THE INFLUENCE OF WORKING MEMORY CAPACITY ON INFERENCE GENERATION AND READING COMPREHENSION

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▪ ABSTRACT**:** This research aimed at investigating whether there is a relationship between Technical High School Brazilian students' Working Memory capacity, inference generation and reading comprehension in L2**.** A group of 36 students from the third year of the Technical High School Course participated in this study. Participants were pre-intermediate speakers of English as an L2. The instruments used in this study comprised a Reading Span Test (RST); two texts, being one narrative and one expository text; a Pause Protocol and two sets of comprehension questions (one for each text). Data from participants' Reading Span Test, the inferences they generated during reading (categorized in accordance with Narvaez; Broek; Ruiz' (1999) Inference Categorization Model), as well as their answers in the reading comprehension questions were analyzed both qualitatively and quantitatively, and the main results show that WMC positively correlates with reading comprehension, and also with explanatory inferences, which are strictly connected to reading comprehension.

▪ KEYWORDS: reading comprehension; working memory capacity; inference generation.

Introduction

The influence of an individual's working memory capacity (WMC) on the accomplishment of higher order cognitive tasks has been extensively researched. There has also been a considerable increase in the number of studies related to the inference generation process, especially in the past thirty years. However, studies that investigate the relationship between individuals' WMC and the generation of inferences still need research, especially because most investigations regarding WMC and inference generation were carried out concerning L1, not second (L2) or foreign languages (FL).[1]

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[1] Throughout this research the terms *Second Language* (L2) and *Foreign Language* are going to be used interchangeably to refer to a language that is learned by an individual after the mother tongue has already been acquired.

Likewise, despite the fact that researchers have demonstrated interest in determining the circumstances in which particular inferences are generated, as well as the effects of readers' individual characteristics on inferential activity (NARVAEZ; BROEK; RUIZ, 1999), the latter has not received the same amount of attention.

Regarding the aforementioned prospect, the need of filling these gaps is the motivation of this study, which is part of a broader doctoral research and aims at investigating how students' WMC affect their inference generation and reading comprehension, more specifically regarding Brazilian students enrolled in a Technical High School course.

Reading Comprehension and Inference Generation

In the present study and in agreement with most literature in the area, reading is understood as a meaning construction process, which is the result of the interaction between a reader and a text (DAVIES, 1995; ESKEY, 1998; KINTSCH; DIJK, 1978; RUMELHART, 1977; TOMITCH, 2003; URQUHART; WEIR, 1998). Reading here is also seen as interactive in Rumelhart's (1981) sense, that is, higher-level processes (e.g the use of prior knowledge in inference generation) may interact with lower-level processes (e.g. decoding) in order to achieve comprehension.

For the purpose of the present study the term inference refers to "any information about events, relations, and so on that the reader adds to the information that is explicitly presented in the text" (BROEK; RISDEN 1995, p.353). Koda (2008) complements this definition asserting that inference generation is a part of the reading process and is crucial for 'text-meaning construction'. When reading the sentence 'John fell on the floor. He stayed a whole week at home' (CALDART, 2012), most readers are able to infer that John had to stay home because he got hurt when falling on the floor, and even that his accident was relatively serious, due to the period he had to stay home in order to get better. Baretta (2008, p.138) claims that the ability to generate inferences is "a constructive cognitive process in which the reader strives for meaning and expands knowledge by formulating and evaluating hypotheses about the information in the text".

As stated by Dijk and Kintsch (1983) for reading comprehension to take place, the reader needs to construct an adequate mental representation of the message, connecting the information at both the local level[2] (microstructure), and the global level[3] (macrostructure). Therefore, meaning construction is connected to the inferences generated by the readers, provided that these inferences provide the connections that integrate textual information, helping them to construct a solid mental model, which can lead to a better comprehension, retention and recall of the information

[2] The local level refers to the level of the sentences.

[3] The global level refers to the paragraphs or larger sections of the text.

previously read (GERBER; TOMITCH, 2008). As texts are made of isolated pieces of information, the ability to make inferences is crucial for reading comprehension to occur. In the inference generation process the reader relies on his/her memory of the previous sentences as well as on his/her background knowledge related to the content of the text in order to establish a relationship among the sentences being read and the previous ones (BROEK; ROHLEDER; NARVAEZ, 1994; YEARI; BROEK, 2015).

Inference categorizations

Discourse comprehension researchers have been developing taxonomies of inference types, accompanied by an attempt to define their roles in comprehension (see for example GRAESSER; SINGER; TRABASSO, 1994; BROEK; ROHLEDER; NARVAEZ, 1994; NARVAEZ; BROEK; RUIZ, 1999). For the purpose of this study Narvaez, Broek and Ruiz' (1999) Inference Categorization Model is going to be adopted, as it has been used extensively in the literature of reading and inference generation (TRABASSO; SUH, 1993; ZWAAN; BROWN, 1996; TRABASSO; MAGLIANO, 1996; NARVAEZ; BROEK; RUIZ, 1999; MAGLIANO; GRAESSER; TRABASSO, 1999; LINDERHOLM, 2002), and seems to cover most of participants utterances during a think aloud Protocol, as observed in Caldart (2012).

Narvaez, Broek and Ruiz' (1999) Inference Categorization Model is presented in Table 1:

Table 1 – Narvaez, Broek and Ruiz' (1999) inference categorization model

Inference Kind	Features
Explanations	Are related to the reasons why something happens, and include explanations based on background knowledge ("I think that is the cause of the ice age") and text-based explanations ("This must be what they meant by ash");
Associations	Provide information about characteristics and functions of people, objects and events in the text, including background associations ("This reminds me of a planetarium show I saw") and text-based associations ("Okay, this is in the spa");
Predictions	Refer to inferences about future consequences of a specific event ("Okay, the gases will lead them to the actual object");
Evaluations	Regard comments about the text content ("I think that's such a strong assertation"), the text writing ("That sentence was difficult to say"), or the reader's state ("I'm kind of losing track here, being distracted");
Text-based Coherence Breaks:	Relate to statements about the coherence of the text content ("That doesn't make any sense");
Knowledge-based Coherence Breaks:	Include statements regarding the readers' inability to understand as a result of knowledge or experience lack ("It's kind of hard to imagine, I mean, in space");
Repetitions	Regard repetitions of words or phrases in the text.

Source: Narvaez, Broek and Ruiz (1999, p.490).

Inference generation helps readers to comprehend written material, by connecting the information presented in the text to their background knowledge. If readers fail to make these connections, they may fail to remember and even to understand the text (BARETTA, 2008; HORIBA, 2000; LINDERHOLM; BROEK, 2002; TRABASSO; SUH, 1993). For readers to be able to provide the necessary inferences when reading a text, they have to keep the different bits of relevant information to be connected in working memory and also access prior knowledge, if content from the text is not enough. Therefore, it seems legitimate to hypothesize that the success of inference making depends on the reader's working memory capacity, a topic to be discussed in the following section.

Working Memory Capacity

The role played by working memory (WM) in human cognition is undeniable (DANEMAN; CARPENTER, 1980; BADDELEY, 1990; JUST; CARPENTER, 1992;

TOMITCH, 2003; among others); from reading a book to solving complex mathematical problems, there is a need that not only the information presented is temporarily retained but that these pieces of information are processed at the same time, and that is where working memory comes into play.

Working memory is a concept originally proposed by Baddeley and Hitch, in 1974, and has been used since then to refer to individuals' capacity of not only storing information, as short-term memory[4] has been postulated to do, but also processing the pieces of information that come from the text. Working memory is defined as 'an arena of computation' (JUST; CARPENTER, 1992) where processing and storage functions compete for the system's capacity (BADDELEY; HITCH, 1974; DANEMAN; CARPENTER, 1980, 1983; JUST; CARPENTER, 1992). It is a multi-component system responsible for storage and manipulation of information during the performance of tasks considered cognitively complex, such as learning, comprehension and reasoning (BADDELEY; HITCH, 1974; DANEMAN; CARPENTER, 1980; BADDELEY; LOGIE, 1999).

Working memory is undoubtedly involved in L2 learning. Several pieces of research have shown that working memory capacity (WMC) is closely connected to one's ability to perform cognitive and language-related tasks (see for example, WALTER, 2006; LEESER, 2007; JUFFS; HARRINGTON, 2011; YEARI, 2017).

Claiming that individuals' WM capacity is a predictor of their performance in a task implies affirming that WM is limited, and it is, in fact. It is important to highlight that although it may be difficult to come to a consensus as regards what limits WM, ancient and recent theories agree that it is transient and that its capacity is limited (TOMITCH, 2003). Former theories claim that the limitation resides in the number of items that can be held at once. More recent theories believe that what is limited in working memory are the attentional resources available for information storage and processing. Ashcraft (1994) presents a very clear disambiguation of the two constructs (short-term memory and working memory) and their limited capacity; according to him short-term memory, as the name suggests, is too short, meaning that it does not last very long. Departing from the same reasoning, working memory implies, by the use of the active verb 'work' that it is dynamic and that all mental activity happens there. The limitation in the case of the WM regards "how much work can be done at one time, how much working memory capacity there is to share among several simultaneous processes" (ASHCRAFT, 1994, p.146).

The original model proposed by Baddeley and his colleagues (BADDELEY; HITCH, 1974, 1994; BADDELEY, 1992; BADDELEY; LOGIE, 1999) is a multicomponent model of working memory and is comprised of a control system of limited attentional capacity: the central executive, which is assisted by two 'slave' systems: the phonological loop, that processes verbal and phonological information; and the visuospatial sketchpad, which handles visual and spatial information. A fourth component was included in the

[4] For the purpose of this study, short-term memory and working memory are considered distinct constructs.

model later on: the episodic buffer, which is where information is temporarily stored to be later reintegrated (BADDELEY, 2000).

Almost 40 years, and many pieces of research after Baddeley and Hitch first proposed their model, it is still the most prominent and consistent model in the literature. Nevertheless, although the definition of working memory may be a consensus - that it refers to the system in charge of the temporary storage and processing of information necessary for the performance of cognitively complex tasks (BADDELEY; HITCH, 1974; CANTOR; ENGLE, 1993; DANEMAN; CARPENTER, 1980, 1983; MASSON; MILLER, 1983; among others) - the perspectives under which it is investigated differs, as well as the evidence provided by these studies (BARETTA, 2008).

Baddeley (1992) states that WM research can be divided into two types: the first is based on the psychometric correlational approach, while the second is based on dual-task methodology and neuropsychological cases. The psychometric approach "concentrates on devising tasks which involve the processing and storage of information in working memory" (TOMITCH, 2003, p.33). One example of these kinds of tasks is the Reading Span Test (RST) created by Daneman and Carpenter (1980), to be explained later. The other approach "makes use of dual-task methodology and evidence from neuropsychological cases, with the objective of analyzing the structure of the working memory system" (TOMITCH, 2003, p.33). Baddeley's research is included in this kind of study, which consists of the performance of tasks that involve simultaneous processing and storage of information.

As regards individual differences in WMC, the psychometric correlational approach claims that working memory capacity diverges among individuals and that these differences are good predictors of performance in cognitive tasks (DANEMAN; CARPENTER, 1980; JUST; CARPENTER, 1992). According to this approach, individuals with larger WMC perform better on cognitive tasks than individuals with smaller WMC. The reason for such differences is that individuals with greater WMC are able to hold and process greater quantities of information which are significant for completing complex tasks, consequently being able to perform better at them (WHITNEY; RITCHIE; CLARK, 1991; MCNAMARA; SCOTT, 2001).

Working Memory, Inference Generation and Reading Comprehension in L2: Related Studies

Research on individual differences in WMC has found positive correlations with a wide range of higher order cognitive tasks related to L1 (WHITNEY; RITCHIE; CLARK, 1991; SINGER *et al.,* 1992; LINDERHOLM; BROEK, 2002; TOMITCH, 2003, among others). On the other hand, studies conducted in L2 which presented WMC correlations are found in much smaller quantities in the literature. These studies include correlation with reading comprehension (JOH; PLAKANS, 2017; WANG; LIN, 2019); main idea construction in L1 and L2 (TORRES, 2003); reading

inferential comprehension (ALPTEKIN; ERÇETIN, 2010); writing performance (BERGSLEITHNER, 2010); speech production (FINARDI; WEISSHEIMER, 2008); grammar and reading (SAGARRA, 2017) and speech development (WEISSHEIMER; MOTA, 2009).

As inference making depends on the integration of different sources of information (from the text itself and from readers' background knowledge), as already mentioned, WM storage and processing requirements of language comprehension are essential for the generation of inferences (BARETTA, 2008). Working memory capacity enables readers to maintain global themes, integrate text information, and derive the text main points (DANEMAN; CARPENTER, 1980; CANTOR; ENGLE, 1993; LINDERHOLM, 2002), the reason why individual differences in WMC play an important role in reading comprehension achievement (JUST; CARPENTER, 1992).

A seminal study conducted by Trabasso and Magliano (1996) investigated the kinds of information available to consciousness during a reading comprehension task, and how they are used inferentially to build meaning from text. A conscious understanding model was proposed by the researchers, by means of a think-aloud method during the comprehension of narrative texts, assuming that "inference and memory processes function together in order to construct a coherent mental representation of a text" (MAGLIANO, 1996, p.255). Participants' verbalizations from the think-aloud protocols were transcribed, analyzed and categorized as Paraphrases, Explanations (concurrent inferences), Associations (backward inferences), Predictions (forward inferences), or Metacomments. The clauses were also categorized in accordance with the WM operations involved: "(1) activation of relevant knowledge in working memory, (2) maintenance of information in working memory, and (3) retrieval of text prior thoughts from a long-term memory store" (TRABASSO; MAGLIANO, 1996, p.255). Findings indicated that Explanations are the basis of understanding. Besides, the less frequent incidence of Predictions supported the claim that "understanding is also expectation driven" (SCHANK; ABELSON, 1977 *apud* TRABASSO; MAGLIANO, 1996, p.273).

Another referential study was conducted by Zwaan and Brown (1996), who investigated language proficiency (L1 and L2) and comprehension skill (L1) which are two factors that might influence situation-model construction. Twelve college students, native speakers of English and non-fluent speakers of French as a Second Language[5] participated in their study. Participants were instructed to think aloud while reading narratives in their L1 and L2, followed by a verb-clustering task. Zwaan and Brown assumed that four kinds of thoughts occur during thinking aloud, and categorized participants' reports according to these categories, which are *Paraphrases, Explanations*, *Association*s, and *Prediction*s. They predicted that the total number of inferences generated would be greater for L1 when compared with the L2, due to the fact that lower level processing would be more resource consuming for L2 comprehension.

[5] None of the participants had more than 2 years of French classes, or had any relatives who spoke the language, and they had never lived in a French-speaking country.

Additionally, they hypothesized that more *Paraphrases* would be observed in L2 comprehension than in L1. Their findings showed that a stronger situation model was built for the L1 texts than for the L2 texts. Furthermore, more *Explanations* were made for the L1 text than for the L2 text. In addition to that, a greater incidence of *Explanations* was made by skilled participants, who also constructed stronger situation models than their less skilled counterparts.

The third seminal study in which the present research was inspired is Narvaez, Broek and Ruiz' (1999). They conducted a study on how inference generation and comprehension in reading was influenced by reading purpose (namely study and entertainment). Twenty undergraduate students, all native speakers of English randomly assigned to one of the two conditions (narrative or expository) participated in their study. Participants were instructed to read four texts, two aloud (one narrative text and one expository text) and two for comprehension measures (one narrative text and one expository text). The inferences generated during the think aloud protocol of the two first texts were evaluated and categorized according to a model based on Zwaan and Brown's (1996), and Trabasso and Magliano's (1996) studies. Participants also answered comprehension questions about the other two texts. Results showed no correlation between reading purpose and comprehension. Think-aloud, on the other hand, was influenced by the reading purpose. Also, the study purpose increased the number of *Repetitions*, *Knowledge-Based Coherence Breaks* and *Evaluations*, which were less observed in the entertainment purpose condition. According to Zwaan and Brown (1996, p.488), "this pattern was stronger for the expository text than for the narrative text", which probably indicates that not only the reading purpose, but also the text type influenced readers' inference generation process.

Method

Participants. A group of 36 Technical High School students, from the *Técnico em Agropecuária Integrado ao Ensino Médio* course at *Instituto Federal do Rio Grande do Sul (IFRS)*, *Campus Sertão* agreed to take part in the research. Participants were pre-intermediate speakers of English as a Foreign Language, as measured by a reading proficiency test.[6]

The 36 participants for the main study were randomly assigned to one of the following two groups: Group I: Expository Pre-reading (ExpositoryPR) and Group II: Narrative Pre-reading (NarrativePR). Group I was exposed to the pre-reading activities previous to the reading of the expository text, but not to the narrative one; Group II was exposed to the pre-reading activities before the reading of the narrative text, but read the expository text without any activity.[7]

[6] This study was approved by Brazilian Human Research Ethics Committee under the number 1.599.459.

[7] For further information, please refer to Roscioli (2017).

Instruments: The texts. The texts used for data collection were a narrative text and an expository one, having an average of 250 words each, and were taken from the EFL High School book *Inglês: Série Brasil* (MARQUES, 2005).

The Pause Protocol. The Pause Protocol (CAVALCANTI, 1989) in the version adapted by Tomitch (2003) was used in this study because it seems to have less interference in the reading process. In this 'think aloud' method, readers are instructed to read the text and stop whenever they find a problem or something that catches their attention, reporting it. Also, a red sign is posed at the end of each paragraph, in order to remind participants that at that moment they have to stop and verbalize about what they have just read. Participants are also instructed to summarize the text after they finish reading it.

The RST. The RST employed in this study was a Portuguese version of the test developed by Daneman and Carpenter (1980). Linck *et al*. (2013) recommend the use of the RST in participants' L1 so as to avoid intervening variables related to lack of proficiency when analyzing the data. The version used here was created by Tomitch (2003) and partially adapted by Bailer (2011), so that the sentences in the test are more suitable to the adolescent population, as it is also the case in this study.

The test consisted of 60 unrelated sentences, having from 13 to 17 words, ending in a different word, besides 9 additional practice sentences. The sentences were displayed one by one in a PowerPoint presentation, and were arranged in sets of threes, in increasing order, that is, three sets of two sentences, three sets of three sentences, three sets of four, five and six sentences. The following sentence was shown right after the participant read the last word of the sentence on the screen, following the experimenter-administered condition proposed by Daneman and Carpenter (1980), in which the time necessary to read the sentences aloud was the only time allowed to the participants.

A white screen with question marks indicated the end of the set. Participants were asked to read the sentences aloud, trying to comprehend them, and memorize the last word of each sentence. When the screen with the quotation marks was shown, participants had to try to recall the final words of all the sentences in the set, in the order they appeared. The number of question marks presented on the screen was correspondent to the number of words that should be recalled. The training and testing sessions were recorded for later transcription and scoring.

After reading each text, participants were asked to answer a written questionnaire containing comprehension questions related to it. The questionnaire comprehended both objective and open-ended questions (to be answered in Portuguese) as regards the text just read.

The Reading Comprehension Questions. The questions were created based on Gagné, Yekovich and Yekovich's (1993) subdivision of the Component Processes, which includes decoding, literal comprehension, inferential comprehension and comprehension monitoring. The questions elaboration was also supported by Pearson and Johnson's (1978) taxonomy, which divided questions into three categories: *textually explicit* (literal questions, to which answers can be found on the page), *textually implicit* (although

the answers can still be found on the page, in order to answer the question the reader needs to use his/her background knowledge, generating inferences), and *scripturally implicit* (the answer is derived from the reader's background knowledge, not from the text). This study included the three previously mentioned question categories in the reading comprehension task.

Scoring and Statistical Procedures

The RST was scored both strictly and leniently. For the Strict scoring of the RST test, the reading span was determined by the level at which the participant was able to remember at least two trials of a given set of unrelated sentences (DANEMAN; CARPENTER, 1980). A half point was given when the participant passed one trial at a certain level (MASSON; MILLER, 1983; TOMITCH, 2003). For example, if a participant recalled correctly all the words in the right order in the three sets of 2 sentences and in the three sets of 3 sentences recalled correctly just one group, this participant would receive half a point, and his/her span would be 2,5. The test would end when the participant failed the three sets at two subsequent levels.[8]

Participants' answers on the RST test were also scored leniently. This method considered the total number of words recalled in all sets, irrespective of the order. In the lenient score, the total number of words correctly recalled was considered and "the upper and lower third of the frequency distribution of total words recalled by each participant was used to distinguish low- from high-WMC readers" (LINDERHOLM; BROEK, 2002, p.779).

The procedure for inference categorization adopted in this study was based on a study conducted by Narvaez, Broek and Ruiz (1999). Their research was based on two previous studies proposed by Zwaan and Brown (1996) and Trabasso and Magliano (1996).

In order to categorize readers' inferences, participants' utterances were divided into idea chunks (GERBER; TOMITCH, 2008; CALDART, 2012). After that, participants' sentences were categorized according to Narvaez, Broek and Ruiz' (1999) Inference Categorization Model, as *Repetitions*, *Explanations*, *Association*s, *Evaluation*s, *Prediction*s, *Knowledge-Based Coherence Break*s, or *Text-Based Coherence Breaks*. For the purpose of this study two other categories were used, based on Zwaan and Brown (1996): *Incorrect Translations,* and *Translation Attempts.*

The reading comprehension questions were corrected and scored by three independent raters and results from both groups were compared. They were instructed to correct the answers as follows: 1 point if the answer was completely correct; 0,5 point if the answer was partially correct; 0 points if the answer was incorrect. They

[8] All participants performed the RST as a whole, that is, up to the three sets of six sentences; however, for the strict scoring method the answers were only considered until the point they were able to remember at least one set at a certain level.

should only judge the content of the answers, that is, grammatical mistakes should be disregarded.

Cronbach's alpha tests were run in order to check for the internal consistency of the scores on the answers to the comprehension questions of both expository and narrative texts.

Results and Discussion

Reading Span Test. Following the Strict scoring method, 11 participants were categorized with a span between 3 and 3,5 (intermediate spans, according to Daneman and Carpenter (1980)) while 25 were considered low span readers, with a span below 2,5. No participant achieved a span of 4 or 5, and therefore this scoring method did not have any high span individual.

As for the Lenient scoring method, eleven participants recalled from 31 to 38 words, and were categorized as high spans (LINDERHOLM; BROEK, 2002). Fifteen participants were considered intermediate spans, with a range between 26 and 30 words. Ten participants were categorized as low span readers, who recalled from 19 to 25 words.

Inference Generation. A total of 4.775 inferences were generated by the participants during the Pause Protocol task, being 2.342 for the narrative text and 2.433 for the expository one. As regards the total number of inferences generated for each text, and taking the text type into consideration, the findings from this study do not corroborate those of Graesser, (1981), Britton *et al.* (1983), Graesser and Kreuz (1993), Trabasso and Magliano (1996), Narvaez, Broek and Ruiz (1999), Narvaez (2002), among others, who provide evidence that readers generate considerably more inferences when reading narratives. It is possible to observe that in this study participants generated more inferences for the expository text. More specifically, a total of 2.342 inferences were generated for the narrative text, in comparison with 2.433 for the expository one. Furthermore, in the studies conducted by Horiba (2000), Baretta (2008) and Caldart (2012), and in agreement with the results in the present study, inferences were more frequently generated for the expository text, when compared to the narrative one. According to Horiba (2000), and Baretta (2008), a possible interpretation for the discrepant findings resides in the text used in their experiments, which were not as demanding as those from previous studies (TRABASSO; MAGLIANO, 1996; NARVAEZ; BROEK; RUIZ, 1999, among others). In other words, the reading flow of the less demanding expository texts was probably very similar to the reading flow of the narratives, due to the texts specific features, such as topic familiarity and absence of new concepts introduction.

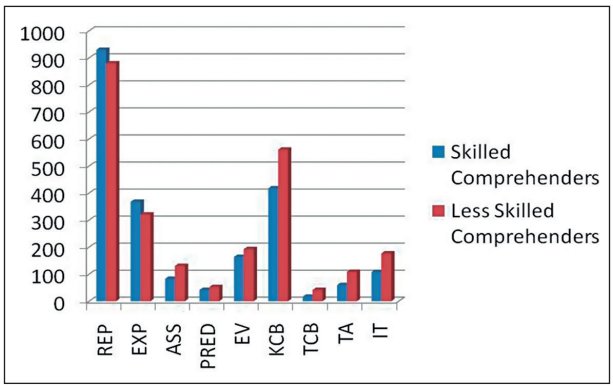
The relationship between inference generation and reading comprehension: qualitative analysis. Regarding the relationship between inference type and performance on the reading comprehension questions, it was observed that for twenty six out of the thirty six participants, or 72%, the number of inferences was inferior for the text

they performed better, which means that less inferencing was necessary to construct coherence. In other words, they generated more inferences in order to try to understand the text. In relation to that, Ericsson e Simon (1993) have argued that for readers to provide data during think aloud protocols it is necessary to make use of tasks that demand readers' strategic and monitored control, so that some automatic processes are 'deautomatized'. In this sense, texts considered easy by the readers are read automatically, and consequently are less available to conscious reporting. According to Pressley and Afflerbach (1995), more challenging texts provide more data because they demand more controlled and careful reading, which was the case of this study, where participants generated more inferences for the text that was more challenging for them.

Taking into consideration the participants with the greatest average scores and those with the lowest average scores in the reading comprehension questions, it is possible to observe that the quantity of inferences did not vary so much among them, so what might have affected their performance was the type of the inferences generated.

Following the attempt to find a pattern of inference generation among more skilled and less skilled comprehenders, the 36 participants were separated into two groups, according to their scores in the reading comprehension questions, with 18 individuals in each group (highest and lowest scores). The highest average scores varied from 9,63 to 7,965, while the lowest varied from 4,9 to 7,96. After this separation, the results were more evident: the total number of inferences was greater for the less skilled readers (2517) when compared with the more skilled ones (2258). However, the most interesting results were related to the kinds of inferences that were predominant in each group. While more skilled readers had the greatest incidence of *Repetitions* and *Explanations*, the less skilled readers generated more *Association*s, *Prediction*s, *Evaluation*s, *Text-Based Coherence Breaks*, *Knowledge-Based Coherence Break*s, *Translations Attempts* and *Incorrect Translation*s. The comparison of the kinds of inferences generated by skilled and less skilled readers can be better visualized in figure 1 below.

Figure 1 – Kinds of inferences generated by skilled and less skilled comprehenders



Source: Survey's data.

As previously stated, *Explanations* are believed to be more closely related to comprehension (GRAESSER; SINGER; TRABASSO, 1994; TRABASSO; MAGLIANO, 1996; ZWAAN; BROWN, 1996; NARVAEZ; BROEK; RUIZ, 1999; MAGLIANO; TRABASSO; GRAESSER, 1999, among others), because *Explanations* are the primary means for coherence to be achieved (BROEK; RISDEN; HUSEBYE-HARTMAN, 1995 *apud* TRABASSO; MAGLIANO, 1996). In fact, the ability to use *Explanatory* inferences is what differentiates skilled from less skilled comprehenders (ZWAAN; BROWN, 1996).

Also, Trabasso and Magliano (1996) stated that *Paraphrasing* (which in this study was included in the *Repetitions* inference type) "increased the availability of a sentence for future use during comprehension" (TRABASSO; MAGLIANO, 1996, p.282), which allows the construction of a "more coherent and complete textbase" (TRABASSO; MAGLIANO, 1996, p.320). Furthermore, *Repetitions* are related to study purpose, which "corroborates readers' assessments of their own reading processes, in particular their perception that school (study) reading involves more rereading and attempts at integration" (LORCH; LORCH; KLUSEWITZ, 1993, p.493). Therefore, as these two inference types (*Explanations* and *Repetitions*) were the only ones in which more skilled readers had the greatest number, this finding seems to corroborate those of Trabasso and Magliano (1996), Zwaan and Brown (1996) and Narvaez, Broek and Ruiz (1999), that observed *Explanations* and *Repetitions* as being related to successful reading comprehension.

The greatest incidence of the other inference types (i.e. *Association*s, *Prediction*s, *Evaluation*s, *Text-Based Coherence Breaks*, *Knowledge-Based Coherence Breaks, Translation Attempts* and *Incorrect Translations*) were observed in the 18 subjects that belonged to the less skilled comprehenders' group. These results are also supported by the literature (TRABASSO; MAGLIANO, 1996; ZWAAN; BROWN, 1996; NARVAEZ; BROEK; RUIZ, 1999), as it is going to be explained hereafter. According to Zwaan and Brown (1996) because *Association*s are not directly related to the text, they tend to be incorrect or irrelevant, the reason why skilled readers are more selective in the generation of *Association*s. As for *Prediction*s, they are not considered effective for understanding because they might be wrong. In what concerns *Evaluative* comments they are not directly related to situation model construction, since the situation model is the representation of what the text is about, while *Evaluations* encompass readers' perceptions of the text content, the text writing, or the readers' state-of-mind while reading the text (NARVAEZ; BROEK; RUIZ, 1999). And finally, *Text-Based Coherence Breaks*, *Knowledge-Based Coherence Break*s, *Translation Attempt*s and *Incorrect Translation*s are directly related with struggle in understanding. Therefore, it seems plausible to assume that a greater incidence of these inference types is related to less successful comprehension (ZWAAN; BROWN, 1996; NARVAEZ; BROEK; RUIZ, 1999).

Correlations between working memory and inference generation. Spearman's Rank Order tests show similar results for both groups in that only one statistically

significant relationship was found between each of the experimental group's working memory and their inference generation process. Regarding the ExpositoryPR group, a positive, moderate statistically significant correlation was obtained (p< .05) between the *Explanations* and WM in relation to the expository text (*r*=.506, *p*=.038). As for the NarrativePR group, a positive, moderate statistically significant correlation was found(*p* < .05) between *Repetitions* and WM concerning the expository text (*r=.468, p=.043*). As far as all of the other variables are concerned, statistical correlation tests run on the data showed no significant relationships in either of the experimental groups.

Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show similar results for both groups in that only one statistically significant relationship was found between each of the experimental group's WMC and their inference generation. Regarding the ExpositoryPR group, a positive, close to moderate statistically significant correlation (*p* <.05)was obtained between the *Explanations* and WM in relation to the expository text (*r*=.497*, p*=.043). As for the NarrativePR group, a positive, moderate statistically significant correlation (*p* < .05) was found between *Repetitions* and WM concerning the expository text (*r*=.587, *p*=.008). No significant relationships were found as regards the other variables in either of the experimental groups considering the Lenient scoring method of the RST.

Spearman's Rank Order tests show similar results for both groups in that only one statistically significant relationship was found between each of the experimental group's WMC and their inference generation considering the narrative text. Similar to the results previously presented, regarding the expository text, for the ExpositoryPR group, a positive, moderate statistically significant correlation was obtained (*p* < .05) between *Explanations* and WM in relation to the narrative text (*r*=.522, *p*=.032). As for the NarrativePR group, a positive, close to moderate statistically significant correlation was found (*p* < .05) between *Repetitions* and WM concerning the narrative text (*r*=.484, *p*=.036). As far as all of the other variables are concerned, statistical correlation tests run on the data showed no significant relationship in either of the experimental groups.

Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show no statistically significant interaction between any of the inference generation and WM variables in relation to the narrative text by both experimental groups (*p* > .05) as far as the lenient scoring method is concerned.

Moving the discussion as regards the results of the correlational statistical tests between inference generation and WMC, concerning the two RST scoring methods employed in this study (Strict and Lenient), two correlations were observed for the expository text, in relation to the relationship between inference generation and WMC, being one for each of the groups. This correlation was equal for both scoring methods, which is explainable by the fact that both scoring methods (Lenient and Strict) correlate positively in this study, meaning that they measure the same constructs. Regarding the ExpositoryPR Group (GI), a positive, moderate, statistically significant correlation was found between *Explanations* and WMC. This result is not surprising, because it is well acknowledged among reading scholars that skilled and less skilled readers can be

differentiated by their ability to generate explanatory inferences (ZWAAN; BROWN, 1996; TRABASSO; MAGLIANO, 1996; BROEK; LORCH, 1993; GRAESSER; SINGER; TRABASSO, 1994, among others). This may be explained by the assertion that *Explanations* help to "integrate the sentence information into a more coherent memory representation" (MAGLIANO; GRAESSER; TRABASSO, 1999, p.616), resulting in a better retention of the text, as well. Also, a better retention of the text was observed among the participants who generated *Explanations* during reading (TRABASSO; MAGLIANO, 1996; MAGLIANO; GRAESSER; TRABASSO, 1999).

Also regarding the expository text, a positive, moderate, statistically significant correlation was encountered between *Repetitions* and WMC for the NarrativePR Group (GII). This result is probably an effect of the text type, because according to Narvaez, Broek and Ruiz (1999, p.493) "expository texts seem to evoke study-type behaviors", which include the generation of *Repetitions*.

As for the narrative text, the same correlations were found between *Explanations* (ExpositoryPR Group) and *Repetitions* (NarrativePR Group) and WMC, but just when considering the Strict score method. However, it is interesting to observe that even though both text types presented correlations between WMC and *Repetitions*/ *Explanations*, the correlations were stronger for the narrative text, when compared with the expository one. The correlation between WMC (Strict scoring) and inference generation for the expository text was r=.506 (p.038), while this same correlation was r=522 (p.032) for the narrative text. Similarly, the correlation between *Repetitions* and WMC for the expository text was r=468 (p.043) as compared with r=484 (p.036) for the narrative text. The influence of the text type might have played a role in the above mentioned results, because narrative texts instigate different reading behaviors when compared with expository texts (NARVAEZ; BROEK; RUIZ, 1999; TRABASSO; MAGLIANO, 1996), especially because they are easier to understand, and promote more inferences in general, especially *Explanations*.

No statistically significant correlations were observed between inference generation and WMC (Lenient score), for the narrative text. The lack of significant results for the Lenient score might be due to the sample size, which is small, and the smaller the sample, the more difficult it is to observe statistically significant results. According to Juffs and Harrington (2011, p.145) "the absence of a significant correlation, especially in comparison to previous studies, may merely reflect direct sample sizes."

Correlations between working memory and reading comprehension. Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show different results for each of the experimental groups. While no statistically significant correlations were found for the first experimental group, the ExpositoryPR group (n = 17), in terms of the relationship between the groups' reading comprehension of both expository and narrative texts and the participants' WMC (p> .05), the results obtained with the statistical tests for the second experimental group – the NarrativePR group (n = 19), showed moderate, positive, statistically significant correlations (p< .05) between the group's reading comprehension of both the expository and narrative texts and their

working memory capacity as far as the strict scoring method is concerned *(r*=.463, *p*=.046), but not the lenient method (*p* > .05).

Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show different results for each of the experimental groups. While no statistically significant correlations were found for the first experimental group, the ExpositoryPR group (n = 14), in terms of the relationship between the groups' reading comprehension of both expository and narrative texts and the participants' WMC (*p*> .05), the results obtained with the statistical tests for the second experimental group – the NarrativePR group (n = 18), showed moderate, positive, statistically significant correlations (*p*< .05) between the group's reading comprehension of both the expository and narrative texts and their WMC as far as the strict scoring method is concerned *(r*=.615, *p*=.007), but not the lenient method (*p* > .05), when outliers were not factored in.

Results from the statistical tests were different for both groups (ExpositoryPR and NarrativePR) in terms of their correlation between WMC and reading comprehension. No statistical correlation between these two variables was found for Group I (ExpositoryPR). However, for Group II (NarrativePR), a moderate, positive, statistically significant correlation between participants' reading comprehension and their WMC was observed. Nevertheless, such correlation was found only as far as the Strict score is considered, not the Lenient method.

A possible explanation for the lack of statistical significance of the ExpositoryPR Group is that it is smaller in the amount of participants (n=17), in comparison with the NarrativePR Group (n=19), which is a small difference but when it comes to statistical analysis, as previously pointed out, the smaller the sample, the more difficult it is to reach statistical significance.

The fact that only the Strict scoring method presented statistical significance, and not the Lenient, may be explained by the fact that "the Lenient score, for its nature, is less related to control than the Strict score which reflects controlled processes." (FINARDI; WEISSHEIMER, 2008, p.380) Because WM capacity limitations are probably more related to control and less related to automatic processes the correlation between working memory and reading comprehension was only observed for the Strict score.

As regards the result observed for Group II (NarrativePR), that presented a moderate, positive, statistically significant correlation between WMC and reading comprehension, it is possible to assume that once again the audiovisual pre-reading activity might have played a role, because the correlation was found for both the narrative and the expository text. Therefore, this group's schemata were probably activated for both texts, which enriched their comprehension (TOMITCH, 1991).

Taking into consideration that expository texts are considered more difficult to understand than narratives (NARVAEZ; BROEK; RUIZ, 1999; TRABASSO; MAGLIANO, 1996; KRAAL *et al.,* 2018), after analyzing the data from higher and lower spans, as well as their reading comprehension scores and the amount of inferences generated for each text, it is possible to observe that the results of the present study do not corroborate the evidence encountered in the literature that supports that

differences between higher and lower spans are more evident when the task is difficult, as opposed to tasks considered easy, in which both groups will present similar results (JUST; CARPENTER, 1992; BUDD; WHITNEY; TURLEY, 1995; BARETTA, 2008, among others). Some of the participants with the greatest RST scores were better in the reading comprehension questions of the narrative text, while others had greater scores with the expository text. The same happened with the participants with the lowest RST scores. Similarly, the number of inferences generated by high and low spans did not follow a pattern. A possible explanation for such results might be the pre-reading activities that activated participants' schemata, making both texts similar in the level of difficulty. Therefore, what might have played a role in participants' results on the reading comprehension questions and on the inferences generated was probably individual interest in the text topics.

Correlations between reading comprehension and inference generation. Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show similar results for each of the experimental groups. A negative, moderate, statistically significant correlation ($p < .05$) was found between *Translation Attempt* and Reading Comprehension for the NarrativePR group (r=-.642, p=.003). No statistically significant correlations were found for the remaining variables (*Repetitions*, *Explanations, Associations*, *Predictions*, *Evaluations*, *Knowledge-Based Coherence Breaks*, *Text-Based Coherence Breaks, Incorrect Translations* and *Total*) for both groups in terms of the relationship between the groups' reading comprehension and the types of inferences generated for the expository text.

In a nutshell, just one negative moderate statistically significant correlation was found between inference generation and reading comprehension of the expository text. The negative correlation encountered was between *Translation Attempt* and reading comprehension for the NarrativePR Group (GII). Also, *Text-Based Coherence Breaks* almost achieved significance (r=-.415, p=.077), and therefore also deserves attention. These results show that the less participants tried to translate the text and the less they had coherence breaks related to the text, the greater was their reading comprehension.

Pearson Product-Moment Correlation Coefficient and Spearman's Rank Order tests show that no statistically significant correlations were found for all of the variables for the ExpositoryPR group in terms of the relationship between the group's reading comprehension and the types of inferences generated for the narrative text ($p> .05$). As for the second experimental group – the NarrativePR group – three statistically significant relationships were found ($p < .05$), which are going to be discussed in the following paragraphs: a negative, close to strong relationship between *Evaluation* and the group's reading comprehension of the narrative text (r=-.690, p=.001); a negative, moderate relationship between *Translation Attempt* and the group's reading comprehension of the narrative text (r=-.548, p=.015); and, finally, a negative, moderate relationship between *Incorrect Translation* and the group's reading comprehension of the narrative text (r=.-460, p=.048) were found.

In a nutshell, no statistically significant correlations were observed between inference generation and reading comprehension for the narrative text when considering the ExpositoryPR Group (Group I). As for the NarrativePR Group (Group II), three statistically significant correlations between inference generation and reading comprehension for the narrative text were found: a negative, close to strong correlation between *Evaluation* and reading comprehension; a negative, moderate relationship between *Translation Attempt* and reading comprehension; and a negative, moderate correlation between *Incorrect Translation* and reading comprehension of the narrative text. Also, *Text-Based Coherence Breaks* and reading comprehension of the narrative text almost reached significance (r=-.433, p=.064), and therefore, their negative correlation deserve attention as well.

The negative correlations were expected, because *Evaluation*s, *Text-Based Coherence Breaks*, *Translation Attempt*s and *Incorrect Translation*s are not integrative inferences. As previously mentioned, *Evaluation*s include the reader's opinion about the topic of the text, or his/her state of mind during the reading activity. *Text-Based Coherence Breaks*, *Translation Attempt*s and *Incorrect Translation*s, when excessively made may have a negative impact on the reading flow, and therefore jeopardize reading comprehension, so the least of these three inference types are made, the better for reading comprehension.

Final Remarks

This research aimed at investigating whether there is a relationship between Technical High School Brazilian students' Working Memory capacity, inference generation and reading comprehension in L2. Overall, the findings from this study seem to speak in favor of the relationship between WMC, inference generation and reading comprehension. Among the major findings of the present research are the following:

Finding 1 - WMC (as measured by the Strict scoring method) correlates significantly with reading comprehension. The results obtained with the statistical tests for GII (NarrativePR) showed moderate, positive, statistically significant correlations between the groups' reading comprehension of both the expository and narrative texts and their working memory capacity as far as the strict scoring method is concerned ($p < .05$), but not the lenient method ($p > .05$). As regards these results, it is possible to assume that the audiovisual pre-reading activity performed by Group II (NarrativePR) might have played a role, because the correlation was found for both the narrative and the expository text. Therefore, this group's schemata were probably activated for both texts, which enriched their comprehension.

Finding 2 - WMC positively correlates with Repetitions and Explanatory inferences. Regarding the ExpositoryPR Group (GI), a positive, moderate, statistically significant correlation was found between Explanations and working memory for the expository text. This result is not surprising, because it is well acknowledged among the reading

scholars that skilled and less skilled readers can be differentiated by their ability to generate explanatory inferences (ZWAAN; BROWN, 1996; TRABASSO; MAGLIANO, 1996; BROEK; LORCH, 1993, GRAESSER; SINGER; TRABASSO, 1994, among others). Also regarding the expository text, a positive, moderate, statistically significant correlation was encountered between Repetitions and working memory for the NarrativePR Group (GII). This result is probably an effect of the text type, because according to Narvaez, Broek and Ruiz (1999, p.493) "expository texts seem to evoke study-type behaviors", which include the generation of Repetitions.

As for the narrative text, the same correlations were found between Repetitions (ExpositoryPR Group) and Explanations (NarrativePR Group) and working memory, but just when considering the Strict score method. However, it is interesting to observe that even though both text types presented correlations between working memory and Repetitions/ Explanations, the correlations were stronger for the narrative text, when compared with the expository one. The influence of the text type might have played a role in the above mentioned results, because, as previously mentioned, narrative texts instigate different reading behaviors when compared with expository texts (NARVAEZ; BROEK; RUIZ, 1999; TRABASSO; MAGLIANO, 1996), especially because they are easier to understand.

Finding 3 - Less skilled readers generate more inferences in general, but more skilled readers generate more explanatory inferences, that are directly connected to comprehension. The total number of inferences was greater for the less skilled readers when compared with the more skilled ones. As regards the types of inferences generated by participants, more skilled readers had the greatest incidence of Repetitions and Explanations, while less skilled readers generated more Associations, Predictions, Evaluations, Text-Based Coherence Breaks, Knowledge-Based Coherence Breaks, Translation Attempts and Incorrect Translations. As previously stated, Explanations are believed to be more closely related to comprehension (GRAESSER; SINGER; TRABASSO, 1994; TRABASSO; MAGLIANO, 1996; ZWAAN; BROWN, 1996; NARVAEZ; BROEK; RUIZ, 1999; MAGLIANO; TRABASSO; GRAESSER, 1999, among others), because Explanations are the primary means for coherence to be achieved (BROEK; RISDEN, 1995). In fact, the ability to use Explanatory inferences is what differentiates skilled from less skilled comprehenders, according to Zwaan and Brown (1996). Therefore, as these two inference kinds (Explanations and Repetitions) were the only ones in which more skilled readers had the greatest number, this finding seems to corroborate those of Trabasso and Magliano (1996), Zwaan and Brown (1996) and Narvaez, Broek and Ruiz (1999), that observed Explanations and Repetitions as being related to successful reading comprehension.

Pedagogical Implications

It is well acknowledged that individual differences play a great role in students' learning. In the case of English as an L2, factors such as language proficiency, background knowledge, reading skills, motivation and WMC must be taken into consideration by any L2 teacher before planning their classes. Although WMC is not measured at school, teachers must be aware of its impact on learning. It is important that the texts selected for reading classes are adequate for students' level of proficiency, so that their WMC is not overloaded with lower level reading processes. Also, taking into consideration that the generation of inferences helps students to construct meaning from texts, understanding how low and high span readers generate inferences, and how inference generation affects comprehension can help teachers to assist their students, aiding them to become more proficient readers.

Findings from this research are believed to contribute, even though in a small scale, to the understanding of the role of working memory capacity on Technical High School Brazilian students' inference generation and reading comprehension. Furthermore, it is expected that this study will add to the existing research on individual differences in WMC and reading performance, not only in the educational area, but also areas like discourse comprehension, text and computational linguistics, and psycholinguistics, providing findings that contribute to a better understanding of the reading comprehension process.

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ROSCIOLI, D.; TOMITCH, L. A Influência da Capacidade de Memória de Trabalho na Geração de Inferências e na Compreensão Leitora. **Alfa**, São Paulo, v.66, 2022.

- *RESUMO: Esta pesquisa teve como objetivo investigar se existe uma relação entre a Capacidade de Memória de Trabalho de estudantes do Ensino Médio Técnico, a geração de inferências e a compreensão leitora em L2. Um grupo de 36 alunos do terceiro ano do Curso Técnico em Agropecuária Integrado ao Ensino Médio do Instituto Federal do Rio Grande do Sul (IFRS) - Campus Sertão participou deste estudo. Os participantes eram falantes pré-intermediários de inglês como L2. Os instrumentos utilizados neste estudo incluíram o Teste de Capacidade de Leitura (Reading Span Test); dois textos, sendo um narrativo e um expositivo; o Protocolo Pausa; e dois conjuntos de perguntas de compreensão (um para cada texto). Os dados coletados através do Teste de Capacidade de Leitura (Reading Span Test), as inferências geradas durante a leitura (categorizadas de acordo com o Modelo de*

Categorização de Inferências proposto por Narvaez, Broek e Ruiz (1999), bem como as respostas dos participantes às perguntas de compreensão foram analisadas e avaliadas tanto quantitativa quanto qualitativamente, sendo que os principais resultados mostram que a Capacidade de Memória de Trabalho se correlaciona positivamente com a compreensão leitora e também com inferências explicativas, que estão diretamente ligadas à compreensão.

- *PALAVRAS-CHAVE: compreensão leitora; capacidade da memória de trabalho; geração de inferências.*

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