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WORKING MEMORY AND SPEECH PERFORMANCE IN A PICTURE DESCRIPTION TASK WITH REPETITION

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ABSTRACT: This study is based on the assumption that L2 speaking is a complex cognitive ability which is carried out within the constraints of a limited-capacity system, working memory, responsible for the online storage and processing of information during complex task execution. In this system there are tradeoffs between its storage and processing functions just as in L2 speaking there is evidence for tradeoffs among the four goals of oral production, namely, fluency, accuracy, complexity and lexical density (Fortkamp, 2000; D' Ely, 2006). Bygate (2001b) found evidence that in a speaking task with repetition learners gained in complexity of L2 speech in the second trial at the expense of other goals of oral performance. This study set off to investigate whether working memory capacity (WMC) is related to gains in speech performance in the second trial of the speaking task with repetition, that is, whether participants with a higher WMC capacity gain more in terms of L2 speech production in this condition. Overall results show that there are gains in performance in terms of L2 complexity of speech, supporting Bygate's (2001b) findings and these gains seemed to have been paid for by gains specially in accuracy. Because of the small number of participants (12), there was no variation in terms of WMC scores, most participants ranging in the middle. So as to find statistical significance the pool of participants should have a large range of WMC allowing for variation and division into high and low spans. The use of this technique was not possible in this study because of the little range of variation of WMC scores and so it was not possible to establish correlations between WMC and gains in L2 complexity of speech.
Key words: working memory capacity; L2 speech performance; gains in complexity; task repetition.

RESUMO: Este estudo parte do pressuposto de que falar um segundo idioma (L2) é uma habilidade cognitiva complexa executada dentro dos limites da capacidade de memória de trabalho (CMT) responsável pela manutenção e processamento simultâneo de informação durante a execução de tarefas complexas. Na memória de trabalho (MT) há uma compensação entre suas funções de processamento e manutenção de informação assim como na produção oral de L2 há evidência de uma compensação entre os objetivos da produção oral, quais sejam, a fluência, acurácia, complexidade e densidade lexical (Fortkamp, 2000; D' Ely, 2006). Bygate (2001b) encontrou evidência de que na repetição de uma tarefa oral há ganhos em termos de complexidade da fala às custas das outras dimensões da produção oral. Este estudo investigou se a (CMT) está relacionada com os ganhos na produção oral de L2 na repetição, ou seja, se os participantes com maior CMT ganhariam mais em termos de produção oral de L2 nesta condição. Os resultados mostram que houveram ganhos na produção oral em termos de complexidade de fala, acrescentando evidência para o estudo de Bygate (2001b) e esses ganhos parecem ter sido alcançados às custas, especialmente da acurácia da fala. Devido ao pequeno número de participantes (12), não houve variação em termos de amplitude de MT, tendo a maior parte dos participantes sido enquadrados num nível intermediário. A fim de se achar significância estatística é preciso ter um grupo de participantes com ampla variação de amplitude de CMT, permitindo, assim, a divisão do grupo entre altos e baixos. O uso dessa técnica não foi possível neste estudo devido à pouca variação de amplitude de memória de trabalho e portanto a correlação entre a CMT e os ganhos na produção oral de L2 na repetição não puderam ser estabelecidos.
Palavras-chave: capacidade de memória de trabalho (CMT); produção oral de L2; ganhos em complexidade; repetição de tarefa.

INTRODUCTION

Speaking a foreign language is a high cognitive skill which involves many complex sub-processes. As with other skills, most of these sub-processes take place without our awareness and/or control and must be proceduralized or automatized so as to free mental capacity to execute other functions (Anderson, 1995, Ashcraft, 1994).

Information processing theory conceptualizes human beings as autonomous and active, processors with limited capacity cognitive system - working memory - responsible for online processing and temporary maintenance of information in the performance of complex tasks such as problem solving, reading and speaking among others (Ashcraft, 1994). The mental processes involved in the performance of complex tasks compete for the limited attentional capacity of working memory, which has to be shared between on-line processing and storage of relevant information (Baddeley & Logie, 1999).

Levelt (1989) conceptualizes speaking as a cognitive process which involves the operation of controlled and automatic processes operating in tandem. Speech production happens in three different stages in his model, namely, the Conceptualization of messages when more controlled processes operate (at least in the case of L1 speaking) and the Formulation and Articulation of messages which involve more automatic processes. Working memory, in Levelt's model, plays a major role in the Conceptualization and Monitoring of messages which require controlled processes, thus, using more attention from working memory. In the case of L2 speech production, there is evidence that the processes involved in the Formulator are not automatic in L2, thus, using more resources from working memory capacity (WMC) than in L1 (Fortkamp, 2000).

Skehan (1998), also taking an information processing perspective explains L2 speech performance and acquisition in terms of the operation of a dual code system made up of a rule-based system responsible for the generation of language in a creative way using much computation for this and a memory-based system which is faster because is relies on lexicalized language which was memorized as a chunk rather than analyzed and created through rules. According to him, fluency is linked to the memory-based system since learners, when operating under processing pressure, have to rely on ready-made chunks of language to be fluent whereas complexity and accuracy are more related to the rule-based system since these two measures require analyses of rules. It follows from this that there are trade-offs among the goals of oral performance, specially in terms of complexity and accuracy, two aspects of speech production which draw on the same pool system. The rule-based system can be used to generate new instances of language when time and conditions allow (producing speech with more complexity and accuracy) and the memory-based system is usually preferred in natural communication where time pressure and processing load are operating, thus, producing more fluent language.

Most studies on L2 speech production agree that mastering a foreign language involves speaking it with complexity, fluency and accuracy (Bygate, 2001b; Fortkamp, 2000; D'Ely, 2004, 2006, to mention but a few). Studies on task effects on speech production show that there are trade-off effects among these three competing goals of oral production. There seem to be, in particular, trade-off effects between complexity and accuracy (Skehan, 1996,

1998; Bygate, 2001b; Fortkamp, 2000; D'Ely, 2004, 2006), two measures closely linked to control processes and working memory capacity.

Bygate (2001,b) studied the effects of task familiarity on speech performance departing from the assumption that when learners had the opportunity to perform the task for the second time, their attention would be targeted to different aspects of the oral production process at each new opportunity, thus leading learners to improve their performance gradually. He claimed that task repetition could influence learners' oral performance by rellocating their focus of attention. He hypothesized that the performance in the repeated task would be better than in the first trial in terms of fluency, accuracy and complexity. His hypothesis was not fully confirmed for there were trade-off effects among the three competing goals of oral performance, that is, accuracy, fluency and complexity. However, he found that, overall, complexity seemed to improve in the repeated task. Thus, he concluded that speech performance lost in accuracy and fluency so as to gain in complexity in the repetition condition.

Similarly to the trade-off effects found in L2 speech production, studies on working memory (MW) show evidence for the trade-off effects between its two main functions, namely, storage and processing of information. Most research to date acknowledges the fact that working memory capacity may be seen as a possible independent variable on the processes involved in both L1 and L2 speaking (Daneman & Green, 1986; Daneman, 1991; Fortkamp, 1999, 2000; Weissheimer, 2006). These studies have shown that individuals with a higher working memory capacity tend to outperform those with a lower capacity at fluency, accuracy, complexity and lexical density.

Bearing this panorama in mind, the goal of this paper is to analyze the role of working memory capacity in the L2 speech production of learners exposed to a task involving describing a picture at first trial and then repeating the task again at second trial. The assumption underlying this paper is that learners who have a higher working memory capacity will be able to allocate more attention in the processes involved in L2 speaking, thus retrieving more information from long-term memory and, as a consequence, benefiting more from the repetition condition than lower spans.

THE STUDY

The main assumption supporting the present study is that L2 speaking is a complex cognitive task which is carried out within the constraints of a limited-capacity system, namely, working memory. In this system, there are trade-off effects between the storage and processing functions of working memory just as in L2 speaking there seems to be now sufficient evidence for the trade-off effects among fluency, accuracy and complexity when L2 learners perform under processing pressure (Fortkamp, 2000; Bygate, 2001b). The research question guiding this study is the following: Is there a relationship between working memory capacity and gains in L2 speech performance in a picture description task with repetition condition? This question originated the following hypotheses:

1. There are no gains in performance in terms of complexity/ accuracy/ fluency of L2 speech in the second trial of the repetition condition.
2. There are gains in performance in terms of complexity/fluency/accuracy of L2 speech in the second trial of the repetition condition and they correlate with individual differences in working memory capacity.
3. There are gains in performance in terms of complexity/fluency/accuracy of L2 speech in the second trial of the repetition condition but they do not correlate with individual differences in working memory capacity.

PARTICIPANTS

This study was conducted in an intact class environment. This class was an experimental class where students attended English classes for free in exchange for participating in research. Different researchers were collecting data in this group in a collaborative enterprise but all of them did so as part of the class routine. The total number of students in the group was 24 but only twelve (6 male and 6 female) were used for this specific study. Although the rest of the group was not used for this particular study (for some of them had missed class or not taken all the tests), all the students in class would follow the same procedure, doing the same tasks and tests as the others. The researcher taught the group during all semester. All the participants in this experimental class were pre-tested with an oral interview and picture description to participate in this group to ensure that all participants had the same L2 oral proficiency level (in this case, intermediate).

DATA COLLECTION

This study consisted of one task for speech elicitation (picture description at first trial and description at second trial with repetition) and a memory test (speaking span test). Participants' WMC was assessed through a speaking span test (SST) which followed Daneman and Green's SST (1986) and was adapted to L2 (Weissheimer, 2004). This test consists of sets of unrelated words, which were read by the subjects silently. At the end of each set, subjects were required to produce a sentence aloud for each word presented. Each sentence had to be formulated following its original form and order of presentation. The participants' score was the total number of sentences made with the correct word.

Speech production was elicited through a picture description task. The picture was an advertisement for clothes in a magazine showing many people on a busy street (Appendix 1). The reason to use a description task was two-fold: the first can be traced back to Fortkamp (2000), who, through linear regression analysis found that WMC was a better predictor of speech performance in the description task than in the narrative task. In the narrative task the performance was only linearly related to WMC. Among the different measures she used for speech performance, complexity held the highest scores, thus, showing that, WMC was a good predictor of speech performance and among the many

measures, especially of complexity. The second reason is that, according to Robinson (1995), picture description is a *here and now* type of task which is less cognitively demanding than *there and then* tasks such as narratives. Since this group was an intermediate level group, the researcher thought that using a less demanding task was the most informed choice in this case.

Four measures of speech performance were calculated following Fortkamp (2000). Complexity (Comp) of speech was measured in terms of number of dependent clauses per minute and was calculated by dividing the total number of dependent clauses by the time taken to accomplish the task in seconds and then multiplied by 60 to express the number in minutes. Fluency (Fl) was measured in terms of speech rate unpruned and was calculated dividing the total number of semantic units produced, including repetitions, by the total time, including pause time and expressed in seconds that the subject took to complete the task. Accuracy (Acc) was calculated by the total number of errors divided by the number of semantic units produced and the resulting figure multiplied by 100 to express the number of errors per 100 words. Finally, lexical density (LD) was calculated by the total number of weighted lexical items divided by the total number of weighed linguistic items and multiplied by 100 so as to obtain the percentage of weighted lexical items over the total number of weighted linguistic items in the speech sample.

In this study gains in performance were operationalized as speech with more complexity and/or fluency and/or lexical density and/or accuracy in the second trial of the description task and was measured through a comparison of means (for T-test see Appendix 2). So as to investigate the relationship between individual differences in working memory capacity and gains in speech production in the second trial of the repetition condition a correlation was run between the speaking span test scores and gains in the speech production measures.

ANALYSIS

In a preliminary analysis of the raw data, (Figure 1), independent sample T-tests were run (Figure 2) for all the speech production measures (complexity, accuracy, speech rate unpruned and weighed lexical density) and no significant gains in performance were found in the second trials except for the complexity measure as can be seen in figures1 and 2.

Figure 1 – Scores memory test and speech production measures

	sst	comp 1	comp 2	acc1	acc2	sr1	sr2	lex1	lex2
1	32	,57	,90	2,61	3,01	87,4	111,30	61,72	55,71
2	29	,00	,39	1,13	6,54	80,0	67,20	60,14	57,50
3	35	,00	,69	1,78	3,19	103	65,58	62,22	58,27
4	34	2,27	1,24	,51	2,48	147	67,08	58,38	58,92
5	23	,00	,79	1,42	4,39	54,5	72,79	67,46	58,67
6	27	1,20	2,52	4,16	9,17	67,2	68,84	60,60	57,40
7	32	1,24	2,64	3,28	6,41	114	82,50	54,88	55,33
8	29	,00	1,71	4,76	3,06	48,5	84,00	78,26	60,74
9	28	,25	,39	3,47	4,68	54,0	48,00	57,55	56,74
10	25	,82	1,31	1,86	3,75	87,9	87,69	60,18	55,35
11	32	,00	,90	1,66	6,21	60,0	36,31	70,68	57,67
12	32	2,68	3,06	3,51	3,06	115	99,79	57,50	58,76

Sst – Speaking span scores
Comp – Complexity
Acc – Accuracy
SR- Speech rate
Lex – Lexical Density

Figure 1- T-Test speech production measures

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	accuracy1 - accuracy 2	-2,1500	2,1821	,6299	-3,5364	-,7636	-3,413	11	,006
Pair 2	speech rate 1 - speech rate 2	10,6108	31,0887	8,9745	-9,1420	30,3636	1,182	11	,262
Pair 3	complexity 1 - complexity 2	-,6258	,7111	,2053	-1,0777	-,1740	-3,049	11	,011
Pair 4	speaking span test - operation word span test	-2,92	5,38	1,55	-6,34	,50	-1,876	11	,087
Pair 5	weighed lexical density description 1 - weighed lexical density description 2	4,8758	5,7461	1,6587	1,2250	8,5267	2,939	11	,013

As can be seen in Figure 1, participants gained in complexity of L2 speech at the expense, especially of accuracy which, except for one participant (P8), was worse for all the others in the second trial of this condition. As for speech rate and lexical density, the panorama that emerges is a little more complex for some participants improved in fluency (operationalized as speech rate) in the repeated task (P1, P5, P6, P8) whereas others (P2, P3, P4, P7, P9, P10, P11, P12) decreased. As for lexical density, except for participants 7 and 12, all the others performed worse in the second trial although the decrease was not as significant as the one in the accuracy measures which seem to have been the most penalized ones.

T-tests were run for the complexity measures showing that in fact there were gains in complexity in the performance of the second trial of the repetition condition and these gains were significant at $p<0.05$ as can be seen in figure 3.

Fig. 3

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	complexity 1 - complexity 2	-,6258	,7111	,2053	-1,0777	-,1740	-3,049	11	,011

However, the result of a Pearson Product Moment Correlation Analysis did not show significant correlations between complexity of speech in the repetition condition and individual differences in working memory capacity as can be seen in fig.4.

Figure 4- Person Product Moment Correlation Analysis for Complexity and WMC

Correlations

		average spans	complexity 2	complexity 1	gains
average spans	Pearson Correlation	1,000	-,041	,028	-,090
	Sig. (2-tailed)	,	,899	,930	,782
	Sum of Squares and Cross-products	279,229	-2,064	1,471	-3,535
	Covariance	25,384	-,188	,134	-,321
	N	12	12	12	12
complexity 2	Pearson Correlation	-,041	1,000	,702*	,357
	Sig. (2-tailed)	,899	,	,011	,255
	Sum of Squares and Cross-products	-2,064	9,088	6,552	2,537
	Covariance	-,188	,826	,596	,231
	N	12	12	12	12
complexity 1	Pearson Correlation	,028	,702*	1,000	-,415
	Sig. (2-tailed)	,930	,011	,	,180
	Sum of Squares and Cross-products	1,471	6,552	9,578	-3,026
	Covariance	,134	,596	,871	-,275
	N	12	12	12	12
gains	Pearson Correlation	-,090	,357	-,415	1,000
	Sig. (2-tailed)	,782	,255	,180	,
	Sum of Squares and Cross-products	-3,535	2,537	-3,026	5,563
	Covariance	-,321	,231	-,275	,506
	N	12	12	12	12

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

The only significant correlation found was between complexity on first and second trials. As can be seen from the above, only hypothesis 3 was confirmed, that is, there were significant gains in terms of complexity of speech in the second trial of the repetition condition but these gains did not correlate with individual differences in working memory capacity, that is, individuals with a higher working memory capacity were not the ones to profit more in terms of complexity of speech in the second trial of the repetition condition.

DISCUSSION

The fact that the highest gains were in terms of complexity of L2 speech (mirroring Bygate's 2001b findings), at the expense, especially of accuracy, lends support to the theory based on studies that found tradeoffs among the four dimensions of oral performance, specially between complexity and accuracy. As reviewed in the introduction to this paper,

both complexity and accuracy are believed to draw in the same pool, namely, the rule-based system (Skehan, 1998) and so, gains in one realm, are usually paid for by gains in the other.

One possible pedagogical implication for this finding is that, in the course of L2 speech development, so as to allow a balance in production among the many dimensions of L2 speech production, different tasks should be used, manipulating participants' attention and performance conditions so as to enable enough practice in all dimensions of speech production.

The lack of correlation between gains in performance in complexity of speech at second trial and individual differences in working memory capacity scores can be explained by the sample size used in this study which was too small to allow statistical variations. Ideally, so as to see differences in terms of working memory capacity, the group should be split into high and low spans. Unfortunately, this group varied very little in terms of working memory capacity for most of the participants were categorized as medium spans and so the number of higher and lower spans was too small to see differences in the treatment.

One variable that may have hindered the results of this study is the fact that the group selected was an experimental group where students had to do many tasks and tests as part of the program. The same group was used in four different studies and so the participants may have felt tired and over exposed to the tests applied. The second trial of the description, for instance, was done in the same day as the SST and although the data collection session took no longer than 30 minutes per participant, they may have been unwilling to take their time and show their best performance in the second trial of the description for they were doing the same task for the second time.

Finally, another aspect which must be taken into consideration when analyzing the results of this study is the fact that some students may have perceived the tasks as tests and so behaved accordingly. As Iwashita et al (2002) suggest, performance on tests differ from performance in class and so have to be analyzed differently and with caution. Whereas some of the students may have perceived the tasks as tests and felt stressed during its performance, others may have simply regarded the tasks as repetitions and so were not willing to show their best. Whatever the case at hand, task implementation for research purposes must be carried out with care and consideration of these issues.

CONCLUSION

The main goal of this study was to analyze individual differences in working memory capacity and their relationship with gains in L2 speech performance of learners exposed to the repetition condition. As can be seen from the analysis, there were significant gains in performance in terms of complexity of speech in the second trial, mirroring Bygate's (2001b) results for this condition, but these gains did not correlate with individual differences in working memory capacity so there is only partial support to the hypothesis put forward in this study, that is, participants benefited from the condition (repetition) gaining in terms of complexity of L2 speech but there is no empirical evidence that the ones who gained more are also the ones who have a higher working memory capacity.

There is evidence for trade off effects, specially between complexity and accuracy of L2 speech in this condition and it was suggested in this study that, based on this finding, task conditions should be varied and manipulated by the teacher so as to allow enough practice in each of the four dimensions of oral production.

The fact that no correlations were found between gains in performance and working memory capacity scores does not implicate that working memory capacity is not related to more gains in performance since the small number of participants did not allow statistical variation, thus, no claims can be made for this assumption that higher spans will perform better in this particular condition.

LIMITATIONS OF THE STUDY

As previously mentioned in the discussion section, any study aiming at analyzing individual differences in working memory capacity and their relationship with task effects should ideally have a large sample so as to allow for variations and statistical significance. Without that, the results of a study such as this, with a very small sample, have to be taken with caution and only as partial support for the theory brought to bear in this study.

SUGGESTIONS FOR FURTHER RESEARCH

The theory supporting the repetition condition is not only logic but also appealing and aligned with the information processing paradigm. Nevertheless, it remains to be seen whether individual differences in working memory capacity play a crucial role in the benefits advocated by such theory.

Since working memory is at the crux of human cognition, it can not be left behind in studies aiming at making claims for the beneficial effects of task designs. There is evidence for the role of both task manipulation and individual differences in working memory capacity in human cognition. Nevertheless, these studies are usually carried out isolatedly and so the results have to be integrated later on if we are to draw a precise map of what affects human cognition in general. So as to fill in this gap, more studies on the effects of task effects and working memory capacity on human cognition in general, and on L2 in particular, are called for.

Last but not least, if we are to have a clear picture of the effects of the repetition condition on speech performance and its relationship with individual differences in working memory capacity, more measures of speech performance would have to be analyzed so as to see how they interact under this specific condition. The same holds true for the construct of working memory capacity, which, as a latent variable, requires indirect techniques of measurement and analysis. One possibility to safe guard against expected shortcomings in measuring latent variables would be to use multiple measures of working memory capacity and complex factor analysis which, unfortunately, were beyond the scope of this paper.

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