

Working memory capacity in the production and acquisition of a syntactic rule in L2 speech

Capacidade de memória de trabalho na produção e aquisição de uma regra sintática na fala em L2

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ABSTRACT: This study investigates the extent to which working memory capacity is related to the production and acquisition of a syntactic structure of L2 speech. Information Processing Theory guides the research, as the authors assume the operation of a dual code cognitive system made up of a rule-based and a memory-based system (SKEHAN, 1998) responsible for analyzing and synthesizing language, respectively. L2 acquisition is also discussed in terms of processing input for meaning and form. Overall results show that working memory capacity is related to the production and acquisition of a syntactic structure in L2 speech, but this relationship is stronger for acquisition.

KEYWORDS: working memory capacity, L2 speech production and acquisition.

RESUMO: Este estudo investiga se há relação entre a capacidade de memória de trabalho e a aquisição de uma estrutura sintática na fala em L2. A Teoria do Processamento da Informação orienta a pesquisa, à medida que se pressupõe a existência de um sistema cognitivo de código duplo, constituído de um sistema baseado em regras e outro baseado na memória (SKEHAN, 1998), os quais são responsáveis pela análise e pela síntese da linguagem, respectivamente. A aquisição da L2 também é discutida no que diz respeito ao processamento de *input* para o significado e para a forma. Os resultados indicam que a capacidade da memória de trabalho está relacionada com a produção e a aquisição de uma estrutura sintática na fala da L2, mas esse relacionamento é mais forte na aquisição.

PALAVRAS-CHAVE: Capacidade da memória de trabalho, produção e aquisição da fala de L2.

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Introduction

L2 speaking is a complex skill approached in this paper within the realms of cognitive psychology, more specifically, Information Processing Theory, which sees human beings as autonomous processors with a limited capacity cognitive system (McLAUGHLIN; HEREDIA, 1996) – termed working memory (WM), which is responsible for the simultaneous storage and processing of information during the execution of complex cognitive tasks (BADDELEY, 1990, 1999). Research on working memory has shown that it plays a major role in the performance of complex tasks such as problem solving, reading, writing, and speaking (e.g., BADDELEY, 1999; CARPENTER; JUST, 1989; DANEMAN, 1991; JUST; CARPENTER, 1992; ENGLE; CANTOR; CARULLO, 1992). Research on speech production also suggests that working memory capacity may be a key constraint on the processes involved in speaking both L1 (LEVELT, 1989; DANEMAN; GREEN, 1986; DANEMAN, 1991) and L2 (FINARDI; PREBIANCA, 2006; FORTKAMP, 1999, 2003; FONTANINI; WEISSHEIMER; BERGSLEITHNER; PERUCCI; D'ELY, 2005; PAYNE; WHITNEY, 2002; TEMPLE, 2000). More precisely, working memory capacity constrains the controlled processes involved in the formulation of messages during the grammatical encoding phase of L2 speech production (FORTKAMP, 2003). To the extent that working memory capacity constrains the controlled processes (those processes that require attention from working memory to be executed) involved in L2 speech production, it may have a more important role to play in the acquisition of L2 speech as will be suggested in the present study which aims at investigating whether working memory capacity is also involved in the acquisition of a syntactic structure as it emerges in L2 speech.

The notion of controlled versus automatized processing¹ is at the heart of cognitive theories that seek to explain complex behavior (McLAUGHLIN; HEREDIA, 1996, for example). So as to address the criticism that cognitive theories received when attempting to explain L2 acquisition through the

¹ Controlled processing is believed to require attention from working memory whereas automatic processing happens without consciousness or attention (FORTKAMP, 2003; SKEHAN, 1998).

concept of automaticity (SKEHAN, 1998), linking gains in performance to the result of more practice, Skehan (1998) offered a view as to how an L2 may be acquired and used, suggesting that L2 learning cannot be understood simply as the accumulation of linguistic knowledge that becomes automatized through practice, but instead, may be explained by the operation of a dual-code cognitive system.²

According to Skehan (1998) before the end of the critical period, language acquisition is qualitatively different from other types of learning because of the possible existence of an innate Language Acquisition Device (LAD) (BLEY-VROMAN, 1989; JOHNSON; NEWPORT, 1989) responsible for helping children to process language during that period. After that period, however, language learning is believed to be constrained by processes similar to those constraining other forms of learning and should be explained by psycholinguistic accounts of complex behavior. Skehan's account of L2 acquisition is an attempt to bring the already existing discussion of cognitive processing involved in the performance of complex tasks into the arena of L2 learning.

Both Skehan (1998) and Swain (1985) call attention to the fact that the level of analysis required during language comprehension (semantic) is different than during language production (syntactic). During speech comprehension learners may not need to undergo syntactic analysis to understand messages, for they have contextual cues to help them. The same cannot be said for speech production since learners necessarily undergo syntactic analyses to produce messages. This is important because depending on the level of analysis undergone by the learner, language development may or may not go beyond a certain proficiency level. Thus, in this account, production is needed to force the learner to process linguistic data at a syntactic level (SWAIN, 1985).

Ellis (2003, p. 114) reminds us that although the importance of production for second language acquisition (SLA) has been clearly established, it would seem to play only an indirect, limited causal role by motivating learners to attend to input. Nevertheless, according to both Skehan (1998) and Logan's Instance Theory (1988), both based on dual-code theories, it may be possible to establish a stronger causal role for production in SLA.

² A dual-code system is made up of a memory-based system, responsible for memorizing items and a rule-based system, responsible for analyzing items (SKEHAN, 1998).

Instance Theory (LOGAN, 1988) suggests that lexicalized units may in part be acquired as a result of memorizing expressions that were created by the instance-based system (memory-based or exemplar-based system in Skehan's terminology), that is, learners construct strings consciously and then store them as chunks, avoiding the need to assemble them again later (ELLIS, 2003, p. 114). According to Skehan (1998), production can serve as a way for items stored as rules in the rule-based system – the system responsible for analyzing language – to move to the memory-based system which is responsible for synthesizing language (ELLIS, 2003; SKEHAN, 1998).

Skehan (1998) proposed this view of L2 learning based on evidence from L1 development that language acquisition goes through three main stages (p. 90). During the first stage children learn language in a lexicalized way. In a second stage, enabled by a LAD, children go through a process of syntacticization of their lexicalized repertoire. Finally, during the third stage of L1 acquisition, children go through a process of relexicalization of language, thus making the language available as a rule and as a memory instance, each of which will be used depending on processing conditions (whereas the learner is speaking or writing, for example). Thus, according to this account, both lexicalization (memory-based) and syntacticalization (rule-based) of language are important in language acquisition.

In L2 learning, meaning has priority over form (SKEHAN, 1998; ELLIS, 2003) and, in the context of a limited capacity information-processing system, there is greater predisposition and, perhaps, more attention devoted towards lexicalized language, with the possible consequence that pressure to syntacticize language does not come into play. Thus, in the course of L2 development, it is necessary to contrive the movement through the three stages of language acquisition, engaging learners in cycles of analysis and synthesis. In this way, language is lexicalized, syntacticized and relexicalized again through production, thus becoming available as a rule and as a memory instance for the L2 learner (SKEHAN, 1998, p. 91).

In short, Skehan (1998) views L2 learning as stemming from the transfer of items from the memory-based system to the rule-based system, and vice-versa, through production, forcing the limited-capacity (working memory) learner to engage in cycles of analysis and synthesis of language. This leads to the processes of lexicalization, syntacticization and relexicalization of language, enabling the learner to operate in these two modes (rule-based or memory-based), depending on processing conditions (for example, speaking or writing or producing for fluency or for accuracy or complexity).

Research on the relationship between working memory capacity and L2 speech production has produced mounting evidence that working memory capacity may be a good predictor of L2 speech performance. Fortkamp (2003) found that working memory capacity (WMC) was related to L2 speech production in terms of speech rate, mean length of run, accuracy and complexity in monologic tasks and it was at least linearly related to fluency, accuracy and complexity of L2 speech performance. She found a negative correlation between working memory capacity and number of grammatical errors in L2 speech production, concluding that WMC was a good predictor of learners' accuracy of L2 speech. Fortkamp (2003) also suggested that the speech production processes captured by the L2 speaking span test (SST)³ were those involved in the grammatical encoding phase (LEVELT, 1989) of the formulator component of Levelt's L1 speech production model. According to Fortkamp, L2 speech production is more complex than L1 speech production among other reasons, because, in the former, the processes involved in the formulation of messages are highly automatic whereas in L2 these processes are believed to require more control.

Other studies also used the L2 SST, finding statistically significant correlations between WMC and fluency of L2 speech (FINARDI; PREBIANCA, 2006), and between WMC and accuracy of L2 speech (FONTANINI *et al.*, 2005). All in all, what these studies show is that individuals with larger WMCs usually outperform those with smaller WMCs in different dimensions of L2 speech.

A conclusion that follows from the account of L2 speech production reviewed is that if acquisition is affected by production, as suggested by Skehan (1989) and Swain (1985), and if L2 speech production is affected by working memory capacity (FORTKAMP, 1999, 2003; FINARDI; PREBIANCA, 2006; FONTANINI *et al.*, 2005), then it might be reasonable to expect that L2 speech acquisition is also affected by working memory capacity. Finding evidence for that hypothesis is the main focus of this research endeavor.

The research question driving this study is whether working memory capacity, assessed in terms of an L2 speaking span test, is related to the production and acquisition of syntactic structure in short response forms of L2 speech. For the purpose of this study, *production* was operationalized as accurate use of the target language structure in a focused (where the production

³ Reference and example of this test is given in the method section.

of other syntactic forms was not possible), immediate test, while *acquisition* was indexed as accurate use of the target language structure in an unfocused (where it is possible to produce other syntactic structures), delayed test. The target language structure tested was short-form responses used to agree with what someone says using the formula *So+aux+I* (e.g., So do I).

Because of the assumption that in the focused test participants would focus on form whereas in the unfocused test they would have the extra burden of having to focus on meaning (besides focusing on form) to respond correctly, it was hypothesized in this study that the performance in the unfocused test would be more demanding in terms of cognitive load than that of the focused test, thus yielding lower scores.

So as to pursue the general goal of this study, which was to look at the relationship between working memory capacity and the production and acquisition of a syntactic structure in L2 speech, the following hypotheses were raised:

Hypothesis 1: Participants' performance on the production test (focused test) will be more accurate than on the acquisition test (unfocused test).

Hypothesis 2: There is a statistically significant and positive correlation between working memory capacity and L2 accuracy scores in the focused speaking test.

Hypothesis 3: There is a statistically significant and positive correlation between working memory capacity and L2 accuracy scores in the unfocused speaking test.

Method

Participants

Fifty-five university students studying English in different courses and programs at Universidade Federal de Santa Catarina (UFSC) were selected to participate in the experiment on a volunteer basis and signed a consent form. The experimental group was formed by 26 students from the English Executive Secretarial Programs, and 21 from the English Extracurricular Course, while the control group was formed by 8 students attending the undergraduate English Language Program. These students had been categorized by their English teachers and in-house tests as belonging to the pre-intermediate level. The cohort consisted of 26 male and 29 female participants ranging in age from 18 to 55, with a mean of 25.5. The control group, which

did not receive treatment, completed only the pretest and a focused written test in class.

Design

The method used in this study was longitudinal, quasi-experimental, and quantitative. The design of the study can be seen in Table 1.

TABLE 1
Design employed in the study.

Time 1	Pretest	Focused Written Test	EG and CG
Time 2	Treatment	Form-focused Instruction	EG
Time 3	Posttest	Focused Speaking Test	EG
Time 4	Posttest	Unfocused Speaking Test Focused Written Test	EG CG
Time 5	Working Memory Test	L2 Speaking Span Test	EG

EG: Experimental Group (n = 47); CG: Control Group (n = 8).

Instruments

Four instruments of data collection were used in this study: one pretest (focused written), two speaking tests to check target language use (TLU) but one focused to test target language production and one unfocused to test target language acquisition, and a L2 speaking span test (SST) to assess L2 working memory capacity. Except for the L2 SST which was designed by Weissheimer (2006) based on Daneman (1991), all the other tests were designed for this study and piloted in a previous study (FINARDI, 2008).

The focused written test was used as a pretest to check whether prospective participants knew the target language structure before they were invited to take part in the study. Those participants who correctly responded to one or more written test items were removed from the study pool, and only those who received a score of zero were invited to participate in this study. The pretest consisted of 10 sentences with which participants had to agree using the formula *So+aux+I* or *Neither+aux+I*. For example, if the participants read the sentence: "I work near here." they were supposed to agree with the statement by replying with "So do I.". Nevertheless, if the participants read a negative sentence such as "I don't like cats.", they were expected to reply with "Neither do I."

The focused speaking test aimed at testing target language structure production for the experimental group and was administered immediately after treatment. The same test was used with the control group as a posttest to verify whether they had learned the target language structure without receiving treatment, but it was administered in a written mode. In the focused tests participants were instructed to agree with the sentences heard using the target language structure (see example in the previous paragraph). Note, however, that only the experimental group provided the answers in an oral form.

The unfocused test was similar to the focused test in the sense that it also consisted of 10 sentences and was also done in the speaking mode, but it differed from the focused test in that for the unfocused test participants were required to *agree* or *disagree*, given their real situations, with the statements presented. For example, when the participants heard the sentence “I can speak Portuguese fluently” they were expected to agree, since all participants were native speakers of Brazilian Portuguese. Thus, the expected answer was “So can I.” It is important to highlight that the unfocused test was designed after the researcher responsible for data collection had met the participants individually so as to be able to collect biographical data to elaborate sentences in which participants had to necessarily agree or disagree, depending on their individual circumstances. The sentences were designed in such a way that participants would have to agree with at least five sentences and disagree with the other five.

The L2 SST used in this study consisted of 120 unrelated words organized in six sets of 2, 3, 4, 5 and 6 words. Each word was presented individually, in the middle of a computer screen, for one second. Participants were instructed to read the words silently. After ten milliseconds, the next word in the set appeared in the same position and this procedure was followed until the set ended and a black screen with question marks (in the same amount as the words presented in that set) appeared on the screen. Participants were informed that these question marks represented the number of words presented and the number of sentences they should try to make. Participants were also instructed to use the words in the correct order presented on screen to form grammatically correct sentences aloud in English. Figure 1 shows the words included in the three trials of the L2 SST that appeared on the screen after the practice trial.

2 words	BOSS ISLAND ??	ARM COURSE ??	SPOON BANK ??
3 words	TEA MOUTH SPORT ???	GUY POINT TRAIN ??????	DATE GAS SKY ??????
4 words	BABY IDEA MOVIE SPACE ????	COW FIRE SHOE KEY ??????	CAR DOOR PEN DISK ??????
5 words	TAXI GIFT CLOCK WOMAN FISH ?????	SNOW OIL DOOR BOAT TOY ??????	BIRD SEAT BATH GIRL CLUB ??????
6 words	MILK LUNCH WINDOW MONEY PROBLEM PARTY ??????	ART BOX FLOOR ROCK COAT BOOK ??????	STREET BED MIND MAIL BEER PAIR ??????

FIGURE 1 - Words used in the L2 Speaking Span Test

Procedures

During the pretest, after explaining the purpose of the research, the researcher in charge of collecting the data gave each student in the group a written form of the focused test and asked them to agree with the sentences given using SO or NEITHER. This procedure was the same for both the control and the experimental group and was repeated with the control group (posttest), which completed only the focused written test.

The control group was tested twice in order to verify whether students in that group would produce the target language structure in the time span of data collection, despite having received no treatment. Results of the two focused written tests (pretest and posttest) administered to the control group

show that this group did not acquire the target language structure, as all participants in this group scored zero in the two focused written tests

The researcher explained the syntactic rule explicitly to the experimental group and gave everyone a focused written exercise (similar to the written test) to practice the structure. She then had individual meetings with each participant to administer the focused speaking test. During these meetings, the researcher began by asking each participant her or his names, age, and program affiliation, along with other questions aimed at making participants comfortable prior to starting the test and collecting important information about the participants' background, necessary for the design of the unfocused test. Once participants were at ease, the researcher began the focused speaking test. The researcher read the 10 sentences and asked the participants to agree with the sentences heard using SO or NEITHER. The individual meetings were recorded in a portable tape recorder and transcribed immediately after each session. The aim of the immediate focused test was to check if participants had retained the target language structure after the instruction.

Two scores were calculated for the focused test, one strict and one lenient. To calculate the strict score, the criterion of one point only for answers completely correct was applied. In the lenient score one point was given for answers completely correct and half a point was given for answers which had either the auxiliary verb or the target structure (so/neither) correct. For example, if in the sentence "I've been to Japan." the participant had produced "So did I" or "Neither have I", half a point would be given for these answers under lenient scoring, since in the first answer the target language structure is correct, but the auxiliary verb is not, whereas in the second answer the opposite is the case.

The unfocused test was a delayed test, administered two weeks after the instruction. The procedures for the unfocused test were similar to those of the focused one, but for this later test participants were required to agree or disagree according to their personal situations with the statements presented. Two scores (one strict and one lenient) were also calculated for the unfocused test, but with scoring criteria slightly modified. In the strict score, similarly to the focused tests, only sentences completely correct were given one point. In the lenient score half a point was given to sentences partially correct, but at this stage the assessment for "partially correct" depended upon whether the response agreed or disagreed given a respondent's true circumstance, and whether either the auxiliary verb or the target structure (so/neither) was correct.

For example, if the response to the sentence “I’m not a millionaire” was “So am I”, the participant would be given half a point in the lenient score because the structure was correct, but he/she hadn’t agreed using the correct form (Neither am I). Similarly, if the answer to the same question as provided were: “I am”, although the sentence is grammatically correct, a participant of modest economic means would be given only half a point, for he/she should have disagreed with this sentence.

The working memory test was administered two weeks after the unfocused test and consisted of a training phase (60 words) which preceded the testing phase (60 words). Because this test was done with the computer and was not familiar to research subjects, all participants had to undergo a training phase before starting the actual test. The test itself did not commence until the participants reported feeling comfortable with the test procedures. Note that the L2 SST was the last to be administered due to its duration and unfamiliar design, which could have caused several participants to withdraw from the study before the other test had been administered, thus avoiding possible high mortality rate.

Each participant’s speaking span was defined as the maximum number of words (out of 60) for which that participant could generate sentences. Strict and lenient scores were also calculated for the working memory test. In the strict score, only sentences which were grammatically correct and used the target word in the correct order were given one point. Under lenient scoring, half a point was given for sentences which were partially correct (e.g.: “The girl live on the farm”) or when the sentence was correct but the target word was in an order other than the one presented. Sentences such as “I don’t know gift” were considered correct if the target word (gift) was produced in the correct order.

A summary of all the variables created in this study follows below:

focused speaking strict	focused speaking lenient
unfocused speaking strict	unfocused speaking lenient
working memory strict	working memory lenient

In order to address the hypotheses proposed in this study, descriptive analyses of the data were conducted so as to present a general picture of the participants’ performance. Because the data were normally distributed, paired-samples *t*-tests were run to analyze the performance between the focused and unfocused tests. This analysis addressed hypothesis 1, which stated that

performance on the focused test would be better than in the unfocused test. The alpha was set at .05 for the *t*-tests. Pearson Correlations were run between working memory capacity scores and scores in the target language tests so as to check if working memory capacity was a good predictor of target language production and/or acquisition in L2 speech. Because of the evidence for the relationship between WMC and L2 speech production (FORTKAMP, 1999; FINARDI; PREBIANCA, 2006; FONTANINI *et al.*, 2005) the correlations were one tailed and the alpha was set at .05.

Results

Focused versus unfocused tests – Hypothesis 1

Based on the assumption that a focused test is less demanding than an unfocused test, since the former requires participants to process only the form to answer correctly, and, in addition, the latter requires meaning to be processed correctly in order to complete the test successfully, hypothesis 1 predicted that the performance on the focused test would be more accurate than the performance on the unfocused tests.

TAB. 2, which displays the results for these tests, reveals that hypothesis 1 was borne out, since the means for the focused test variables were higher than those of the unfocused test (both strict and lenient). Paired-sample *t*-tests revealed that the means differences were statistically significant and moderate effect sizes (*d*) were found for both strict and lenient scores.

TABLE 2
Descriptive statistics and pairwise *t*-tests comparing focused and unfocused tests.

	Strict Focused	Strict Unfocused	Lenient Focused	Lenient Unfocused
Mean (SD)	6.48 (2.51)	5.67 (2.54)	7.61 (2.04)	6.84 (2.23)
Pairwise <i>t</i> -test (df)	2.242 (46)		2.472 (46)	
p-value	.03		.01	
<i>d</i>	.32		.36	

Working memory capacity and the production of the target language structure in L2 speech – Hypothesis 2

Based on evidence that the working memory test (L2 SST) is a good predictor of L2 oral performance (e.g., FORTKAMP, 2003; FONTANINI *et al.*, 2005) and on the assumption that the focused speaking test requires participants to process the form of the target language structure, demonstrating its production in the L2 speech, hypothesis 2 predicted that working memory scores would correlate significantly and positively with scores on the focused speaking test. The descriptive statistics for the focused speaking test were previously presented in TAB. 2.

So as to check if working memory capacity is a good predictor of target language production and acquisition in L2 speech, Pearson Correlations were run, and they were one tailed because of evidence in the literature pointing to the relationship between working memory capacity measured with the L2 SST and L2 speech production measures (e.g., FORTKAMP, 2003; 2006; FONTANINI *et al.*, 2005). TAB. 3 shows the results of the correlational analysis:

TABLE 3
Correlations (r^2 in parentheses) between working memory and focused speaking tests.

	Focused Speaking	
	Strict	Lenient
Working Memory Strict (r^2)	.302* (.091)	.280 (.078)
Working Memory Lenient (r^2)	.345* (.119)	.299* (.089)

* Correlation is significant at the .05 level (1-tailed).

As can be seen in TAB. 3, though weak, there were statistically significant and positive correlations between working memory scores and scores in the focused speaking test. This finding confirms hypothesis 2. That is, the relationship between working memory capacity measured by the L2 SST and the production of a target language structure in an immediate focused test is positive and statistically significant though weak.

Working memory capacity and the acquisition of the target language structure in L2 speech – Hypothesis 3

Finally, based on the evidence that working memory capacity constrains the processes involved in L2 speech production (FORTKAMP, 2003; FINARDI; PREBIANCA, 2006; FONTANINI *et al.*, 2005) and based on Skehan's (1998) claim that production affects acquisition, hypothesis 3 predicted that the scores in the L2 SST would correlate positively with scores in the unfocused speaking test, that is, that individuals with a larger working memory capacity would acquire more the target language structure than those with smaller working memory capacities. Finding confirmation for this hypothesis and establishing a positive relationship between working memory capacity and the acquisition of syntactic structure in L2 speech represented the greatest motivation for this research endeavor.

Pearson correlations were run and the results can be seen in Table 4. Positive statistically significant correlations were found between working memory capacity scores and the performance on the unfocused speaking test, the highest (strong) correlations being between the scores of the working memory capacity strict and the unfocused speaking lenient test (.743, $p = .001$, $r^2 = .552$). After finding support for the most important hypothesis posed in this study, we turn to the discussion of the results so as to attempt to explain what this evidence means for cognition in general and for L2 speech cognition in particular.

TABLE 4
Pearson Correlations (effect size in parentheses) between working memory and unfocused speaking tests.

	Unfocused Speaking	
	Strict	Lenient
Working Memory Strict	.700** (.490)	.743** (.552)
Working Memory Lenient	.725** (.526)	.706** (.498)

** Correlation is significant at the .01 level (1-tailed).

Discussion

Based on the assumption that the acquisition of a particular syntactic structure would not take place without formal instruction due to the fact that participants' exposure to the target language was mainly in English as a Foreign

Language (EFL) classes, and that all participants had been pre-tested to check whether they knew the target language structure (TLS) before the experiment took place, it was predicted that there would be no learning of the TLS for the control group, and this hypothesis was fully confirmed. This panorama would probably be different, and a control group would be more important in studies of L2 development which use global measures of accuracy instead of using target language use in focused tests such as was the case in this study.

One reason for using focused tests (to evaluate production) and unfocused tests (to evaluate acquisition) in this study emerged during the first phase of the experiment in which the researchers were piloting the tests to be used in the experiment and observed that, during the focused tests participants were getting most questions correct because they were not processing the sentence semantically. Evidence of this was found in the fact that subjects did not wait for the researcher to finish the sentence, instead, they simply focused on the beginning of each sentence so as to determine whether it was affirmative or negative in order to select the auxiliary verb to complete the memorized formula (so+aux+I / neither+aux+I). Interviews with the participants, during this phase of instrument piloting, confirmed this hypothesis. When the researchers selected this particular target language structure, it was based on an intuition that participants would have to undergo a similar processing as that involved in working memory, that is, information production and processing online, in order to use that target language structure correctly. However, the researchers had not anticipated the fact that when required to process only the form, as was the case in the production test (focused), participants might have enough working memory capacity to undertake this computation without penalizing accuracy. The focused test, administered in the way it was done in this study, was testing target language production, that is, whether participants remembered the formula and could process the form of the sentence so as to respond appropriately to it immediately following instruction. Nevertheless, the researchers were interested in going a step further, investigating L2 acquisition which cannot be defined as simple production demonstrated in performance in a focused, immediate test.

Acquisition of this particular target language structure was conceptualized in this study as the possibility to retain a syntactic rule, generalizing it to other contexts, and using it in a delayed communicative test in which other structures would also be possible. Moreover, acquisition was thought of as involving processing the sentence semantically and syntactically, that is,

processing meaning and form. In terms of working memory capacity, this means processing the meaning (which in the context of L2 learning has primacy over form (SKEHAN, 1998)), and still having enough attentional resources to process the form. Thus, an unfocused test was tailored for this study (based on participants information given during the first interview for the focused test) so as to assess participants' target language acquisition, asking them to agree or disagree (depending on whether the sentences were true or false for them) with the sentences given, thus forcing them to process the sentences semantically as well as syntactically. In order to perform correctly under these conditions, participants would have to process both meaning and form online, and this double processing was likely to be attention depleting, taxing working memory more than the focused test, in which they could bypass meaning decoding, focusing only on form.

Recall that in the model of L2 acquisition reviewed in this study (Skehan, 1998), meaning has priority over form, and in the context of a limited-capacity system, a focus on form has to be manipulated (through production) so as to allow acquisition. In this model, acquisition happens when material stored in the memory-based system is syntacticized in the rule-based system, and then is relexicalized again, thus becoming available in both modes of operation, depending on processing conditions.

Based on this view of L2 acquisition, it is possible to say that in this study, because of the way production and acquisition were operationalized - production of a rule in a focused immediate test with a focus on form and production of a rule in a delayed communicative task with focus on meaning and form, respectively - working memory capacity was more related to acquisition, as shown by the strong correlations, than to production, precisely because the acquisition test required more attention from working memory than the production test.

Indeed, the degree of association between working memory capacity and L2 production and acquisition was different, the difference clearly pointing to a stronger association between working memory capacity and L2 speech acquisition (.743, for the unfocused speaking lenient and working memory strict, and .725 for the unfocused speaking strict and working memory lenient, both at $p = .001$). That is, though working memory capacity, as measured by the L2 SST correlated with both L2 production and acquisition, the degree of association was stronger for acquisition, while the correlations between working memory capacity and L2 production were only weak, the highest

being between working memory lenient and the focused speaking strict (.345 , $p = .05$).

Two explanations are offered for this difference in association, one of a methodological nature and one concerning the processes involved in the focused and unfocused speaking tests. Regarding the implementation of the tests, as pointed out in the method section, the focused speaking test was an immediate test, administered after the instruction focused on form. The focused speaking test probably became too easy because of the way in which it was administered, requiring less attentional resources from working memory than the unfocused speaking test. Put differently, it might be that, because participants did not have to process meaning in the focused test (since this process probably happened during the instruction and treatment), they may have used their attentional resources to simply apply the rule just learned.

In terms of the cognitive processes involved in the focused speaking test, the researchers had predicted that the performance on this test would be demanding in terms of controlled attention (from working memory), because participants would have to use their limited attention to process the sentences semantically, maintain this information in working memory while processing the answer syntactically to figure out the correct structure (So or Neither) and the correct auxiliary verb to use in the response. However, this process of maintaining while processing information in working memory was probably achieved during the treatment. While doing the focused speaking test, participants were probably focusing only on the form of the sentence (evidence of this comes from the observation that most of them would start responding before the researcher had finished reading the sentence), since its meaning was probably decoded in the focused written task (which contained the same 10 sentences as the focused test, but in a written form) administered as practice and part of the treatment, immediately before this test.

In the unfocused test, this was not a problem, since so as to respond to the sentences participants would necessarily have to focus both on meaning and form. Further, it was not possible to respond correctly only focusing on the form. In that sense, the unfocused speaking test proved to be the most demanding in terms of working memory capacity since it required participants to apply a rule (probably using the rule-based system), while maintaining the meaning active in working memory. This conclusion seems to be confirmed by the strong correlations found in this study. Moreover, since the unfocused test was administered in a delayed form, as part of a communicative test

requiring participants to generalize a rule learned to a larger context where other forms were possible, it is considered a good measure of L2 syntactic acquisition (ELLIS, 2003). Finally, because of the strong association between working memory capacity and the performance on the unfocused test, it is possible to suggest that both the L2 speaking span test and the unfocused speaking test were tapping into the same processes, which, according to the rationale presented here, are probably those involved in maintaining and processing meaning and form, simultaneously in working memory using controlled processes to achieve this goal.

One of the main questions permeating this study was whether working memory capacity, assessed in terms of an L2 SST was related to the production of a TLS in the L2 speech. Following Mendonça (2003), who found that working memory capacity was related to L2 vocabulary production, hypothesis 2 predicted that participants with a higher working memory capacity would also be the ones to retain more TLS in the focused speaking test. This hypothesis was confirmed, but with a weak correlation, and thus demands further scrutiny.

One possible explanation for the lack of strong correlations between working memory capacity and the production of a TLS in L2 speech may be that production of vocabulary in L2 speech is different from the production of a target language structure. Retaining a vocabulary item may mean that participants retained the form (syntax) and meaning (semantics) of a particular item. The way production was operationalized in this study (accuracy on a focused test) implies that participants had to retain only the form without having to undergo semantic processing to accomplish the test. This having been said, results of the present study can neither confirm nor contradict Mendonça's (2003) findings since production was conceptualized differently across these two studies.

Another possible explanation for the weak correlations found between working memory capacity and the production of a TLS in L2 speech relates to the way in which the speaking focused test was administered. As previously explained, the focused speaking test was exactly the same as the written task used as part of the treatment. Participants may have memorized parts of the sentences as chunks (specifically the beginning so as to use SO or NEITHER plus auxiliary verb correctly) while performing the same task twice in a mechanical fashion (they did not have to process the meaning, only the form). Thus, the focused test may have tested subjects' long-term memory retention

instead of their working memory storage and processing capacity. One way to check if this hypothesis is correct is to change the written task and/or to avoid administering the focused test right after treatment. Using this approach, one could assure that the performance on the focused test will be due to the TLS production in L2 speech only, thereby ruling out the possibility of test practice effects on long-term memory.

Finally, another explanation for the lack of strong correlations between working memory capacity and the production of a TLS in L2 speech has to do with the cognitive processes involved in the focused test. As mentioned in the discussion of the focused and unfocused tests, it was assumed, and confirmed by the data in this study, that the performance on the focused tests was less demanding in terms of working memory capacity than that of the unfocused test. One possibility raised in this study was that the focused test required participants to process only the form of the sentence while the unfocused test required participants to process both meaning and form, thus, taxing more working memory capacity than the focused test. Thus, while in the unfocused test the processes were similar to those involved in working memory (processing and storing both meaning and form), it was hypothesized that in the focused test, participants were only storing and processing the form.

The biggest challenge undertaken by this study can be synthesized in hypothesis 3, which predicted that working memory capacity, assessed in terms of a L2 SST, would correlate with TLS acquisition in L2 speaking, that is, that participants with larger working memory capacities would also be the ones to acquire more the TLS in their L2 speech. This assumption was made in face of the literature on L2 acquisition which states that the acquisition of linguistic items proceeds from a movement from the rule-based system to the memory-based system and vice-versa (SKEHAN, 1998; ELLIS, 2003), that is, language acquired as a rule, can, through production, become available as a memorized formula, enabling its automatic use in subsequent opportunities. By the same token, items learned as a formula, through production can be analyzed and used later on to generalize to other creations.

Recall that in Skehan's (1998) account of L2 acquisition, production plays a key role, and since there is evidence in the literature that WMC constrains L2 speech production (e.g., FINARDI; PREBIANCA, 2006; FONTANINI *et al.*, 2005), it remained to be seen whether WMC would also affect L2 speech acquisition. Based on this rationale, acquisition was operationalized in this study as the use of a memorized formula (*so+aux+I/*

neither+aux+I) which, through production (occurring first during the focused test), was analyzed and used to generalize (in the unfocused test) to other situations (communicative test in which other structures were possible).

The strong correlations found between working memory capacity and the unfocused test proves that this was the right direction to be taken and this finding is in itself the greatest contribution of this study. The main research question driving this study was satisfactorily answered (working memory capacity seems to be related to the acquisition of a target language structure in L2 speech), giving these researchers confidence to pursue the issue further.

As previously pointed out by Skehan (1998), among others (e.g.: Van Patten, 1996), in L2 learning, meaning has priority over form and in the context of a limited capacity system, teachers may have to manipulate tasks so as to force students to focus on form. In this study, the limited capacity of working memory became more evident when participants were required to process both meaning and form and that was supported by the strong correlations found. Taken together, these results might be an indication that the processes captured by the L2 SST might be the same as the ones captured by the unfocused speaking test.

Conclusion

This study departed from evidence that individual differences in working memory capacity constrain L2 speech production (FORTKAMP, 1999, 2003; FINARDI; PREBIANCA, 2006; FONTANINI *et al.*, 2005) and that production affects acquisition and vice-versa (SKEHAN, 1998; ELLIS, 2003) to advance the possibility that working memory capacity was related to the production and acquisition of a syntactic structure in L2 speech. A relationship was found for working memory capacity and the production and acquisition of an L2 syntactic structure, though in the case of L2 TLS production, the relationship was only weak, perhaps due to methodological problems. So as to confirm findings in this study and scrutinize the relationship between working memory capacity and the production of a TLS, further studies are needed. Notwithstanding the weak correlations found between working memory capacity and the production of a TLS, this study represents a step further for producing evidence that working memory capacity is not only related to L2 speech production but also, and perhaps more importantly, to L2 speech acquisition.

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