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EFL Speech Production: Exploring the relationship between working memory capacity and proficiency level

Produção Oral em Língua Estrangeira: explorando a relação entre capacidade de memória de trabalho e nível de proficiência

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Abstract: The present study explores the relationship between working memory capacity (WMC) and proficiency level in EFL[1] speech production. Forty-one participants performed two WMC tests – the Speaking Span Test in L1 and in L2. The statistical analysis indicated both a variation on WMC scores in L2 as a function of proficiency as well as a difference between WMC scores in L1 and in L2. Findings are explained mainly in respect to the interplay between automatic and controlled processes on memory retrieval and on the development of L2 proficiency.
Key-words: EFL speech production. Working memory capacity. Proficiency level.

Resumo: O presente estudo explora a relação entre capacidade de memória de trabalho (CMT) e nível de proficiência na produção oral em língua estrangeira. Quarenta e um participantes desempenharam dois testes de CMT – o teste de amplitude oral em L1 e em L2. A análise estatística indicou uma variação nos índices de capacidade de memória de trabalho em ambas as línguas. Os resultados são explicados levando-se em conta a interação entre

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[1] In this paper, the terms EFL and L2 are used interchangeably and refer to a language one speaks or is studying other than his/her mother tongue.

processos controlados e automáticos na recuperação de itens da memória e o desenvolvimento da proficiência em L2.
Palavras-chave: Produção oral em língua estrangeira. Capacidade de memória de trabalho. Nível de proficiência.

Introduction

Memory, more specifically working memory (WM), plays an important role in speaking, as acknowledged by Levelt (1989). This is so because the products of the sub-processes that need to be stored for further processing are all deposited in working memory, thus becoming easily accessible. In the present study, WM is considered as "…those mechanisms or processes that are involved in the control, regulation, and active maintenance of task-relevant information in the service of complex cognition, including novel as well as familiar, skilled tasks." (MIYAKE; SHAH, 1999, p. 445).

In her 2000 study, Fortkamp found evidence for the relationship between working memory and L2 speech production, proposing that the two constructs are related to the processes that occur in the stage of message formulation, more specifically in the Grammatical Encoder sub-component of Levelt's (1989) L1 speech model. That is to say, she proposed that the processes involved in the formulator (which are automatic in L1) are not so in L2, thus requiring more attention from WM. Fortkamp also emphasized that L2 speech production is likely to be more complex than L1 speaking since in L2, less automatized procedures operate.

With that in mind, the present research aimed at investigating the relationship between working memory capacity (WMC) and proficiency level by hypothesizing that there will be a difference in the mean working memory capacity scores in L1 and in L2. Furthermore, it is predicted that whereas L2 working memory capacity scores vary according to proficiency, L1 working memory capacity scores remain stable.

1 Review of Literature

1.1 The capacity of Working Memory

One of the main claims of Cognitive Psychology to date refers to the fact that the human cognitive system is limited in the amount of information it can process and maintain simultaneously. One of the most explanatory views on the nature of such limitations is the Controlled-Attention View, proposed by Turner and Engle back in 1989 (and advocated by colleagues such as CONWAY; ENGLE, 1996; ENGLE, 2001, 2002; KANE et al., 2001), which posits that the nature of the individual differences in WMC relates to individuals' ability to control attention in the face of interference so that the necessary information to perform the cognitive task at hand is kept active in working memory for further retrieval and processing.

Turner and Engle (1989) have demonstrated that WMC differences cannot be exclusively due to processing efficiency, once their studies showed that the statistical correlations between WM and reading in Daneman and Carpenter's (1980) study were sustained even when the processing component of the task was changed. This finding led Engle and colleagues to propose that WMC is not related to the processing efficiency capacity in a particular cognitive task but rather to individual's ability to control attention. According to Engle (2002), the fact that higher spans are better able to regulate attention when performing demanding cognitive tasks may result in a greater amount of information stored, but it is not directly connected to the individual's processing efficiency. Engle and colleagues also claim that individual differences on attentional capacity become even more evident when individuals need to inhibit or suppress extra information irrelevant to the performance of the task at hand.

1.1.1 Individual differences in Working Memory Capacity and Speech Production

Research on speech production has shown that individual differences in WMC can be a significant constraint on the performance of both L1 (DANEMAN, 1991) and L2 speaking (FORTKAMP, 1999, 2000; MENDONÇA, 2003; FONTANINI et al., 2005; WEISSHEIMER, 2005; GUARÁ TAVARES, 2005, 2006; FINARDI; PREBIANCA, 2006; XHAFAJ, 2006; FINARDI, 2009; PREBIANCA; D'ELY, 2009; PREBIANCA, 2010).

The rationale supporting studies relating WMC and speech production is that the larger individuals' WMC, the better their oral performance.

Of particular relevance for the present investigation are Weissheimer's (2007) findings. She set out to investigate whether lower and higher span individuals would experience any kind of improvement on WM scores as a function L2 speech development. Intermediate English learners performed the L2 speaking span tests in the two phases of the experiment. Results showed that only lower span individuals improved WM scores from one phase to the other. Weissheimer (2007) concluded that this might be attributed to the fact that higher spans were already more efficient in the SST from the start thus having little room for improvement. Lower spans, on the contrary, might have improved their WM scores due to their improvement on L2 speech proficiency between experimental phases. In fact, results showed that both lower and higher spans tended to experience gains in the L2 speech measures investigated, namely speech rate, accuracy, complexity and weighted lexical density. Taken together, these results suggest that the improvement on WM scores may not be related to L2 proficiency only, once higher and lower spans improved on speech production measures, but only lower spans had their WMC affected by that. The researcher then suggested that future studies should assess individuals' WMC in several moments during the course of L2 acquisition/learning so as to verify to what extent WM scores vary as a function of L2 proficiency. As advanced by several researchers (HARRINGTON, 1992; HARRINGTON and SAWYER, 1992; BERQUIST, 1998), L2 proficiency might be the key factor determining the low correlations between L1 and L2 working memory scores, suggesting that, whereas the former may refer to a biological endowment, the latter may be related to the amount of knowledge of the language one possesses. To scrutinize the relationship between WMC in L1 and in L2 and to examine the effects of L2 proficiency on WM scores variation are the main goals of the current study.

2 Method

2.1 Participants

Forty-one Brazilian-Portuguese native speakers enrolled at an English course of a private English Institute in Blumenau/SC volunteered to

participate in the present study. The pool consisted of 15 male and 26 female students[2] with ages ranging between 13 and 44. Thirteen and forty-four were the extreme ages. Most participants were adolescents or young adults. None of them had been to an English speaking country by the time they took part in the experiments. The only formal contact with the L2 was during class time – approximately 2,5 hours a week.

Participants were divided into two groups according to their level of proficiency – intermediate and advanced. The intermediate group consisted of 19 students and the advance of 22. Proficiency level was not assessed by means of standardized tests in the present study. Instead, participants were assigned to different proficiency groups based on the level they were enrolled at their English courses a week prior to data collection. However, a post hoc analysis of the L2 sentences they were able to produce in the Speaking Span Test indicated that participants' classification was coherent, once there seemed to be a relative difference in the quantity and quality of the foreign language knowledge each proficiency group possessed. That is, advanced learners seemed to be able to produce more accurate and more elaborated L2 sentences than the intermediate ones (see Appendix E for some transcriptions of L2 oral sentences).

2.1.1 Data Collection and Analysis

• *The Speaking Span Test in L1*

The monolingual version of the SST applied in the present study was designed by Fortkamp (1999), based on Daneman's (1991) test, and was partially adapted by the present researcher so as to be more similar to the L2 version of the test (with 3 test blocks). It consists of 60 unrelated words presented in sets of 2, 3, 4, 5 and 6 words each. The words are 7 letters long and were presented in the center of a computer screen for 1 second. After 10 milliseconds the next word of the set would appear. After all words of a specific set had been presented, questions marks on the computer screen

[2] In the current study, the number of male and female participants was not a concern because gender variables are usually not taken into consideration in most studies dealing with WMC in the L2 field.

followed by a noise would signal it was the time for participants to start formulating the oral sentences for each word they had seen in that set. The L1 SST was performed right after the L2 SST and, because of that, no block practice was applied. The instructions followed the same for the L2 SST, but were given orally by the researcher (see Appendix A for the list of words used in the test).

Individual memory spans were calculated taking into consideration the number of words for which participants were able to produce a grammatically and coherent sentence in Portuguese (L1). Following Daneman (1991), two measures of working memory capacity were analyzed: (1) a strict score, in which only the words for which participants were able to produce a grammatically and coherent L1 sentence respecting the order and form of presentation were counted; and (2) a lenient score, in which the sentences produced in a form and/or order other than the one presented were also accepted. Sentences which were meaningless or could not be understood due to recording problems were excluded from analysis (see Appendix B for individual scores on this test).

A test set of the experiment with three words would look like the following:

CARRO – LUA – VASO

If participants were able to retrieve all three words respecting the exact form and order of presentation of each one, then he/she would be awarded 3 points. For the strict score, for instance, sentences could be of the following kind:

- Meu carro está sem gasolina
- A lua não apareceu hoje
- O vaso quebrou

TOTAL OF POINTS: 3

For the lenient scores then, one could alter the words presentation order or even produce them slightly different from how they had been presented, however, in this case, they would only be awarded half a point for each sentence. Some examples of these types of production are:

- Meu carro **tá** sem gasolina(the use of a less formal version of the verb form **está**)
- Os **vasos** quebraram (plural form + inverted presentation order)
- A **lua** não apareceu hoje (inverted presentation order)

TOTAL OF POINTS: 1,5

Participants' oral sentences were recorded with the sound editing software Audacity 1.2.6, converted into mp3 files, transcribed and scored according to the aforementioned criteria. The test was designed and run using Microsoft PowerPoint 97-2003.

• *The Speaking Span Test in L2*

The SST used to measure participants' working memory capacity in the present study was a bilingual version of Daneman's (1991) original test and was designed by Weissheimer (2007).

Similarly to the L1 version, in this task, participants were required to memorize words in English for further recall and use them in the production of L2 (English) oral sentences. Words were presented in sets of two, three, four, five and six words each. Participants' individual span scores correspond to the total number of words for which they were able to produce a grammatical sentence using the word previously memorized. Following the criteria for the Portuguese version, two measures of working memory capacity were computed and analyzed - a strict and a lenient score (see Appendix B for individual scores on this test). The L2 SST was performed in the first data collection session, followed by the L1 SST. Because participants had never done the test before a set of detailed instructions were given in participants' L1 together with three blocks of practice (see Appendix A for the list of words used in the test). The softwares for running the test and recording participants' oral responses were the same used for the L1 version (Microsoft PowerPoint 97-2003 and Audacity 1.2.6, respectively).

3 Results and Discussion

To reiterate, the main objective of the preset study was to investigate the relationship between working memory capacity (WMC) and proficiency level in L2 speech production. In doing so, data were submitted to a series of statistical tests comprising descriptive statistics and T-tests. Due to the exploratory nature of the present study, all correlations were two-tailed and the alpha level for all statistical tests was set at .05.

In order to conduct the statistics of this study, the Statistical Package for Social Science (SPSS) - version 10.0 was used. In what follows, data analysis and the discussion of the findings are presented.

3.1 WMC in L2 and in L1

This sub-section addresses the relationship between working memory capacity in L1 and in L2. Hypothesis 1 predicted that there would be a difference in the mean working memory capacity scores in L1 and in L2. In order to verify this prediction, descriptive statistics were run for the intermediate and advanced groups. Table 1 displays the results.

3.1.1 The Intermediate Group

Table 1 displays the mean (M), standard deviation (SD) and the minimum (Min) and maximum (Max) scores for the SST – strict and lenient scores in L1 and in L2 (see Appendix B for individual scores on these variables). It also reports on scores for skewness and kurtosis.

Table 1 – Descriptive Statistics for the SST in L2 and in L1in the Intermediate group

	SSTL2STR	SSTL2LEN	SSTL1STR	SSTL1LEN
M	11.94	17.23	22.94	26.42
SD	4.71	4.49	6.49	6.35
Min	4.00	10.50	8.00	10.50
Max	20.00	27.50	32.00	34.50
Skewness	-.009	.407	-.679	-1.002
Std. Error	.524	.524	.524	.524
Kurtosis	-.725	-.069	.228	1.114
Std. Error	1.014	1.014	1.014	1.014

N=19
SSTL2STR= strict scores on the L2 Speaking Span Test
SSTL2LEN= lenient scores on the L2 Speaking Span Test
SSTL1STR= strict scores on the L1 Speaking Span Test
SSTL1LEN= lenient scores on the L1 Speaking Span Test

As can be seen from Table 1, participants' scores were found to be normally distributed in all the variables. The highest possible score of the speaking span test in L2 and in L1 was for the lenient variables – 27.50 and 34.50, respectively. This result was somehow expected, since this score took into consideration sentences that were not grammatically correct and/or sentences produced for words in a different order of presentation or whose

grammatical class was altered. Differently, the strict scores in both versions of the test (L2 and L1) were lower, with L1 scores surpassing L2 scores, thus indicating that participants presented a better performance in the Portuguese version of the speaking span test. This tendency seems to be confirmed by the comparison of means for both versions of the test. The difference between the means of the strict scores in L1 and in L2, for instance, was of 11-point range and, for lenient scores was of around 9-point range thus supporting Hypothesis 1. I will return to this issue later in the article.

For the minimum scores, although L1 strict scores were once again higher than the L2 strict scores – 8.00 and 4, respectively, the minimum lenient scores were equal – 10.50. The degree of variability for the strict and lenient variables of the L2 speaking span test is, as displayed by Table 1, relatively lower than the one for the strict and lenient variables of the L1 version of the test – 4.71 and 4.49 against 6.49 and 6.35, respectively.

3.1.2 The Advanced Group

Table 2 displays the mean (M), standard deviation (SD), the minimum (Min) and maximum (Max) scores and the skewness and kurtosis coefficients for the SST – strict and lenient scores in L1 and in L2 – in the advanced group (see Appendix B for individual scores on these variables).

Table 2 – Descriptive Statistics for the SST in L2 and in L1in the Advanced group

	SSTL2STR	**SSTL2LEN**	**SSTL1STR**	**SSTL1LEN**
M	19.77	25.02	28.31	32.27
SD	7.75	6.46	6.32	5.49
Min	7.00	13.50	15.00	22.50
Max	38.00	39.50	42.00	44.00
Skewness	.443	.213	.061	.229
Std. Error	.491	.491	.491	.491
Kurtosis	.375	-.080	.077	-.552
Std. Error	.953	.953	.953	.953

N= 22
SSTL2STR= strict scores on the L2 Speaking Span Test
SSTL2LEN= lenient scores on the L2 Speaking Span Test
SSTL1STR= strict scores on the L1 Speaking Span Test
SSTL1LEN= lenient scores on the L1 Speaking Span Test

As can be observed in Table 2, the scores of the advanced group were all normally distributed. Mirroring the intermediate group, the highest possible scores were found for the lenient variable of the L1 and L2 versions of the speaking span test – 44.00 and 39.50, respectively. Once again, the L1 lenient scores were higher than the L2 lenient scores, with a difference of 4.5-point range. The L1 strict scores were also higher than the L2 strict scores – 42.00 and 38.00, respectively. The minimum scores follow exactly the same patterns, with L1 lenient and strict scores overpassing L2 scores. These results indicate that advanced and intermediate participants likewise, performed better in the L1 version of the speaking span test, thus supporting Hypothesis 1.

Accordingly, as displayed by Table 2, L2 means are lower than L1 means. The difference between the means of the strict scores in L1 and in L2 is around 8-point range, whereas for the lenient scores it is around 7-point range. The standard deviation covered 7 and 6 on the L2 strict and lenient scores and 6 and 5 on the L1 strict and lenient scores, respectively.

Because the descriptive statistical analysis revealed lower means for the strict and lenient scores in the L2 version of the speaking span test, Paired Sample *T*-tests were run to attest statistical significance to the patterns of working memory variation found in the data of the intermediate and advanced groups. Table 3 shows that the increase in the L1 strict and lenient scores in the Intermediate group is of statistical significance: $t(18) = 11.00$ $p<.05$ and $t(18) = 9.18$ $p<.05$, respectively. This result reinforces previous analysis, confirming that intermediate participants had a better performance in the Portuguese version of the SST.

Table 3 – Paired Sample T-tests for working memory scores in L2 and L1 in the Intermediate group

	Paired Differences				
	Mean	**St. Dev.**	**t**	**df**	**Sig. (2-tailed)**
SSTL1STR X SSTL2STR	11.00	5.91	-8.10	18	.000*
SSTL1LEN X SSTL2LEN	9.18	5.15	-7.76	18	.000*

N=19
*p< 0,05
SSTL2STR= strict scores on the L2 Speaking Span Test
SSTL2LEN= lenient scores on the L2 Speaking Span Test
SSTL1STR= strict scores on the L1 Speaking Span Test
SSTL1LEN= lenient scores on the L1 Speaking Span Test

Results for the advanced group can be seen in Table 4. Mirroring the results of the intermediate group, the mean difference between the strict and lenient scores in both versions of the SST proved to be statistically significant – $t(21) = 8.54$ $p<.05$ for L1 and L2 strict scores comparison and $t(21) = 7.25$ $p<.05$ for L1 and L2 lenient scores comparison thus, confirming that advanced learners were also better at the Portuguese version of the test.

Table 4 – Paired Sample T-tests for working memory scores in L2 and L1 in the Advanced group

	Paired Differences				
	Mean	**St. Dev.**	**T**	**df**	**Sig. (2-tailed)**
SSTL1STR X SSTL2STR	8.54	5.63	-7.11	21	.000*
SSTL1LEN X SSTL2LEN	7.25	4.72	-7.19	21	.000*

N=22
*p< 0,05
SSTL2STR= strict scores on the L2 Speaking Span Test
SSTL2LEN= lenient scores on the L2 Speaking Span Test
SSTL1STR= strict scores on the L1 Speaking Span Test
SSTL1LEN= lenient scores on the L1 Speaking Span Test

Taken together, results of both groups seem to indicate that participants' working memory capacity is different when speaking in L2 and in L1 thus confirming Hypothesis 1 which had predicted that there would be a difference in the mean working memory capacity scores in L1 and in L2. The fact that the L1 version of the SST yielded higher scores for both groups might indicate a more efficient behavior of participants in the processing component of the task. That is, because participants were asked to produce L1 instead of L2 sentences, their level of efficiency was greater than in the L2 version of the WM test. Although this finding seems to support, at first glance, the processing efficiency view of working memory capacity, it will be argued that participants' supremacy on the L1 version of the SST is related to the less automatic fashion of L2 formulation processes which are likely to require more controlled attention (WMC) to be executed. I will further develop this assumption in the Discussion section.

3.2 WMC and proficiency

Although the Paired Sample *T*-tests indicated that L1 and L2 working memory capacity are not the same, one question remained unanswered: Is the difference found in the means of intermediate and advanced groups regarding strict and lenient scores both in L1 and in L2 of statistical significance? Hypothesis 2 predicted that whereas L2 working memory capacity scores would vary according to proficiency, L1 working memory scores would remain nearly stable. So as to be able to address this prediction, Independent Sample *T*-tests were applied to the data (the assumption of equal variances for Independent *T*-tests was satisfied).

Table 5 shows Hypothesis 2 was partially supported. The means of both groups differed significantly in about 7 points for the L2 strict and lenient scores: $t(39) = 7.82$ $p<.05$ and $t(39) = 7.78$ $p<.05$, respectively. For the L1 strict and lenient scores, the mean difference was of about 5 points and also significant: $t(39) = 5.37$ $p<.05$ and $t(39) = 5.85$ $p<.05$, respectively. Regarding L2 WMC, it will be argued that advanced learners might have developed a more automatized knowledge of the L2 and as a result were better able to focus controlled attention on L2 speaking formulation processes, by inhibiting proactive interference and maintaining task relevant information activated (KANE; CONWAY; HAMBRICK; ENGLE, 2007). This idea will be fully addressed in the Discussion section of the article.

On the other hand, regarding L1 WMC results, I hypothesize that one of the reasons why advanced learners outperformed intermediate learners in the L1 SST might be related to individual differences in WMC within the advanced group itself. Another explanation for this unexpected result may be connected to a restructuring of the L1 knowledge as a result of L2 acquisition/development. I will return to these assumptions in the Discussion section.

Table 5 – Independent Sample T-tests for WM scores in L2 and L1 in the Intermediate and Advanced groups

	T-test for the equality of means			
	Mean differences	**t**	**df**	**Sig. (2-tailed)**
SSTL2STR Intermediate X Advanced	7.82	-3.84	39	.000*
SSTL2LEN Intermediate X Advanced	7.78	-4.40	39	.000*
SSTL1STR Intermediate X Advanced	5.37	2.67	39	.011*
SSTL1LEN Intermediate X Advanced	5.85	-3.16	39	.003*

N=41
*p< 0,05
SSTL2STR= strict scores on the L2 Speaking Span Test
SSTL2LEN= lenient scores on the L2 Speaking Span Test
SSTL1STR= strict scores on the L1 Speaking Span Test
SSTL1LEN= lenient scores on the L1 Speaking Span Test

3.3 Discussion

The discussion in this section addresses the issues of whether working memory capacity varies in L1 and L2 speaking and if this variation is also a function of L2 proficiency. To reiterate, hypothesis 1 predicted that there would be a variation in the mean working memory capacity scores in the L1 and L2 versions of the test. This hypothesis was confirmed by the results of the present study, since the mean difference between both versions of the span test proved to be statistically significant. Hypothesis 2, on the other hand, predicted that working memory scores would be different for intermediate and advanced learners in L2, but would remain stable in L1. As could be observed in the Results section, this hypothesis was just partially

confirmed. The mean working memory capacity scores was statistically different between both levels of proficiency and for both languages (L1 and L2). In what follows, I will attempt to address these two findings in light of theoretical and empirical literature in the area of working memory capacity and L2 speech production.

3.3.1 Is working memory capacity in L1 different from working memory capacity in L2?

According to the results of the present study, the answer for this question is YES. Paired-sample *T*-tests provided evidence for the mean difference between L1 and L2 strict and lenient working memory capacity scores, with L1 surpassing L2 performance. At first glance, we may be tempted to suggest that what led participants to perform better in L1 was their efficiency in L1 speaking. Such an explanation would support the processing efficiency view of working memory capacity (DANEMAN; CARPENTER, 1980) which postulates that differences in span scores reflect the degree of efficiency in the processing component of the task being executed – speaking in L1, in this case.

Although this might be an appealing explanation for L1 and L2 WMC differences, it is worth mentioning that Turner and Engle (1989) challenged Daneman and Carpenter's (1980) WMC theory, showing that skilled readers presented a larger WM capacity for both reading and non-reading related tasks. This finding led the researchers to claim that differences in WMC are not task-specific but rather domain-free. Ever since then, Engle and colleagues have argued that working memory capacity refers to a general individual ability to regulate, control and devote attention to the execution of higher-level cognitive tasks. According to this view, higher spans are also better at (i) maintaining information relevant to the execution of the task active in memory, (ii) recuperating access to information easier and faster and (iii) suppressing interference.

Another study questioning the reliability of the processing efficiency view of WMC was carried out by Bayliss, Jarrold, Gunn and Baddeley (2003). Their results showed that processing efficiency alone did not explain the patterns of performance on complex span tasks. In other words, both processing efficiency and storage capacity played important roles in constraining complex span performance. In addition, when the residuals of

the regression analysis were examined, a distinct ability was found to impact on the performance of complex span tasks. Researchers argued that this was individuals' ability to coordinate the processing and storage operations required in the performance of the span tasks. According to them, this ability is subject to the work of the central executive (the core component of the working memory system, as initially proposed by Baddeley and Hitch, 1974).

Bayliss' et al. (2003) findings do not seem to rule out the Controlled-Attention view of working memory, since researchers acknowledge that the execution of the processing component of a complex span relies on domain-free operations, whereas the storage component requires domain-specific resources to be accomplished (p. 81). Moreover, it seems that what Bayliss et al.(2003) identified as the residual ability is what Engle and colleagues understand as the source of individual differences in WM, which, in turn, seems to be the central executive referred to by the authors. Kane, Conway, Hambrick and Engle (2007, p. 24) confirm this idea,

> Working memory span tasks are obviously and multiply determined tasks, and so none of them can be considered a process-pure measure of executive function. Instead, WM span tasks measure, in part, executive attention processes that we believe are domain general and contribute to WM span performance irrespective of the skills or stimuli involved. In addition, WM span tasks reflect the contributions of rehearsal, coding, storage, processing skills, and strategies that are domain specific and vary with the component tasks and stimuli presented […]. Our view is that WM span tasks reflect primarily general executive processes and secondarily, domain-specific rehearsal and storage processes.

As argued by Kane et al.(2007), working memory spans can be influenced by several variables. Perhaps the most salient factor having affected the variation on scores observed in the present study is the dual-task inherent characteristic of the SST. While performing this test, participants had to memorize words for further recall, as in the case of some short-term memory span tests, and also engage in some processing so as to be able to produce the speech output.

In order to produce an oral sentence, speakers need, as explained by Levelt (1989), to perform a series of mental processes that involve conceptualization, formulation and articulation of the message. Levelt, however, emphasizes that the attentional demands are greater, in case of monolingual speech production, in the Conceptualization component, in which speakers need to apply more controlled processes so as to be able to create a mental representation of the content and form of what they wish to communicate (macro- and micro-planning).

Regarding L2 speaking, another panorama seems to emerge. Fortkamp (2000) showed that the attentional demands on working memory capacity seemed greater for the formulation processes rather than for the conceptualization ones. This is so, according to her, because L2 formulating aspects of message generation are less automatized, requiring thus more controlled attention to be executed. Fortkamp claimed that what differed higher from lower spans in her study was their ability to allocate and devote controlled attention to formulation processes, thus scoring higher in the memory span test. Fortkamp's conclusions are in line with Engle and colleagues' controlled view theory of working memory capacity.

Based on what has been discussed so far it seems plausible to suggest that the participants of the current study had a better performance on the L1 version of the SST due to their apparently lower capability to focus attention on the formulation processes when speaking in L2. As for L1 speaking, the mental processes involved are assumed to be more automatic (LEVELT, 1989), consuming fewer attentional resources from working memory (SEGALOWITZ, 2003) and thus, reducing the cognitive demands imposed by the dual-task of retrieving access to relevant information and processing it simultaneously as required by the SST. To the extent that L1 formulation processes require less controlled attention, the participants of the present study may have focused their attention on recalling words rather than formulating sentences, resulting in the use of rehearsal, coding, chunking and other domain-specific strategies (KANE et al., 2007) so as enhance their chances of recalling the greatest number of words. Contrary to the Processing Efficiency view of WM, storage and recalling capacity rather than processing efficiency might have guided span performance. Once recall was guaranteed, automatized procedures would take over the speaking generation processes.

3.3.2 Does working memory capacity vary according to proficiency?

Based on the analysis of the Independent-Sample *T*-tests the answer to the above question is YES. The mean on the strict and lenient working memory scores of the intermediate and advanced groups in both versions of the SST were found to be statistically different. As claimed before, one possible explanation for this finding is the fact that as L2 proficiency level increases, knowledge of the language becomes more automatized requiring thus less attentional resources from working memory to be executed. According to information processing models, (McLAUGHLIN; ROSSMAN; McLEOD, 1983; HULSTIJN; HULSTIJN, 1984; BIALYSTOK, 1994;), L2 learning involves the development of a cognitive skill that requires practice and attentional resources to develop (McLAUGHLIN; HEREDIA, 1996).

One of the best known theories of skill acquisition is the ACT*[3] model proposed by Anderson (1983). The model assumes that skill acquisition and development involve the proceduralization of initially declarative knowledge which is said to be explicitly stored and used in the first learning phases. In Anderson's (1983) view, a skill is fully acquired when the rules for its execution are compiled, becoming thus implicit, automatic and used effortlessly. As pointed out by Segalowitz (2003, p. 395), "automaticity, then, describes an end point in the acquisition of skill in this model". With that in mind, it seems feasible to argue that L2 advanced learners may have reached a further stage on skill acquisition than intermediate learners and, as a result, might have developed more automatic procedures and a greater amount of implicit knowledge of the language. Therefore, despite any other variable that might have helped advanced learners in their performance, I hypothesize that they were already in advantage in relation to intermediate learners of the present study. That is, advanced participants would use their more automatized procedures to deal with the increasing burden on working memory resources across speaking span test trials, having thus more spare resources to devote to the controlled attention task of formulating speech in L2.

I further extend this supposition claiming that individual differences in working memory capacity will come into play only when task demands

[3] ACT* (ACT star) stands for Adaptive Control of Thought.

increase thus stretching the limits of individuals' working memory. This assumption seems to be in line with Bayliss' et al. (2003) who found that, independently of storage measures, visuospatial processing did not account for the significant variability in their complex span measures in comparison to verbal processing. This led researchers to conclude that, despite storage capacity and processing efficiency contributions to working memory span variations, less attentionally demanding processing is not captured by the complex span tests thus not constraining span task performance. In other words, individual differences in WMC are, in part, subject to the level of processing required by the task.

Kane et al. (2007) also call attention to the fact that, working memory differences are most salient when the task being performed requires the blocking of interference. Rosen and Engle (1997; 1998) have demonstrated that in the absence of interference, high and low spans are equally able to retrieve information from long-term memory in terms of accuracy and speed. However, when proactive interference comes into play, only high spans can use their attentional control to inhibit irrelevant stimuli. As put forward by Kane et al.(2007), working memory span scores are susceptible to the effects of proactive interference because as information from previous span trials begins to accumulate, the access to the relevant information becomes more difficult. Deriving from Kane's et al (2007) claims, I suggest that the advanced learners of the current research presented better working memory span performance in relation to intermediates learners also because of their ability to block proactive interference caused by the competition between the number of words from previous trials of the test and the words being considered for actual processing. Conversely, intermediate learners might have been less skilled at preventing interference therefore having problems to maintain access to target information. The very act of keeping that access, as explained by Kane et al., is not a simple task since the processing component of the working memory span task requires individuals to shift their focus of attention between storing and processing operations. Again, I reiterate that, in the present study, advanced learners were better than intermediate ones in accomplishing such endeavor.

In order to try to explain why advanced learners outperformed intermediate learners in the L1 version of the SST, I infer that individual differences in WMC within the advanced group might have impacted on their SST scores. However, because no statistical test was run so as to verify

whether advanced participants were also higher span individuals, this assumption is to be taken as speculative in nature. Another reason that seems to account for advanced learners' supremacy in the L1 SST might be related to a possible restructuring of their L1 system. As it has been claimed previously in this sub-section, the development of the L2 speaking skill may be seen as a continuum in which knowledge of the language goes from a more explicit to a more implicit status (ANDERSON, 1983). Although the advanced learners of the present study might have a greater amount of L2 knowledge in an implicit fashion, it is expected that still part of this knowledge is yet explicit, being used to think of and about the language when new structures need to be acquired/learned. As put forward by McLaughlin and Heredia (1996), the development of L2 expertise requires learners to shift to more complex stages in which novel grammar structures are combined with already stored knowledge, causing it to be transformed, restructured and restored under a more elaborated fashion. Therefore, as a consequence of L2 restructuring, I hypothesize that advanced learners were able to start thinking about their own L1 in a more explicit fashion, making them more aware of the particularities of their native linguistic system, reflecting in some kind of improvement. That improvement is what might have led them to outperform intermediate learners in L1 SST. Caution needs to be exercised when generalizing on this assumption, since it is totally data-driven and exploratory. The third and last explanation might be the simple fact that advanced learners, as well as intermediate learners, performed the L1 SST right after the L2 SST in the same data collection session, which may have caused some kind of practice effect. Despite that intermediate learners also had higher WM scores in L1, advanced learners, might have been more strategic in order to take better advantage of task familiarity. Again, since they were not asked about what strategies they used and if they used, this explanation is also purely speculative.

Conclusion: Limitations and suggestions for further research

The major aim of the present study was to examine how working memory capacity (WMC) behaves in two different languages (L1 and L2) and whether any score variation in L2 WMC would be a result of learners' development of more automatic procedures and a greater amount of implicit L2 knowledge.

In sum, the main findings suggest that WMC in L2 is apparently a function of L2 proficiency, that is, the greater amount of knowledge one has in the foreign language, the better will be his/her performance in the bilingual version of the SST. Once the processing component of the span test is not a problem, such as in the case of the L1 SST, attentional resources can be devoted to word storage and retrieval, thus allowing participants to score better at the L1 version of the test if compared to the L2 version.

The current study suffered from some limitations. In what follows I acknowledge the shortcomings and make suggestions for further research.

- Sample size: only 19 intermediate and 22 advanced learners participated in this study, which prevented using a tertile split design so as to assign learners to groups of higher and lower spans. Future studies aiming at analyzing individual differences in WMC should consider expanding the number of participants so as to allow statistical variation without which it is difficult to convert interval data into nominal.
- Proficiency level: learners' proficiency level was not assessed by any kind of standardized proficiency exam prior to data collection. Considering the importance of this variable to the analyses carried out in the present study, it is recommended that further research pre-test participants for proficiency level.
- Measures of WMC: two memory span tests were administered in order to measure WMC, namely the Speaking Span Test in L1 and in L2. Both tests assume that WMC is a task-specific construct, particularly related to individuals ability to process and store information efficiently in the task being performed, in this case, speaking. However, as stated previously in this article, the theory on the limits of WMC adopted by the present study sustains that WM capacity is not related to processing efficiency but rather to individual's ability to control attention. On the other hand, proponents of the Controlled-Attention View of WMC also assume that rehearsal, coding, chunking and other domain-specific strategies (KANE et al., 2007) may be applied by individuals when coping with the dual-task of keeping information active for further recall and producing speech as required by the SST. Notwithstanding such criticism, future studies should consider using

a more domain-free measure of WMC such as the Operation Word Span Test (one in which so as to be more consistent with the view of WMC limitations adopted.

- The L1 SST: in this study, the L1 SST was administered right after the L2 SST, in the same data collection session. This fact might have led participants to benefit from practice effects, once both span tests are structurally and functionally similar. A solution so as to avoid possible practice effects would be to administer the tests on separate occasions or to adopt a split half design in which half of the participants perform first the L1 version, and the other half first the L2 version.

Despite the aforementioned limitations, I hoped that the present study brings fruitful insights to be further pursued by those who aim at having a better understanding of the issues here investigated.

Appendices

A The SST in L1: list of words

Test 1	Test 2	Test 3
Direção	Memória	Relógio
Matéria	Assalto	Correio
Cerveja	Galinha	Telhado
Exilado	Decreto	Chinelo
Árvores	Estação	Planeta
Natação	Bondade	Cortina
Cadeira	Teatral	Desenho
Palhaço	Suborno	Abóbora
Estrela	Caminho	Inverno
Besouro	Beliche	Lixeira
Polícia	Viveiro	Cimento
Camisas	Caderno	Azulejo
Amizade	Laranja	Pássaro
Revista	Bordado	Toalhas

Test 1	Test 2	Test 3
Padaria	Estádio	Papelão
Violino	Gráfica	Cérebro
Leitura	Perfume	Remédio
Tesouro	Aquário	Abelhas
Futebol	Redação	Estrada
Cozinha	Lâmpada	Nublado

B The SST in L2: list of words

Practice 1	Practice 2	Practice 3	Test 1	Test 2	Test 3
House	People	Boss	Arm	Spoon	Ball
Beach	Earth	Island	Course	Bank	Tool
School	Soccer	Tea	Guy	Date	Ice
Hobby	Wife	Mouth	Point	Gas	Bread
Family	Power	Sport	Train	Sky	Sea
Team	World	Baby	Cow	Car	Bag
Night	Summer	Idea	Fire	Dog	Year
Friend	Ocean	Movie	Shoe	Disk	King
Music	Apple	Space	Key	Pen	Band
Snack	Ball	Gift	Snow	Bird	Flag
Drug	Nurse	Clock	Oil	Seat	Job
Honey	truck	Woman	Door	Bath	Air
Light	Actress	Taxi	Boat	Girl	Brain
Face	Room	Fish	Toy	Club	Boy
Coffee	Worker	Milk	Art	Street	Class
Mother	Dress	Problem	Box	Bed	Farm
Prison	Head	Window	Floor	Mind	Bus
Number	City	Lunch	Rock	Mail	TV
Flower	Plant	Party	Coat	Beer	File
Poem	Moon	Money	Book	Pair	Crowd

C Individual Scores on the L1 SST

Intermediate Group			Advanced Group		
	Strict	**Lenient**		**Strict**	**Lenient**
Part.			Part.		
1	24,00	29,50	2	34,00	35,50
7	31,00	34,50	3	24,00	32,00
8	26,00	31,00	4	25,00	29,00
9	27,00	31,00	5	35,00	38,00
11	12,00	14,50	6	15,00	26,00
12	22,00	26,50	10	26,00	28,50
13	20,00	25,00	14	22,00	30,00
17	25,00	29,00	15	38,00	39,50
19	22,00	23,50	16	33,00	36,00
22	24,00	25,00	18	29,00	32,00
23	32,00	34,50	20	27,00	31,00
24	8,00	10,50	21	25,00	25,50
26	15,00	21,00	25	21,00	26,00
29	19,00	23,50	27	32,00	35,50
33	27,00	28,00	28	31,00	34,00
34	31,00	32,00	30	32,00	39,00
35	22,00	26,00	31	23,00	26,50
38	30,00	33,50	32	30,00	38,00
40	19,00	23,50	36	28,00	29,00
			37	31,00	32,50
			39	20,00	22,50
			41	42,00	44,00

D Individual Scores on the L2 SST

Intermediate Group			Advanced Group		
	Strict	**Lenient**		**Strict**	**Lenient**
Part.			Part.		
1	17,00	20,50	2	25,00	29,50
7	19,00	27,50	3	17,00	24,00
8	18,00	23,00	4	19,00	23,00
9	7,00	13,50	5	26,00	31,50
11	4,00	10,50	6	9,00	20,00
12	10,00	14,50	10	15,00	19,50
13	4,00	10,50	14	7,00	13,50
17	13,00	21,00	15	18,00	26,00
19	11,00	14,50	16	16,00	22,50
22	11,00	17,00	18	23,00	25,50
23	15,00	21,00	20	23,00	29,00
24	9,00	13,50	21	16,00	18,00
26	15,00	18,50	25	19,00	23,00
29	14,00	17,00	27	18,00	23,50
33	20,00	21,50	28	17,00	22,50
34	13,00	19,00	30	24,00	29,50
35	7,00	12,00	31	14,00	20,00
38	11,00	16,00	32	21,00	30,00
40	9,00	16,50	36	32,00	33,00
			37	31,00	33,50
			39	7,00	14,00
			41	38,00	39,50

E Transcriptions of some oral sentences produced in the L2 SST

Intermediate participants:

Participant 01

– I will snow on the…
– Have too many oil in the water
– I like read book

Participant 02

– In year I go to United States

– Every people take arm
– I have a drink beer in the weekend

Participant 03
– In my word is not arm
– I have very key
– My pen is between for the books

Participant 04
– The boy play soccer
– The last year it was great
– I make the course

Participant 05
– I like family guy
– I never see snow
– I have very spoons in my house

Participant 06
– My house is fire
– The bird sing
– The class is finish

Participant 07
– I have a box black
– What a date today?
– I have a bird yellow

Participant 08
– What is course?
– Door is necessary
– Sea is very important

Participant 09
– Have a black point on the wale
– Have a fire in brush?
– My address is Chapecó Street number 299

Participant 10
– It spoon is big
– It name is my dog is Jilly
– My bag going to the airplane

Advanced Participants:

Participant 11
– I wanna go back to that street
– Are we gonna have bread for breakfast?
– Those are beautiful flowers

Participant 12
– The guy is taller than me
– My favorite subject is Art
– The man is talking on the phone

Participant 13
– I have an appointment with my doctor on the date of my wedding anniversary
– My mind is empty right now
– There was a crowd in front of the theater yesterday night

Participant 14
– Can you lend me your toy?
– I just want a slice of bread
– I don't want to go to the club

Participant 15
– I'm gonna check the mail
– He went to buy some beer
– I wish I could understand how your brain works

Participant 16
– There is snow under my car
– I'm not seeing that bird
– Our class is crowded

Participant 17
– I have never seen the snow
– I have never seen the snow
– I went to the bank last week

Participant 18
– I have a problem with my right arm
– I haven't seen the snow
– My boyfriend works in a bank

Participant 19
– If I make a correct sentence, I get a point
– I almost never watch TV
– My brain is very confused now

Participant 20
– The fire destroyed the city
– The boat is moved by oil
– The refrigerator produces ice

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