correlations between reading span and comprehension questions scores were smaller when advanced participants received treatment with the Contextual Redefinition. Conversely, there was an increase in the correlations between reading span and written free recall scores when the pre-intermediate group received treatment with the same pre-reading activity. Also, there was a decrease in the correlations between reading span and written free recall scores when pre-intermediate participants received treatment with the Graphic Organizer. Altogether, the Contextual Redefinition reduced processing demands for the advanced participants, whereas the Graphic Organizer did the same for the pre-intermediate group.

Keywords: Pre-reading activities. Working memory capacity. Reading comprehension.

Resumo: Pesquisas em leitura descobriram que as atividades de pré-leitura afetam positivamente a compreensão, podendo também atuar como uma ferramenta para reduzir as demandas de processamento na memória de trabalho (ROSCIOLI; TOMITCH, 2022). O presente estudo investigou se havia uma correlação entre a capacidade de memória de trabalho de estudantes brasileiros de inglês nos níveis pré-intermediário e avançado medida pelo *Reading Span Test* e seus resultados obtidos em testes de compreensão após receber tratamento com duas atividades de pré-leitura: Redefinição Contextual e Organizador Gráfico (MOORE; READENCE; RICKELMAN, 1999). A primeira focou na construção do vocabulário, enquanto a última visava o padrão organizacional do texto. Havia

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duas medidas dependentes: recordação livre escrita e perguntas de compreensão. Nossa hipótese era que os tratamentos mudariam as correlações entre a capacidade de memória de trabalho dos leitores e seu desempenho nas tarefas. Especificamente, esperávamos que as correlações entre a memória de trabalho e a compreensão fossem menores nas condições de tratamento em comparação com o controle. Os resultados revelam que as atividades podem afetar a compreensão da leitura de maneira diferente, dependendo da proficiência dos alunos. As correlações entre a memória de trabalho e as pontuações nas perguntas de compreensão foram menores quando os participantes avançados receberam tratamento com a Redefinição Contextual. Por outro lado, houve um aumento nas correlações entre a memória de trabalho e os escores na tarefa de recordação livre escrita quando o grupo pré-intermediário recebeu tratamento com a mesma atividade de pré-leitura. Além disso, houve uma diminuição nas correlações entre memória de trabalho e os escores de recordação livre escrita quando os participantes pré-intermediários receberam tratamento com a atividade Organizador Gráfico. No todo, a Redefinição Contextual reduziu as demandas de processamento para os participantes avançados, enquanto o Organizador Gráfico fez o mesmo para o grupo pré-intermediário.

Palavras-chave: Atividades de pré-leitura. Capacidade de memória de trabalho. Compreensão leitora.

Resumen: La investigación de lectura ha encontrado que las actividades de pre lectura afectan positivamente la comprensión y también pueden actuar como una herramienta para reducir las demandas de procesamiento en la memoria de trabajo (ROSCIOLI; TOMITCH, 2022). El presente estudio investigó si había una correlación entre la capacidad de memoria de trabajo de los estudiantes brasileños de inglés en los niveles pre-intermedio y avanzado, medida por el *Reading Span Test*, y los puntajes obtenidos en las pruebas de comprensión después de recibir tratamiento con dos actividades: Redefinición Contextual y Organizador Gráfico (MOORE; READENCE; RICKELMAN, 1999). La primera estaba enfocada en la construcción del vocabulario, mientras que la segunda lo estaba en el modelo de organización del texto. Había dos medidas dependientes: recuerdo escrito libre y preguntas de comprensión. Presumimos que los tratamientos cambiarían las correlaciones entre la capacidad de la memoria de trabajo de los lectores y el desempeño de sus tareas. Específicamente, esperábamos que fueran más bajas en las condiciones de tratamiento en comparación con el control. Los resultados revelan que las actividades pueden afectar la comprensión lectora de manera diferente según la competencia de los estudiantes. Las correlaciones fueron más bajas cuando los participantes avanzados recibieron el tratamiento con la Redefinición Contextual. Por otro lado, hubo un aumento cuando el grupo pre-intermedio fue tratado con la misma actividad de pre lectura. Además, hubo una disminución en las correlaciones entre la memoria de trabajo y las puntuaciones de recuerdo escrito libre cuando los participantes de nivel pre-intermedio recibieron tratamiento con la actividad Organizador Gráfico. En general, la Redefinición Contextual redujo las demandas de procesamiento para los participantes avanzados, mientras que la actividad de pre lectura Organizador Gráfico hizo lo mismo para el grupo pre-intermedio.

Palabras-clave: Actividades de pre lectura. Capacidad de memoria de trabajo. Comprensión de lectura.

Introduction

The human cognitive system is viewed as a complex interaction of various factors, including intelligence, executive functioning, attentional control, processing speed, and working memory. Working memory (WM) relates to one's ability to maintain and manipulate information simultaneously for a limited time (BADDELEY; HITCH; ALLEN, 2021). The term differs from the conception of short-term memory, which refers "to the simple temporary storage of information, in contrast to WM, which implies a combination of storage and manipulation" (BADDELEY, 2012, p. 4). As a psychometric construct, WM influences performance in highly demanding cognitive tasks such as learning novel words (GRAY *et al.*, 2022), long-term memory encoding (FORSBERG *et al.*, 2021; MELROSE *et al.*, 2020), mathematical problem-solving (SWANSON; ARIZMENDI; LI, 2021), and video game acquisition (JAKUBOWSKA *et al.*, 2021), among others.

Working memory capacity (WMC) also plays a role in reading comprehension: readers must keep the syntactic, semantic, and pragmatic information in a sentence active while processing incoming text for meaning to build a coherent mental representation of the whole passage (PENG *et al.*, 2018). Perhaps, for this reason, WMC has become one of the most investigated individual differences in reading comprehension. Several correlational studies have found that readers' WM span can predict their performance in first language (L1) reading tasks such as: answering objective questions about narrative and expository texts (VERNUCCI *et al.*, 2021), online inference generation (YEARI, 2017), inferential comprehension of expository texts (BARREYRO *et al.*, 2019), to mention some recent research. Similarly, studies in the second language[2] (L2) have found WMC to

[2] In this article, the terms second and foreign language are used interchangeably.

be consistently associated with reading in tasks like written free recall (OLIVEIRA; TOMITCH, 2021), answers to open-ended questions (WOELFER; TOMITCH, 2019), and global measures of comprehension (ALPTEKIN; ERÇETIN; ÖZEMIR, 2014).

Most research regarding WMC and reading comprehension has focused on predicting the influence of the former on the latter (WEN; LI, 2019). Fewer studies have used experimental paradigms to investigate whether reading treatments can reduce the processing demands related to WMC on performance (ALPTEKIN; ERÇETIN, 2011; ROSCIOLI; TOMITCH, 2022; SHIN; DRONJIC; PARK, 2019), the focus of the present research. In this article, we report the results of a quasi-experimental study with Brazilian EFL students that investigated whether there was a correlation between their WMC and the results they obtained in two measures of reading (written free recall and comprehension questions) in a control condition and two experimental conditions: after receiving treatment with two prereading activities, namely Contextual Redefinition and Graphic Organizer (MOORE; READENCE; RICKELMAN, 1999)[3]. The remainder of this article presents a relevant literature review, the method used for data collection, the results and discussion, and some final remarks.

Review of Literature

The memory system responsible for activating knowledge stored in long-term memory is known as working memory (WM), which is also responsible for processing and storing novel information, according to the Processing Efficiency Hypothesis advocated by Daneman and Carpenter (1980). The authors argued that individual differences in reading comprehension could be related to variation in WMC; in other words, readers' ability to store and process information simultaneously. They devised the Reading Span Test[4] (RST), a complex measure of WM, to test this hypothesis. In contrast with traditional tests of short-term memory, which did not correlate well with reading comprehension, the RST showed very high correlations with different measures of reading comprehension. Individuals with a higher span[5] in the RST, those who could remember more final words after reading the sentences aloud, also performed better in the reading comprehension tasks. On the other hand, individuals with a low span also performed poorly in the reading comprehension tasks.

After the study by Daneman and Carpenter (1980), many other researchers have used the RST to discover whether WMC can predict performance in various reading comprehension tasks (for instance, ALPTEKIN; ERÇETIN; ÖZEMIR, 2014; OLIVEIRA; TOMITCH, 2021; WOELFER; TOMITCH, 2019, to cite some studies conducted in the L2). The explanation for the relationship between WMC and the results of the reading comprehension measures is that the tasks require participants to engage in highly demanding cognitive processes, which can sometimes exceed their capacity. With that in mind, some L2 researchers have attempted to find ways to facilitate comprehension and reduce the processing demands of WM on performance. They either modified the texts to be read (ALPTEKIN; ERÇETIN, 2011), provided readers with appropriate knowledge before reading (SHIN; DRONJIC; PARK, 2019), or applied treatment with pre-reading activities (ROSCIOLI; TOMITCH, 2022).

To investigate the role of WMC on L2 reading comprehension, Alptekin and Erçetin (2011) manipulated the cultural content of narrative texts. The participants were sixty-two English as a second language Turkish students at the university level with advanced proficiency in the language. They had to read texts either in their original format reflecting the American culture or

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[3] This article is a partial report of the master's thesis research conducted by the first author under the supervision of the second author (see RONDON; TOMITCH, 2020, for complementary information).

[4] In the Reading Span Test (DANEMAN; CARPENTER, 1980), participants had to read groups of sentences aloud and memorize the last word of each sentence. The number of sentences per group increased gradually, starting with two and ending with six sentences. After participants read one group of sentences, they saw a cue card signaling the moment they had to say the last words they had memorized.

[5] Reading span concerns the measurement of WMC through the RST. In the study by Daneman and Carpenter (1980), participants with a high span could recall four to five final words, whereas those with a low span could recall only two words.

nativized versions referring to specific traditions and customs typical of Turkey. The researchers measured WMC using a computerized version of the RST (based on DANEMAN; CARPENTER, 1980) with simple English sentences in the active voice. To ensure participants were processing the sentences for meaning, Alptekin and Erçetin (2011) included a grammaticality judgment component. Participants' reading spans were the total number of final words recalled in the test. The researchers found that WMC was not related to literal comprehension. Chiefly, the nativization of the culture-specific texts had a significant positive effect on readers' inferential comprehension regardless of their working memory span. In other words, the text modification Alptekin and Erçetin (2011) implemented facilitated the performance of lower and higher-span readers.

In a more recent study, Shin, Dronjic and Park (2019) provided participants with relevant information regarding the topic of specific texts selected from TOEFL reading sections: The rise of Teotihuacan; Agriculture, iron, and the Bantu people; History of the chickenpox vaccine; and Ancient Rome and Greece. They were seventy-nine EFL Korean students of intermediate to advanced proficiency. The researchers also used a version of the RST in English to measure participants' WMC. One difference from the previous study is that reading span was a composite score reflecting storage, processing, and the tradeoff between the two, indicated by reaction time (based on WATERS; CAPLAN, 1996). Before data collection, participants read about Teotihuacan and the Bantu people in their native language, thus creating two conditions: reading with and without background knowledge. Shin, Dronjic and Park (2019) found that all readers had improved comprehension in the first condition, but the high-span readers benefitted significantly more. Expressly, providing readers with appropriate knowledge before reading facilitated comprehension for low and high-span readers, especially for the latter.

Roscioli and Tomitch (2022) verified the online inference generation of thirty-six beginner to intermediate EFL Brazilian students. They created a treatment with a selection of pre-reading activities (MOORE; READENCE; RICKELMAN, 1999) that activated readers' previous knowledge through visual tools such as videos and cartoons. The NarrativePR group received treatment with the pre-reading activities before reading a narrative text but no treatment before reading an expository text. The other way around was valid for the ExpositoryPR group. The researchers measured WMC using a version of the RST in Brazilian Portuguese, the participants' native language (BAILER; TOMITCH; D'ELY, 2013; TOMITCH, 2003). They reported that, for the ExpositoryPR, there was a facilitative effect of the pre-reading activities (*i.e.*, no correlation between WMC and reading comprehension). For the NarrativePR, there was no facilitative effect (i.e., there was a significant positive correlation between WMC and reading comprehension). Also, the authors found that high and low-span participants' performance in the reading comprehension questions did not follow a pattern. Some high-span readers had higher scores in the expository text, while others scored more points in the narrative text. The same happened with low-span readers. These results led Roscioli and Tomitch (2022) to assume that the treatment with the pre-reading activities might have compensated for the level of difficulty of the texts.

The three studies reviewed in this section attempted to find ways to facilitate L2 readers' comprehension and reduce their processing demands. Despite the differences in how they measured WMC in the L1 or L2, the results seem to favor teacher intervention to support reading. To our knowledge, the only previous study that investigated the facilitative effect of pre-reading activities on reading comprehension and their relationship with WMC was the one by Roscioli and Tomitch (2022). Some possible limitations in their study concern participants' heterogeneity in proficiency level, a confound with text type, and the activities used as treatment. The present study attempted to improve on those aspects. First, we had groups of participants from pre-intermediate and advanced proficiency levels. Second, we

used only expository texts. Third, we chose two pre-reading activities: Contextual Redefinition and Graphic Organizer (MOORE; READENCE; RICKELMAN, 1999).

Objectives, Research Questions, and Hypotheses

The objective of this study was to investigate whether there was a correlation between pre-intermediate and advanced participants' WMC as measured by the RST (BAILER; TOMITCH; D'ELY, 2013; DANEMAN; CARPENTER, 1980; TOMITCH, 2003) and their results obtained in comprehension tests in three conditions: Contextual Redefinition, Graphic Organizer (MOORE; READENCE; RICKELMAN, 1999), and control (no pre-reading activity). Accordingly, this study aimed at answering the following research questions:

> (1) Is there a correlation between RST scores, comprehension questions scores and written free recall scores when the prereading activity Contextual Redefinition is used with pre-intermediate and advanced EFL students?
>
> (2) Is there a correlation between RST scores, comprehension questions scores and written free recall scores when the prereading activity Graphic Organizer is used with pre-intermediate and advanced EFL students?

We hypothesized there was a correlation between RST scores, written free recall scores, and comprehension questions scores when pre-intermediate and advanced participants read the texts appropriate to their proficiency level in the control condition. The correlation would indicate that the reading task was cognitively demanding. We also hypothesized RST scores, written free recall scores, and comprehension questions scores would not correlate when pre-intermediate and advanced participants read the texts appropriate to their proficiency level in the treatment conditions. The lack of correlation would indicate that the Contextual Redefinition and Graphic Organizer pre-reading activities reduced the processing demands of the reading task.

Groups and Participants

The participants[6] were teenage and adult L1 speakers of Brazilian Portuguese (BP) studying English as a foreign language (EFL). We invited forty-six students from seven intact pre-intermediate and advanced groups[7]. We collected data during their regular classes. The students who decided not to participate in the research still engaged in the experimental tasks as classroom activities; however, we did not use their data. Because some participants missed one of the sessions, only thirty students were part of the final sample, fifteen in each proficiency level. Participants in both groups ranged between 12 and 66 years old ($N = 30$, $M = 32.33$, $SD = 19.43$). We confirmed that the pre-intermediate (PI, $n = 15$) and advanced (ADV, $n = 15$) groups did not differ in age ($t(28) = 0.90$; $p = .38$) when compared to each other. Three participants in the PI group were older than 45 years old; in the ADV group, five participants were older than 45. Also, the proportion of male and female participants in each group was approximately the same (PI 53.3% female and ADV 60% female).

Because participants were tested in their L2, English, they did a proficiency test based on the reading section of a Cambridge placement test. We interpreted the results considering the Common European Framework of Reference (CEFR): participants at the B1 level were pre-intermediate, and those at the C1 level were advanced. An independent measures t-test confirmed that the groups were different in terms of proficiency ($t(28) = 11.07$; $p < .001$). We decided to have two proficiency groups because previous studies show that pre-reading activities can affect students' reading comprehension differently depending

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[6] All participants provided written informed consent before data collection, and underage participants' legal guardians. Also, this study was approved by the Brazilian Ethics Committee and registered under the number 3.326.440.

[7] Data collection with intact groups means that the participants are the same as the students in a regular class, which usually occurs when the experimental sessions are during the time of the classes.

on their level of proficiency (HUDSON, 1998; MIHARA, 2011).

Materials

We employed a BP version of the RST (DANEMAN; CARPENTER, 1980) developed by Tomitch (2003) and later slightly adapted by Bailer, Tomitch and D'Ely (2013) for use with teenagers. We decided to use this test because there were teenagers in both groups of participants. The test comprised three sets of two, three, four, five, and six sentences each (15 in total) and nine additional ones for practice. We administered a silent reading version of the RST in groups (TORRES, 2003) using a grammaticality judgment test (GJT) to ensure processing. We syntactically modified half of the sentences by inverting the order of three words, with alterations randomly located at the beginning, middle, and end of sentences. While reading each sentence silently, participants had to decide whether they were grammatical or not. Then, they wrote their answers in a response booklet (either a correct sign for a grammatical sentence or an incorrect symbol for an ungrammatical one). After reading and judging all the sentences in a set, they wrote the last word of each sentence in the same response booklet. Participants received oral and written instructions in BP.

We selected six texts, three for each proficiency group, from the British Council[8] webpage according to the following criteria: approximately the same number of words, fit one page, they were well-structured expository texts, and were appropriate for B1 or C1 levels on the website[9]. The materials for the pre-reading activities Contextual Redefinition (CR) and Graphic Organizer (GO) were: ten unfamiliar words chosen from each text (CR), a sentence with contextual clues to the meaning of the chosen words (CR), a list of dictionary entries of those words (CR), and diagrams with the main ideas of the texts displayed according to their text structure (GO). For each text, there were six comprehension questions written in participants' native language.

The prereading activity Contextual Redefinition is designed to provide students with the relevant vocabulary before reading a text through context clues for the meaning of unknown words. This activity is supposed to enhance comprehension because "context enables readers to predict a word's meaning by making connections between their prior knowledge and the text" (MOORE; READENCE; RICKELMAN, 1999, p. 38). The prereading activity Graphic Organizer presents "a schematic diagram for major concepts and additional terms which convey information to students before they read" (MOORE; READANCE; RICKELMAN, 1999, p. 54).

Data Collection

Data collection took place in two experimental sessions with participants during their regular English classes. In the first session, participants completed three tasks. First, they took about ten minutes to answer a profile questionnaire. Then, they had a limit of twenty minutes to do the reading proficiency test. Last, they completed the RST in approximately twenty-five minutes; after receiving booklets with instructions in Portuguese, participants practiced the procedure in a training session with one set of two, three, and four sentences. Participants had twelve seconds to silently read each sentence displayed on a PowerPoint presentation on the screen, judge its grammaticality, and memorize its last word. They wrote a correct sign next to the sentence number on their booklets if they thought it was grammatical. If not, they had to write an incorrect symbol. After participants finished reading all sentences in one set, question marks appeared on the screen (???), indicating recall. Then, they turned to the next page on their booklets and wrote the last word of each sentence in the set in the order they appeared on the screen.

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[8] The British Council is an international organization of the United Kingdom for cultural relations and educational opportunities. https://www.britishcouncil.org.

[9] The texts selected for the pre-intermediate group (B1) were: *Digital Habits Across Generations* (432 words), *The Legend of Fairies* (387 words), and *Robot Teachers* (346 words). For the advanced group (C1), we selected the texts: *Do you have the right mindset?* (462 words), *Me and My Brain* (472 words), and *The Rise of Fake News* (466 words).

In the second experimental session, we collected data related to the dependent measures. We counterbalanced the order of the conditions and the texts within each group (see Table 1 below). In the control condition, the PI and ADV groups read an appropriate text to their proficiency level while attempting to understand its central idea and remember as much information as possible for about ten to twelve minutes. In the written free recall task, they wrote down everything they remembered from the passage in their native language using complete sentences. They had about five minutes to do this task and did not have access to the texts. Then, participants had about five to seven minutes to answer the comprehension questions in BP without access to the original texts or their recall.

TABLE 1 – Counterbalancing for the second encounter of data collection

PI Group 1 (*n* = 7) **/ ADV Group 1** (*n* = 3) **/ ADV Group 2** (*n* = 5)		
Order	**Text**	**Condition**
1	Text 1	Control
2	Text 2	CR
3	Text 3	GO
PI Group 2 (*n* = 3) **/ ADV Group 3** (*n* = 4)		
1	Text 3	CR
2	Text 1	GO
3	Text 2	Control
PI Group 3 (*n* = 5) **/ ADV Group 4** (*n* = 3)		
1	Text 2	GO
2	Text 3	Control
3	Text 1	CR

Source: Prepared by the authors (2023).

In the CR condition, the PI and ADV groups saw the unknown words previously selected from the texts. These words were presented in isolation on a computer screen with a PowerPoint presentation, and participants in their intact groups collectively attempted to guess their meanings. After that, they saw the words in the sentences with context clues. Again, they tried to guess the meanings of the words, this time departing from the context provided by the sentences. Finally, participants received the dictionary entries to check their guesses. After the treatment, participants performed the same tasks presented in the control condition. In the GO condition, the PI and ADV groups saw a diagram representing the text organization and its central ideas. We asked participants how the ideas and text structure were related, creating a meaningful representation of the passage. As in the other conditions, participants did the written free recall and answered the comprehension questions after reading the texts.

Data Analysis

Based on the findings of the study conducted by Roscioli and Tomitch (2022), we analyzed the results of RST with strict scorings. Participants received full marks when they could remember the correct word in at least two out of three sets and a half mark if they could remember one out of three (BAILER; TOMITCH; D'ELY, 2013; ROSCIOLI; TOMITCH, 2022). Because we used a GJT to ensure processing, participants only received points if they judged the sentences appropriately. In other words, if participants recalled the last word of a sentence but failed to identify whether the cor-

responding sentence was grammatically correct or incorrect, they did not receive a point, which means they had to remember the words in the order of presentation. The rationale for this scoring is that some participants favored writing the last words instead of analyzing the grammaticality of the sentences and vice-versa, which could lower the processing and storing demands of working memory. Also, we did not consider differences concerning plurals and noun gender, counting as a correct word.

We interpreted participants' recall protocols based on the number of propositional units they remembered using a method developed by Tomitch (1990). It consists of labeling the parts of the sentences in key propositions and attributes that modify them. We scored the comprehension questions following an answer key in which the correct answers were subdivided into six essential components that constituted a complete answer. For each component, participants received a 0.5 point. Thus, scores for each question ranged from 0 to 3 points. Because there were six comprehension questions for each text, the total scores could range from 0 to 18 points.

Finally, we evaluated data normality through histograms, box plots, Q-Q plots, and two tests of normal distribution: the Kolmogorov-Smirnov and the Shapiro-Wilk tests. We found that pre-intermediate participants' scores for the comprehension questions in the GO condition had a bimodal distribution. However, there were no outliers in this variable. There was one outlier in the pre-intermediate participants' scores for the comprehension questions in the control condition, Participant 2, who had an extremely high score. For the advanced group, analysis of box plots revealed two outliers in the control condition for the written free recall variable (Participant 22, extremely high; Participant 30, extremely low) and two outliers for the comprehension questions variable (Participants 16 and 22, whose scores were extremely high), also in the control condition. Because of the small number of participants, we did not exclude the outliers from the analysis. We explored correlations between the variables using parametric and non-parametric tests. Whenever they differed, we presented both.

Results and Discussion

We conducted a two-way 2 (Group: PI or ADV) x 3 (Condition: CR, GO, or Control) mixed ANOVA with repeated measures on written free recall scores. The results revealed a significant main effect of Group at the 5% level ($F(1,28) = 17.33$, $p < .001$), which means that, generally, the ADV group had a significantly better performance than the PI group. There was no significant main effect of Condition nor a significant interaction between Group and Condition. These results indicate that the pre-reading activities did not significantly affect participants' comprehension. However, we made some considerations based on their raw scores (see Table 2 below). The scores indicate that the PI group performed similarly in the Control and GO conditions. Comparatively, their results in the CR condition were worse. Thus, one could say that the pre-reading activity Contextual Redefinition was detrimental to pre-intermediate participants' comprehension, even though the difference between the Control and the CR did not reach significance. The ADV group obtained the highest scores in the Control condition, followed by CR and GO. Comparing the raw scores, one could say that the pre-reading activity Graphic Organizer was unfavorable to advanced participants' comprehension, despite the difference between the Control and the GO not being significant.

TABLE 2 – Participants' raw scores in the written free recall

Pre-intermediate (n = 15)				**Advanced** (n = 15)			
	Control	**CR**	**GO**		**Control**	**CR**	**GO**
Mean	14,53	11,93	14,6	Mean	23,6	22,93	19,66

CR - Contextual Redefinition GO - Graphic Organizer

Source: Prepared by the authors (2023).

We also conducted a two-way 2 (Group: PI or ADV) x 3 (Condition: CR, GO, or Control) mixed ANOVA with repeated measures on comprehension questions scores (see Table 3 below for the raw scores). The results revealed no significant main effect of Group or Condition. We found one pairwise effect of Condition approaching significance: CR in relation to GO for the PI group ($p = .092$), which means the two pre-reading activities had significantly different effects on pre-intermediate participants' comprehension. Also, there was a significant interaction between Group and Condition at the 5% level ($F(2,56) = 4.411$, $p < .05$). We used a Bonferroni correction and found only one pairwise effect for the CR condition ($p = .003$). This finding indicates that the pre-reading activity Contextual Redefinition significantly affected ADV participants' reading comprehension compared to the PI group. Altogether, the data revealed that the pre-reading activity Contextual Redefinition had an advantageous effect for the ADV group, whereas the Graphic Organizer was beneficial for pre-intermediate participants' comprehension.

TABLE 3 – Participants' raw scores in the comprehension questions

Pre-intermediate (*n* = 15)				**Advanced** (*n* = 15)			
	Control	**CR**	**GO**		**Control**	**CR**	**GO**
Mean	3,56	3	4,26	Mean	4,06	5,26	4,06

CR - Contextual Redefinition GO - Graphic Organizer

Source: Prepared by the authors (2023).

The results of the RST used in the present study reveal that the test was very cognitively demanding (see Table 4 below), even though participants did the test in BP, their native language. Participants in both groups had difficulties processing the sentences to judge their grammaticality and simultaneously store the last word of each sentence. Six participants could remember correctly only one of the three sets at the two-sentence level. Thus, following the strict scoring method, these participants had a span of 1.5. Also, two participants could not remember any of the three sets at the two-sentence level. For this reason, they had a span of 1.0. We present the WM spans of the two groups separately for comparison. Importantly, the PI and ADV groups did not differ in terms of their WMC, as confirmed by an independent measures t-test ($t(28) = 1.38$; $p = .18$). Next, we discuss the possible implications of these findings, considering the correlations of the results participants obtained in the comprehension measures with WMC. We refer to the correlations that are statistically significant and the ones that are not considering our hypotheses that the treatment conditions affect the relationships between variables.

TABLE 4 – Participants' scores in the Reading Span Test

Pre-intermediate (*n* = 15)		**Advanced** (*n* = 15)	
	Control		**Control**
Mean	2,1	Mean	2,56
Minimum	1	Minimum	1
Maximum	3,5	Maximum	4

Source: Prepared by the authors (2023).

Table 5 below presents the correlations between WM and written free recall scores. Results of the PI group show that the previously mentioned variables only correlate significantly in the CR condition, $r(13) = .59$, $p < .05$. Despite not reaching significance, the other correlations

deserve consideration. There is a moderate positive correlation between WMC and written free recall for the control condition, r (13) = .47, p > .05. Thus, there is an increase in the strength of the correlation when comparing the control and the CR conditions. Based on these results, we speculate that the CR caused the written free recall task to be more cognitively demanding for the pre-intermediate group than the control condition. We suppose it taxed WM, even though the difference between participants' scores in the written free recall task in the two conditions did not reach statistical significance. As for the GO condition, there was a weak positive correlation between WMC and written free recall, r (13) = .11, p > .05. There was a decrease in the strength of the correlation between WMC and written free recall scores when comparing the control condition with the GO. Thus, we might argue that the prereading activity Graphic Organizer mitigated pre-intermediate participants' cognitive demands. However, this difference did not appear in their written free recall scores, which were barely higher than the control.

TABLE 5 – Correlations between working memory and written free recall x written free recall scores

Correlations	**PI WM x WFR**			**ADV WM x WFR**		
	Control (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)	**Control** (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)
Pearson's Coefficient r Sig.	.467 .079	.589* .021	.104 .712	-.121 .667	.093 .742	-.188 .502
Raw Scores	**PI WFR**			**ADV WFR**		
	Control (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)	**Control** (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)
Mean	14,53	11,93	14,6	23,6	22,93	19,66

*. Correlation is significant at the 0.05 level (2-tailed).

PI - Pre-intermediate ADV - Advanced WM - Working Memory WFR - Written Free Recall CR - Contextual Redefinition GO - Graphic Organizer

Source: Prepared by the authors (2023)

Regarding the advanced group, there were no significant correlations between WMC and written free recall. However, we present some observations regarding the patterns found. There was a weak negative correlation between WMC and written free recall scores for the control condition, r (13) = -.13, p > .05, and in the GO condition, r (13) = -.19, p > .05, indicating that both conditions taxed WM similarly. In the CR condition, there is a change in the direction of the relationship between the variables: there is a weak positive correlation between WM and written free recall, r (13) = .10, p > .05. For this group, the correlations do not appear to relate to participants' scores in the written free recall task.

In Table 6 below, it is possible to observe that there were three significant correlations between WMC and comprehension questions scores for the PI group: control, r (13) = .52, p < .05; CR, r (13) = .56, p < .05; and GO, r (13) = .61, p < .05. Thus, we can state that answering the comprehension questions caused a high processing demand on pre-intermediate participants' WMC, regardless of the condition. For this group, the correlations do not seem to correspond to performance in the comprehension questions.

TABLE 6 – Correlations between working memory and comprehension questions x comprehension questions scores

Correlations	**PI WM x CQ**			**ADV WM x CQ**		
	Control (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)	**Control** (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)
Pearson's Coefficient r Sig.	.516* .049	.551* .033	.602* .017	.420 .119	.249 .371	.273 .324
Raw Scores	**PI CQ**			**ADV CQ**		
	Control (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)	**Control** (*n* = 15)	**CR** (*n* = 15)	**GO** (*n* = 15)
Mean	3,56	3	4,26	4,06	5,26	4,06

*. Correlation is significant at the 0.05 level (2-tailed).

PI - Pre-intermediate ADV - Advanced WM - Working memory CQ - Comprehension Questions CR - Contextual Redefinition GO - Graphic Organizer

Source: Prepared by the authors (2023).

Regarding the advanced group, we did not find any significant correlation between WMC and participants' scores in the comprehension questions using parametric tests. However, since two outliers in the control condition had extremely high scores, we also ran non-parametric tests. The only difference in the pattern of correlations was precisely for the control, which turned out to be significant: rs (13) = .54, $p < .05$. Thus, WMC predicted advanced participants' scores in the comprehension questions when they received no treatment before reading. We did not find any other significant correlations using parametric and non-parametric tests. It is worth mentioning that there was a weak positive correlation between WMC and comprehension questions scores in the CR and GO conditions (r (13) = .25, $p > .05$; r (13) = .28, $p > .05$). Based on the decrease of the correlations between WMC and comprehension questions in the experimental conditions regarding the control, we speculate that the treatment with the pre-reading activities reduced advanced participants' processing demands. This assumption receives partial support from their scores in the comprehension questions: their raw mean scores in the CR condition were higher than the control.

Final Remarks

This study aimed to investigate whether there was a correlation between pre-intermediate and advanced participants' WMC as measured by the RST and the results they obtained in comprehension tests after receiving treatment in three pre-reading conditions: Contextual Redefinition, Graphic Organizer, and control. We expected to find a significant correlation between RST scores, written free recall scores, and comprehension questions when pre-intermediate and advanced participants received no treatment. Also, we did not expect to find a significant correlation between the previously mentioned variables when the pre-reading activities Contextual Redefinition and Graphic Organizer preceded the reading of the texts.

The stated hypotheses received partial support from the findings. Regarding the pre-intermediate group, WMC was not significantly correlated with written free recall, although this relationship approached significance. We found a substantial interaction between WMC and written free recall when participants received treatment with the Contextual Redefinition and a weak positive relation in the second treatment condition, Graphic Organizer. Comparing the correlations with participants' performance in the written free recall,

we can conclude that the pre-reading activity Contextual Redefinition was not advantageous for use with students at the pre-intermediate level for two reasons. It overloaded their cognitive resources and, consequently, negatively affected their comprehension. Also, because the pre-reading activity Graphic Organizer practically did not affect their results in the written free recall but reduced their processing demands, we speculate that other factors might have interfered with the interaction. This hypothesis received further support from the correlations between WM and the scores of the comprehension questions. We found a significant positive correlation between the two variables in the three treatment conditions. However, this pattern was not apparent in the pre-intermediate participants' performance in the comprehension questions.

Concerning the advanced group, WMC was also not significantly correlated with written free recall. Furthermore, there was no significant interaction between the variables when participants received treatment with both pre-reading activities. We can conclude that written free recall did not impose a high cognitive demand on advanced participants, regardless of the condition. Because their comprehension, measured by the written free recall, did not relate to the stated patterns, we speculate that other factors might have interfered with the results. Concerning the comprehension questions, the findings confirmed the hypotheses. We found a significant positive correlation between WMC and the scores of the comprehension questions in the control condition, which disappeared when participants received treatment with both pre-reading activities. We interpret these findings as evidence of a facilitating effect of the instructional intervention, especially for the Contextual Redefinition activity, which also positively affected advanced participants' scores in the comprehension questions.

Altogether, the results of this study offer evidence to support the use of the pre-reading activity Contextual Redefinition with advanced EFL students. The findings reveal that it can positively affect their comprehension and impose a lighter-than-normal processing demand on their cognitive resources. Interestingly, the results of this research discourage the use of this activity with pre-intermediate EFL students for the opposite reasons. Regarding the Graphic Organizer, this study provides better evidence for its use with pre-intermediate EFL students because it can positively impact their performance depending on the comprehension measure used and reduce their processing demands. For advanced students, the same activity could have a negative or null effect on their comprehension. However, depending on the comprehension measure, it could alleviate the burden on their working memory. Finally, we can conclude that different pre-reading activities can affect reading comprehension differently depending on students' proficiency.

The results of this study are suggestive rather than conclusive due to several limitations. First, the number of students who participated in this research is small, thirty in total. If we had data from more participants, the likelihood of reaching statistical significance for some tests would be higher. Future studies could recruit more participants to see whether the findings are different. Second, we measured participants' proficiency using only one instrument, the reading section of a Cambridge placement test. Perhaps the results would be different if we had used a standardized measure of language knowledge. Future research could use other tests, such as the Test of English as a Foreign Language (TOEFL). Also, we selected the reading passages based on the assumption that they were appropriate for students' proficiency. Future studies could employ other texts controlling for metrics such as lexical readability and density (see SCARTON; ALUÍSIO, 2010) to examine whether vocabulary knowledge plays a role in the efficacy of pre-reading activities. Another setback of this research might be related to the participants' age, ranging from teenagers to older adults. Future studies could target a specific age group.

Other suggestions for further research outside the scope of the present article concern the

use of diverse pre-reading activities, especially those that focus on activating readers' previous knowledge regarding the topic of the texts. Even though Roscioli and Tomitch (2022) employed a selection of activities with this objective, their research design did not include a control condition for all text types, which created a confound in the analysis. Also, like Roscioli and Tomitch (2022), who targeted beginner to intermediate students, future studies could focus on different proficiency levels. Additionally, we recommend the application of alternative comprehension measures and the use of other text genres. Another possibility is to explore the joint effect of pre-reading activities and students' WMC on objective measures of online comprehension.

Ultimately, we believe the present research has relevant pedagogical implications. Generally, reading researchers and teachers agree that pre-reading activities positively affect readers' comprehension (HUDSON, 1998; MIHARA, 2011; TAGLIEBER; JOHNSON; YARBROUGH, 1988; TOMITCH, 1991). To our knowledge, this is the only study showing that, in certain conditions, they can hamper students' understanding of the text. This research provided reading teachers with empirical evidence favoring the pre-reading activity Contextual Redefinition with advanced students and the Graphic Organizer with pre-intermediate students. Also, while it may be possible to use this activity at the advanced level, this study indicates that the former is inappropriate for the intermediate.

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