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Working memory and the effect of topic familiarity on comprehension of information read on computer screens

Memória de trabalho e o efeito da familiaridade com o tópico na compreensão de informações lidas em telas de computadores

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Abstract: Several independent studies have investigated the effects of working memory capacity and prior knowledge (in this study explored as topic familiarity) on text comprehension. However, until the present moment, few, if none, studies have simultaneously addressed both constructs, that is, how comprehension of information read on computer screens, among readers with lower and higher working memory capacity is impacted by topic familiarity. Thus, this study was carried out in order to investigate how comprehension tests scores of texts read on screens varied with the presence or absence of topic familiarity with groups of readers of different working memory spans. The results indicate a positive impact of topic familiarity, especially for the group of readers with lower working-memory spans, which leads us to consider this study motivating for future research that seeks ways to reduce the demands on working memory capacity and thus enabling better reading comprehension for students with cognitive challenges. Furthermore, reading on digital media has become an inevitable part of contemporary life, hence the importance of obtaining comprehension scores from readings done on electronic devices.

Keywords: Working Memory. Topic familiarity. Comprehension of information read on computer screens.

Resumo: Diversos estudos investigaram, de forma independente, os efeitos da capacidade de memória de trabalho e do conhecimento prévio (aqui neste estudo explorado na forma de familiaridade com o tópico) na compreensão de textos. No entanto, até o momento, um estudo que aborde de forma simultânea o impacto dos dois construtos, ou seja, sobre como a compreensão de informações lidas em telas de computador, entre leitores com menor e maior capacidade de memória de trabalho, é impactada pela familiaridade com o tópico, é algo ainda escasso e que precisa de mais investigação. Dessa forma, propusemo-nos investigar, em grupos com diferentes níveis de memória de trabalho, como os escores em teste de compreensão, de textos lidos em telas,-variam com a presença ou não da familiaridade com o tópico do texto. Os resultados mostram que houve um impacto positivo da familiaridade com o tópico, especialmente, para o grupo de leitores com menores amplitudes de memória de trabalho, o que nos leva a considerar o estudo motivador para a busca de formas de diminuir as demandas na capacidade de memória de trabalho, desse modo proporcionando oportunidades de melhor compreensão textual para indivíduos com desafios cognitivos. Ademais, a leitura em meios digitais tem se tornado parte inevitável da vida contemporânea, por isso a importância em se obter escores de compreensão advindos de leituras feitas em telas de dispositivos eletrônicos.

Palavras-chave: Memória de Trabalho. Familiaridade com o tópico. Compreensão de informações lidas em telas de computador.

Introduction

Reading processing is not restricted to decoding the letters that make up a text. A complete process results in the apprehension of the content, passing through stages in which an effective understanding of the message is necessary. Consequently, this process is divided into four phases: decoding (in which written symbols are related to their proper meanings), comprehension (in which the reader manages to assimilate the meaning of the text, its structure, genre and context, as well as explicit ideas), interpretation (in which the reader assimilates the implicit ideas of the text in a deeper way, interacting with it and taking a critical position on the presented ideas), and finally, retention (in which the information from the text is retained in memory, so that the reader is able to relate the learned content to his/her prior knowledge, and is even able to apply the retained knowledge in other contexts (Menegassi, 1995).

Likewise, current theories of reading comprehension share the idea that there are several factors that can influence this multifaceted process of

comprehension. Among these factors, the influences of working memory capacity and prior knowledge can be highlighted (Shin; Dronjic; Park, 2019). Research on the role of working memory reinforces the construct as an effective predictor for comprehension, emphasizing that higher memory spans are positively correlated with high scores in comprehension tests (Tomitch, 2003; Prat; Just, 2011; Jeongsoon, 2015; Fujii; Weissheimer, 2017; Baretta; Guará-Tavares, 2018; Li; Brantmeier, 2021, among others).

Prat and Just (2011) investigated the functional connectivity associated with processing demands in a reading task. The results showed that individuals with higher working memory capacity exhibited greater efficiency, greater adaptability, and better synchronization of language neural networks than participants with lower spans, in sentence comprehension.

Jaeggi et al (2012) investigated whether a brief cognitive training intervention resulted in a specific performance increase in the trained task, and whether there were transfer effects to other nontrained measures. The children investigated considerably improved their performance in the trained working memory task. Additionally, compared to a matched control group, the experimental group significantly enhanced their reading performance after training, providing further evidence for shared processes between working memory and reading.

The study by Fujii and Weissheimer (2017) investigated the development of reading competence of public high-school students in Brazil and its relationship with working memory capacity. The results indicated that students' reading competence was linked to their working memory capacity, mainly regarding the phonological component.

Li and Brantmeier (2021) investigated the relationship between working memory capacity (WMC) and second-language reading performance.

Correlation analysis showed that the contribution of working memory capacity to reading comprehension varied according to the type of comprehension measure used and that readers with higher working memory scores employed a greater variety of reading strategies than those with lower ones.

In summary, according to such studies, working memory capacity seems to exert influence on the reader's ability to mentally analyze the text, which consequently seems to affect the ability to monitor while processing the text. Furthermore, according to Baddeley (2000), working memory is responsible for manipulating and temporarily storing new information while retrieving already processed and stored information (prior knowledge) in long-term memory. Such understanding leads us to question if there is any interaction between working memory capacity and prior knowledge, as a way of compensating lower memory capacity, thus helping lower memory span readers to process texts more efficiently, at the point of having balanced comprehension scores compared to higher working memory span readers.

The role of prior knowledge in reading comprehension began to be of interest in the 1970s, when schema theory was introduced (Rumelhart, 1980), and since then, several studies have been carried out to investigate how readers can benefit from this construct, which involves merging new information extracted from the text to the existing knowledge stored, which implies effective text comprehension (McNamara et al., 1996; Siqueira and Zimmer, 2006; Priebe et al., 2012; Abdelaal and Sase, 2014; Smith et al., 2021; Tarchi, 2015; ; Oliveira, 2015, among others). Also, it is important to point out that one of the most comprehensive models that accommodate this view of reading is Kintsch's Construction-Integration model (1988), which deals with a

reformulation of the textual comprehension model of Kintsch and Van Dijk (1978) and Van Dijk and Kintsch (1983).

Recht and Leslie (1988) published the famous research called the “baseball study”. In it, the authors found that having prior knowledge about baseball led individuals with lower reading skills to have greater comprehension than individuals with higher reading skills without knowledge about baseball. In other words, this study led us to reflect on the great impact of prior knowledge on readers with lower working memory spans.

McNamara et al. (1996) reported having found that readers benefited from topic familiarity by recalling text elements regardless of their reading capacity. The authors hypothesized that the ability to recall information was directly related to the formation of an adequate text base, which can be enhanced by prior knowledge.

Abdelaal and Sase (2014) investigated the relationship between prior knowledge and reading comprehension in a second language of graduate students. The result showed a significantly high relationship between higher prior knowledge and reading comprehension. However, the results showed a significantly low relationship between low prior knowledge and reading comprehension. Still, the reading comprehension performance of students with higher prior knowledge was significantly better than that of students with lower prior knowledge.

In turn, Tarchi (2015) highlighted, among higher order skills, that prior knowledge and inferences are considered the most important predictors of reading comprehension. The results of his study indicated that, in the intervention based on the activation of prior knowledge, participants demonstrated better comprehension, metacognition, and inference processes.

Oliveira (2015) also analyzed how prior knowledge interferes with reading comprehension. The results showed that participants' prior knowledge contributed to text comprehension, as the acquired and stored knowledge was activated, this way helping reading comprehension.

Smith et al. (2021) conducted a critical review to investigate the influence of background knowledge on reading comprehension of primary school-aged children. The results indicated that prior knowledge impacted differently individuals with higher and lower reading capacity. Readers with lower reading capacity were able to compensate somewhat for their relatively weak reading skills in the context of a higher degree of prior knowledge.

Finally, our review of studies has shown that the effects of working memory capacity and prior knowledge on text comprehension, whether in L1 or L2, in digital media or print media, have been independently investigated. However, until the present moment, few attempts have been made to simultaneously investigate the effects of working memory capacity and topic familiarity on reading comprehension. With that in mind, the objective of this study is to investigate how comprehension of information read on computer screens, by readers with lower and higher working memory spans, varies according to two different reading contexts: with and without a familiar topic:

- Context 1: when the text is about an unfamiliar topic.
- Context 2: when the text is about a familiar topic.

Moreover, reading on digital media has become an inevitable part of contemporary life. However, it is also inevitable to think that there is a greater cognitive effort caused by eye fatigue due to the light emitted by devices, inattention caused by simply "scrolling through the text" or interruptions when browsing other pages or receiving notifications from

social networks. Ultimately, there is, without a doubt, a greater cognitive impact on the demands of working memory capacity when reading on a screen. For all these reasons, we chose to gather data of reading comprehension on digital devices.

In addition, it is important to emphasize that this study is based on three theoretical supports. First, the updated version (Baddeley, 2000) of Baddeley and Hitch's working memory model (1974), since this model describes working memory as responsible for manipulating and temporarily storing new information and retrieving already processed and stored information (prior knowledge) from long-term memory.

The second relevant theory is the Taxonomy of reading comprehension levels, described by Barret (1968) and studied by Alliende and Condemarín (1987). Reading comprehension is here understood as a complex process resulting from the intercurrence of several factors. Thus, the analysis of reading comprehension levels of the participants in this study is described in detail, as presented by Barret (1968). This taxonomy served as the basis for formulating the questions used in the reading comprehension tasks.

Finally, this study is also based on the reading model proposed by Van Dijk and Kintsch (1983). This model emphasizes the important role of prior knowledge in the construction of the mental representation of the text, since working memory retrieves information previously stored in reader's long-term memory and connects such information with the text ideas temporarily stored in itself to generate a coherent whole. Therefore, it is a model of construction-integration that meets the objectives of this study.

Method

This study was motivated by one general research question: How does comprehension of information read on computer screens, by readers of lower and higher working memory spans, vary according to different reading contexts: with and without topic familiarity? More specifically:

1) Do readers with higher working memory spans achieve significantly higher comprehension scores than readers with lower working memory spans in two reading contexts: without and with topic familiarity?
2) Does comprehension of information read on computer screens vary significantly when there is topic familiarity, in both working memory groups?
3) Does one group of working memory readers benefit more from topic familiarity than the other?

In order to answer these questions, an experimental quantitative study was designed.

Context and participants

This research was carried out with 30 students from two federal universities in the northeast of Brazil, majoring in Portuguese and English. The cohort consisted of 18 female and 12 male participants, with ages ranging between 20 and 38 years old, thus an adult population.

Instrument: Reading Span Test

The Reading Span Test is a memory test created by Daneman and Carpenter (1980) with the aim of measuring working memory capacity for written language, measuring the ability of readers to recall target words

while processing sentences. However, this study used a version of Daneman and Carpenter Reading Span Test (1980). Such version developed by Oliveira, Woelfer and Tomitch (2021), does not require reading aloud and can be applied without constant intervention from the researcher, allowing self-administration and enabling application in groups. The instrument was developed in JavaScript with the Psych library (Leeuw, 2015; Leeuw; Motz, 2016), and its validity was attested in an experiment that showed a statistically significant moderate positive correlation between the original test and the version developed by the researchers mentioned above.

The test was programmed with 180 sentences selected from a news corpus. Each time the test is run, 60 out of these 180 sentences are randomly selected before being presented to the participants. Therefore, each participant must read sixty sentences, organized into 3 sets. Each set is composed of blocks that increase in number of sentences: 2, 3, 4, 5, and 6 sentences. Thus, the first block of each set contains 2 sentences and the last contains 6. When reading each sentence, each participant must choose, from two options, the last word that completes it correctly, while at the same time trying to memorize the chosen word, that is, the last word of each sentence read. For example, in a sentence like “In order to perform brain thinking activities, neurons get energy from oxygen and: futurists/glucose,” our participant must choose one of the two options, futurists or glucose, to complete the sentence, while also memorizing the chosen word.

Thus, in a block of two sentences, after reading the sentences, the participant must type the two words used to complete the sentences read and press “continue” to continue with the other blocks in the set. Likewise, in a block of six sentences, at the end of reading them, the participant must type the six words used to complete each sentence, in the same sequence in which they were presented. It is important to note that at the

end of the test, the program itself automatically calculates the score in the test (how many words they could remember).

In order to categorize participants into groups with lower and higher working memory spans, we used an extreme groups design, which refers to situations in which a continuous variable is categorized in such a way that only the categories that represent the upper and lower ends of the distribution of the continuous variable are represented (Conway et al., 2005). Furthermore, when it comes to categorizing working memory scores into two extreme groups (higher and lower working memory span), the most common approach in the literature is to establish a division into "quartiles."

This way, our participants were categorized into four ordinal groups: the first group that obtained ≤22 scores, the second group that obtained from 23 to 27 scores, the third group that obtained from 28 to 35 scores, and the fourth group that obtained >35 scores. It was observed that 30% of the participants were in the first group, 26.7% in the second, 23.3% in the third group, and 20% in the fourth group. So, these data indicate a relatively balanced distribution of participants among the different levels of working memory capacity. Consequently, only the data from participants in the first (lower working memory spans) and the fourth groups (higher working memory group) were analyzed in this study.

Instruments: texts and reading comprehension tasks

Participants read two different texts in two different contexts on computer screens. After reading, they answered two different reading comprehension tasks, one for each text read:

- In context 1, participants read text 1, which is about an unfamiliar topic.
- In context 2, participants read text 2, about a familiar topic.

Regarding the two reading comprehension tasks, it is important to note that they had a standardized number of five questions, containing four options each. Furthermore, each question evaluated different levels of reading comprehension, according to Alliende and Condemarin (1987): literal (recognition of the main idea, of details, comparisons, frequency and cause-and-effect relationships) as well as inferential (from textual base and from context base). It is also important to emphasize that the comprehension level of question 1 of text 1 was the same as that of question 1 of text 2, as a way of controlling variables.

Instrument: Questionnaires

Participants completed a questionnaire used to assess their profile (age and reading habits on electronic devices), as well as to verify familiarity with some textual topics. To verify familiarity with textual topics, ten different topics were given, and participants were asked to rank their familiarity with the topics on a scale from 0 (not at all familiar) to 4 (very familiar). The text with the topic marked as the most familiar was chosen as text 2 / context 2, in which there is familiarity with the topic. The topic which participants reported having the lowest familiarity with was chosen as text 1 / context 1 (without topic familiarity).

Data collection procedures

Data Collection was divided into three moments (with the researcher in a computer lab on three different days), each moment was organized according to the following description:

- **Moment 1:** Participants completed the Reading Span Test (Oliveira; Woelfer, Tomitch, 2021) followed by the questionnaire used to determine participants' profiles and their levels of familiarity with some topics.

- **Moment 2:** Participants completed task 1, in which they read a text about an unfamiliar topic (Context 1) and answered a multiple-choice comprehension task about the text read.
- **Moment 3:** Participants completed task 2, in which they read a text about a familiar topic and answered a multiple-choice comprehension task about the text read. It is important to highlight that a conversation about the topic of the text was held before asking each participant to start reading, as a kind of contextualization.

Data analysis

The first step of data analysis consisted of checking the results of the comprehension questions of each text; the score of each task was computed by-the number of correct answers. This way, if the participant scored 10 out of a total of 11 points in context 1, his/her comprehension score in context 1 was represented by the number 10. The second step was to verify how comprehension varied between working memory groups, according to the different reading contexts.

The following analysis was then conducted to answer the three specific questions of the research:

1) To answer specific question 1, the means of comprehension scores between lower and higher working memory span groups were compared for each context (Contexts 1 and 2).
2) To answer specific question 2, the means of comprehension scores in context 1 (No familiarity) were compared to the means in context 2 (with familiarity), for each group of memory and in general (Context 1 X Context 2).

3) To answer specific question 3, the means of comprehension increase (gains) from context 1 to context 2 were compared between the two groups of working memory.

Besides the descriptive analysis, hypothesis tests were used to verify if the results were statistically significant. This way, a more detailed description of these tests is made as the result for each question is presented.

Results and discussion

In this section, in order to answer each question of this study, the results of the descriptive and inferential analyses carried out are presented, as well as the discussion for clarification of the results.

Do readers with higher working memory spans obtain significantly higher comprehension scores than readers with lower working memory spans in two reading contexts: without and with topic familiarity?

In order to answer Question 1, reading comprehension scores of the participants were measured and the results are shown in Table 1, according to memory group and reading context, including number of participants analyzed (n), mean, median, minimum (Min), maximum (Max), standard deviation (Std), variance (Var), and coefficient of variation (CV). The aim was to have a clear understanding of how data are distributed.

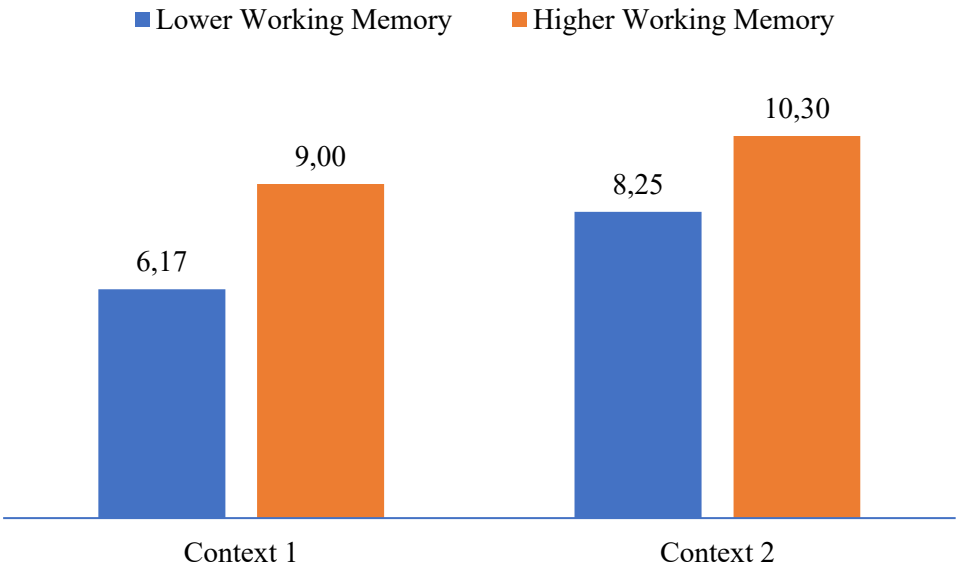
Table 1 – Descriptive measures for comprehension levels by group of memory in each reading context

Context	Groups	n	Mean	Median	Min	Max	Std	Var	CV
1	General	30	7.30	7.00	3.00	10.00	1.90	3.60	25.98%
	Lower Working Memory	12	6.17	6.50	3.00	7.00	1.19	1.42	19.35%
	Higher Working Memory	10	9.00	9.00	8.00	10.00	0.82	0.67	9.07%
2	General	30	9.00	9.00	6.00	11.00	1.51	2.28	16.76%
	Lower Working Memory	12	8.25	8.00	6.00	10.00	1.14	1.30	13.80%
	Higher Working Memory	10	10.30	10.00	9.00	11,00	0.67	0.46	6,55%

Source: Elaborated by the authors.

Then, to verify if higher working memory span readers had significantly higher levels of comprehension than lower working memory span readers in two different reading contexts (Question 1 of the study), means of comprehension scores between lower and higher working memory readers in each reading context were compared. Figure 1 below shows chart bars that represent this comparison. It is possible to observe that higher working memory readers had higher comprehension scores than lower working memory readers in both Contexts 1 (without topic familiarity) and 2 (with topic familiarity). However, it can also be noticed that the difference of comprehension scores between the memory groups is more pronounced in context 1, whereas in context 2, this difference is more subtle.

Figure 1 – Comprehension scores between lower working memory readers and higher working memory readers in each context (1 and 2)



Source: Elaborated by the authors.

In order to verify whether the results of the descriptive analyses had statistical significance, hypothesis tests were run. Before tests were run, analyses were performed to verify the assumptions about data for the application of the parametric t-test. Shapiro-Wilk test was used to check for normality, and Levene's test was used to check the assumption of homogeneity of variances. If the assumptions were satisfied, the parametric t-test would be the most appropriate, otherwise nonparametric Mann-Whitney U test should be used. These are the results:

- In context 1, Shapiro-Wilk test was used and indicated that data for both memory groups did not follow a normal distribution (p-value < 0.05), while Levene's test confirmed homogeneity of variances between the two groups of memory (p-value = 0.472). Since the normality assumption was not satisfied, Mann-Whitney U test was used, which revealed a statistically significant difference between higher and lower working memory groups (p-

value < 0.01). In other words, higher working memory span readers had significantly higher levels of comprehension than lower working memory span readers in Context 1, when readers had no prior knowledge of the subject of the text.

- In context 2, while data for lower working memory span group showed normality (p-value = 0.158), data for higher working memory group did not follow a normal distribution (p-value = 0.015) and homogeneity of variances was maintained (p-value = 0.435). Again, Mann-Whitney U-test was used and showed significant differences in reading comprehension scores between lower and higher working memory groups (p-value < 0.01). This way, it can be said that higher working memory span readers had significantly higher comprehension scores than lower working memory span readers in Context 2, when readers had prior knowledge of the subject of the text.

In short, according to Table 2, the results of the statistical analyses showed that higher working memory span readers had significantly greater scores of comprehension than lower working memory span readers in both contexts. However, it is also worth noting that the U statistic value = 0.00 in the Mann-Whitney U test occurs when all values of one group are consistently higher or lower than those of the other group. This can indicate an extreme difference between the groups, meaning that one group has values so different from the other that there is no overlap between their distributions. In Context 1, a U-statistic of 0.00 was observed, indicating an extreme difference between the means of comprehension scores of the two memory groups. Therefore, it can also be concluded that this difference in the means of comprehension scores between the memory groups is statistically more salient in context 1. The results of the statistical tests are presented in Table 2.

Table 2 – Results from Shapiro-Wilk, Levene's and Mann-Whitney U tests regarding differences of comprehension between participants with lower and higher working memory spans in each reading context

Context	Shapiro-Wilk test		Levene's test	Mann-Whitney U test statistic	Mann-Whitney U test p-value
	Group 1	Group 3			
1	W = 0.72 p-value < 0.01	W = 0.83 p-value = 0.03	W = 0.54 p-value = 0.47	U = 0.00	< 0.01
2	W = 0.90 p-value = 0.16	W = 0.80 p-value = 0.01	W = 0.63 p-value = 0.43	U = 8.00	< 0.01

Source: Elaborated by the authors.

In order to analyze the first obtained result, it is important to consider that, in the Construction-Integration Model (Kintsch, 2009), working memory becomes a crucial construct for reading, given that it is responsible for temporarily storing the information read in a text while simultaneously processing such information to fill in gaps in coherence that give meaning to the information read, thus creating what the model calls a "textbase". It is this "textbase" that is integrated with prior knowledge stored in long-term memory (stored in the form of propositions) and the result of this integration is what is called "situation model." This integration also occurs in working memory. Consequently, the amount of information read, comprehended and retained in long-term memory depends greatly on the amount of information that working memory is able to store and process during reading. It is this "textbase" that is integrated into the reader's prior knowledge and that will enable effective comprehension, that is, the "situation model," which is the product of what was read and stored in long-term memory.

Therefore, it is quite understandable that in both reading contexts, individuals with higher working memory spans obtained greater comprehension scores in the reading test, since such readers have the

capacity to store a greater amount of new information that is read and processed and that will be integrated into prior knowledge. Also, it is quite understandable that the differences between the averages of comprehension scores between the two memory groups were more salient in the context in which there was no topic familiarity: readers with greater storage and processing capacity are more likely to obtain much higher comprehension scores.

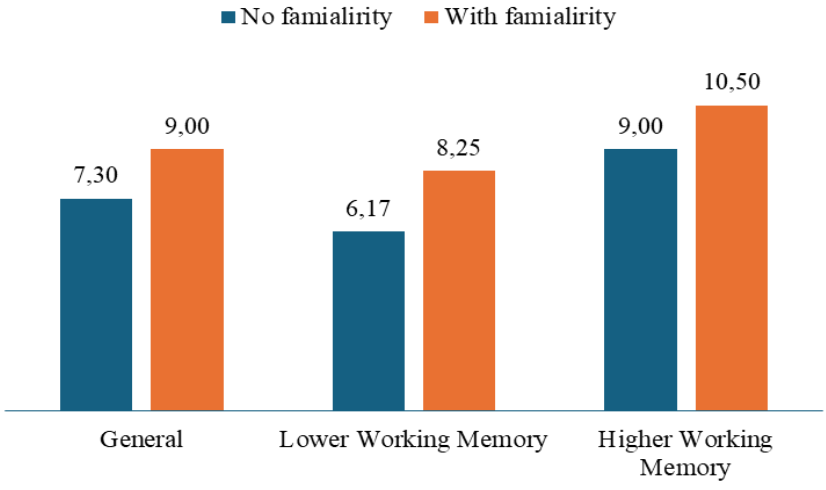
However, it is important to remember that working memory has a limited capacity to store and process new information, for example, a text on an unfamiliar topic (Baddeley and Hitch, 1974). Thus, this storage capacity can be positively or negatively impacted by the cognitive load imposed by the degree of familiarity or unfamiliarity with the text topic: higher topic familiarity imposes a lower cognitive load on working memory, leaving more resources for the storage and processing task, that is, allowing individuals with lower working memory spans to use more available resources to store more information and process it more effectively, generating a better quality of "textbase".

Consequently, it is plausible to hypothesize that this was the reason why the differences in comprehension scores between the two groups were less prevalent in the reading context in which the topic was familiar: in the context of familiarity with the topic, the group of lower working memory spans continued to have higher comprehension scores but such differences between the groups tended to become more balanced in the context that required less cognitive load for readers with lower working memory spans.

Does comprehension of information read on computer screens vary significantly when there is topic familiarity, in both working memory groups?

In order to analyze if comprehension scores varied significantly when the topic of the text was familiar, in both memory groups, the results of the comprehension test obtained by participants in Contexts 1 and 2 were compared in general and by group. In Figure 2, it is possible to notice that, in general and by groups, comprehension scores were higher when the topic was familiar. In addition, it is possible to observe that this difference was more salient for the lower working memory group than for the higher working memory group of readers.

Figure 2 – Comprehension levels in general and for each group of working memory according to familiarity with the topic.



Source: Elaborated by the authors.

Again, to assess if the results above had statistical significance, hypothesis tests were conducted to compare means of comprehension scores under different familiarity conditions within the same groups of participants (paired measures). That is, means of comprehension scores of participants, from both memory groups (higher and lower working memory spans) in context 1 (no familiarity) were compared to means of comprehension scores of participants in context 2 (with familiarity). So, according to the results shown in Table 3, in general and by working memory group, there were significant differences between contexts 1

and 2. Specifically, the means of comprehension scores varied significantly in context 1 to 2. Thus, when the topic was familiar, comprehension levels were significantly higher than when there was no familiarity, in general, as well as by memory group.

Table 3 – Results from Shapiro-Wilk and Wilcoxon tests of comprehension scores of the participants in general and with lower and higher working memory spans for context 1 and 2

Group	Shapiro-Wilk test		Wilcoxon test statistic	Wilcoxon test p-value
	Context 1	Context 3		
General	W = 0.94 p-value = 0.07	W = 0.91 p-value = 0.02	0.00	< 0.01
Lower Working Memory	W = 0.72 p-value < 0.01	W = 0.90 p-value = 0.16	0.00	< 0.01
Higher Working Memory	W = 0.83 p-value = 0.03	W = 0.80 p-value = 0.01	0.00	< 0.01

Source: Elaborated by the authors.

In order to understand these results, it is important to rely on the explanation, previously mentioned, that the storage capacity of working memory could be positively or negatively impacted by the cognitive load imposed by the degree of familiarity or unfamiliarity with the text topic: greater familiarity with the topic of the text imposes a lower cognitive load on working memory, leaving more resources for the storage and processing task, that is, making it possible for both groups, with lower working memory spans and with higher working memory spans to take advantage of the "leftover" resources to store more information and process it more effectively, generating a better quality "textbase".

Consequently, both memory groups achieved significantly greater mean scores in the comprehension test when reading a text on a familiar topic. Both groups stored and processed more information so that a better quality "textbase" was possible: the greater and better amount of information that the working memory can integrate with prior knowledge stored in the long-term memory, the greater and better the comprehension that will be generated (Kintsch, 2009). Furthermore, when there is topic familiarity, the process of integrating the "textbase" with prior knowledge stored in long-term memory becomes more automatic and effectively effortless for both groups of memory, reducing the demands on working memory and, therefore, cognitive load (Kintsch, 2009).

Does one group of working memory readers benefit more from topic familiarity than the other?

As previously seen, topic familiarity impacted comprehension levels in both working memory groups of readers significantly. In addition, it is observable in Figure 2 that this difference seemed to be higher for the group with lower working memory than for the group of readers with higher working memory. Moreover, the comparison of the average differences in comprehension levels between those two working memory groups shows that the gain in comprehension levels caused by topic familiarity was greater for the lower working memory span group than for the group with higher working memory spans. It was found that the average difference between the comprehension levels in contexts 2 and 1 for the lower working-memory group was equal to 2.083, while for the group with higher working memory spans, this average was equal 1.3. In other words, the average gain in comprehension levels caused by familiarity with the topic of the text was 2.083 for lower working memory readers and 1.3 for higher working memory readers.

Consequently, with the aim of investigating if such difference, which seemed to be more salient for lower working memory readers, would have statistical significance, hypothesis tests were applied. Prior to conducting the test to compare comprehension differences between the two working memory groups, the assumptions of normality and homogeneity of variances for both groups were verified, as detailed in Table 4. The Shapiro-Wilk test was used to verify normality and the Levene test was used to assess the assumption of variance homogeneity. If both assumptions are met, the T-Test is the most appropriate, otherwise the non-parametric Mann-Whitney U test is used.

Considering a significance level of 0.05, Shapiro-Wilk test indicated that the differences for the lower working-memory group followed a normal distribution, while for the higher working-memory group, the normality hypothesis was rejected (p-value < 0.05). Levene test confirmed the homogeneity of variances (p-value = 0.138). Since the normality assumption was not met, the Mann-Whitney U test was used and revealed that the impact of familiarity with the topic on text comprehension levels was significantly greater for the lower working-memory group of readers.

Table 4 – Results of Shapiro-Wilk, Levene and Mann-Whitney U tests between the differences in numbers of comprehension caused by topic familiarity for participants with lower and higher working memory spans

Shapiro-Wilk test		**Levene Test**	**U Mann-Whitney Test**	**p-value of U Mann-Whitney Test**
Lower W. M.	**Higher W. M.**			
W = 0,877 p-value = 0,080	W = 0,594 p-value < 0,01	W = 2,133 p-value = 0,138	U = 88,000	**0,024**

Source: Elaborated by the authors.

It was hypothesized that the differences in comprehension scores would be greater for the group with lower working-memory spans because higher working-memory span readers had already obtained higher comprehension levels, even when they had no familiarity with the topic of the text. Likewise, the means were significantly greater when the topic of the text was familiar. However, there were smaller differences between the two contexts, with and without familiarity with the topic, when compared to the levels obtained by the group with lower working-memory spans.

Readers with lower working memory spans obtained lower comprehension scores in the comprehension test with the text which they were not familiar with, which made more evident the differences found, that is, demonstrating a greater impact of familiarity with the topic on reading comprehension. In fact, according to Smith et al. (2021), in most studies they reviewed, prior knowledge provides a substantial increase in the elaboration of more effective situation models, especially for lower working-memory readers, but not to the point of surpassing comprehension levels of readers with higher working memory capacity.

In addition, if prior knowledge reduces demands on working memory, it should be agreed that the benefits of topic familiarity would be particularly evident within the lower working-memory readers. This enables the understanding that, for the group with lower working-memory spans, this is a great benefit and, consequently, that such group benefits more because it is the group that needs more resources, such as familiarity with the topic, to help them have a more effective comprehension of what they read.

Final Considerations

The main purpose of this study was to investigate how reading comprehension levels varied for different working memory groups of readers in the presence or absence of topic familiarity. In summary, the results indicated that: (1) Higher working-memory readers had significantly greater reading comprehension levels than lower working-memory readers in both contexts analyzed: with and without topic familiarity. However, it could also be noticed that the difference in comprehension levels between the memory groups was significantly higher when the text topic was not familiar; (2) Comprehension increased significantly from context 1 (without topic familiarity) to 2 (with topic familiarity) regardless of the memory group; and (3) The impact of familiarity with the topic on the levels of text comprehension was significantly greater for the lower working-memory group of readers.

All the results highlight a substantial impact of prior knowledge on reading comprehension. Familiarity with the topic of the text made comprehension scores obtained in the reading test more balanced for both groups of readers (those differences were significantly more salient when there was no topic familiarity). Likewise, both memory groups showed significantly different comprehension levels when the text was about a familiar topic.

Regardless of having higher or lower working-memory spans, both groups had better comprehension levels when reading the text with a familiar topic. Also, topic familiarity allowed lower working-memory readers to have a very expressive increase in the scores in the comprehension test. In this study, the differences in the comprehension levels of the lower working-memory span group were more substantial than those of the higher working-memory span group. In summary, when the topic was

familiar, readers were able to do more (achieve greater comprehension levels) with less (despite having lower working memory spans).

There are a large number of studies on the importance of prior knowledge in reading comprehension. However, a study that highlights such benefits for a specific population with limited reading ability, for having lower working-memory spans, is quite enriching. Reading deficiencies often make students lose motivation in the classroom and even abandon learning. Consequently, educators should keep in mind that the proper contextualization of the topic of the text can save cognitive resources and reduce demands on working-memory capacity. Educators should reflect on the quality of contextualization that is provided in the classroom, so that readers with lower working-memory capacity can maximize their comprehension, and consequently, overall learning.

Finally, it is important to point out that this study has limitations regarding the distribution of texts by reading context, so that the interference of the text in the results could be excluded. It would be a good suggestion to use different texts for different participants, respecting the reading context. Furthermore, rather than conclusive, the results of this study should be seen as motivation for future studies which aim to investigate different methods of decreasing working-memory demands so that lower working-memory readers can hold and manipulate a greater number of information at one time and apply more effective reading strategies while reading (Just & Carpenter, 1992).

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