

RELATIONSHIP AMONG INDIVIDUAL DIFFERENCES IN WORKING MEMORY CAPACITY, NOTICING, AND L2 SPEECH PRODUCTION

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ABSTRACT

Working memory is the human cognitive system in charge of the simultaneous and temporary processing and storage of information in the performance of complex cognitive tasks. A long tradition of research has shown that individual differences in working memory capacity are related to level of performance in these tasks. In the present study, we examine the relationship among individual differences in working memory capacity, noticing, and L2 speech production. It is suggested that working memory capacity is related to accuracy in L2 speech production but not to the ability to notice L2 formal aspects in the input.

Keywords: Working memory capacity. L2 speech production. Noticing.

1 INTRODUCTION

In the last decades, the constructs of working memory capacity (BADDELEY and HITCH, 1974; BADDELEY, 1990; DANEMAN and CARPENTER, 1980, 1983; DANEMAN and GREEN, 1986; MIYAKE, CARPENTER, and JUST, 1994; MIYAKE and FRIEDMAN, 1998; SHAH and MIYAKE, 1999; FORTKAMP, 1999, 2000), noticing (SCHMIDT, 1990, 1995; ROBINSON, 1995, 2001, 2002; LEOW, 1997), and second/foreign language (L2) speech production (GREEN, 1986; DE BOT, 1992; POULISSE, 1994, 1997; POULISSE and BONGAERTS, 1994; KORMOS, 2006) have gained increasing attention on the part of researchers and the findings of the studies carried out have consequently brought important contributions to the L2 acquisition and cognitive psychology fields. However, for the most part, this literature has addressed working memory capacity, noticing, and L2 speech production in isolation, despite the sound theoretical reasons for a relationship among the cognitive processes involved in each construct. In the present paper, we investigate how individual differences in working memory capacity, noticing, and L2 speech production relate. More specifically, the paper sets out to investigate how individual differences in working memory capacity relate to L2 learners' noticing and use of a grammatical structure in an L2 oral task.

In what follows, we first present an overview of the relevant literature on working memory capacity, noticing, and L2 speech production. Then, we present the method adopted for data collection and analysis. This is followed by the presentation and discussion of results. We conclude by advancing the proposal that noticing can be indeed a necessary condition for L2 learning to take place, as Schmidt (e.g., 1995, 2001) has proposed. However, learners' ability to notice a grammatical form and later use it in speaking is mediated by their working memory capacity.

2 REVIEW OF THE LITERATURE

INDIVIDUAL DIFFERENCES IN WORKING MEMORY CAPACITY

The idea that individual differences in first language use may reflect individual differences in working memory capacity is now relatively well accepted in the area of cognitive psychology. Broadly defined, working memory is the human cognitive system responsible for the simultaneous and temporary processing and storage of information in the performance of cognitive tasks (e.g., BADDELEY and HITCH, 1974; DANEMAN and CARPENTER, 1980, 1983; MIYAKE and SHAH, 1999), including language tasks such as reading, listening, writing, and speaking. Of a dynamic nature, the system shares its limited capacity between the work (i.e., the mental processing) and the storage of information necessary to accomplish task goals.

As recently pointed out by Unsworth and Engle (2007), it was with the work of Daneman and Carpenter (1980) that researchers started to investigate how individual variation in working memory capacity affected the performance of cognitive tasks. Daneman and Carpenter (1980) created a reading span test and were able to show that performance on this test was related to individuals' performance on reading comprehension tasks. Their claim was that individuals with a larger working memory capacity were also more efficient in carrying out the cognitive processing involved in reading comprehension. From 1980 on, a large body of research has been produced showing that variation in working memory capacity is related to a number of higher order cognitive tasks, from vocabulary learning (DANEMAN and GREEN, 1986) to visual search (KANE, POOLE, TUHOLSKI, and ENGLE, 2006).

Of particular interest to us is the study carried out by Daneman (1991), which examined how individual differences in working memory capacity are related to speech production in L1. Daneman (1991) hypothesized that individuals with a larger working memory capacity would be more efficient in the coordination of the cognitive processes involved in speech production. Using the speaking span test, Daneman (1991) showed that working memory capacity was related to oral fluency at the discursive and articulatory levels.

Further, Fortkamp (1999) replicated Daneman (1991) in order to verify whether Daneman's hypothesis would be also true in L2 speech production. Fortkamp's results were in line with Daneman's in that individuals with a larger L2 working memory capacity were also more fluent in L2 oral production tasks at the discursive and articulatory levels. In a follow-up study, Fortkamp (2000) hypothesizes that working memory is an attentional system whose capacity is shared by at least 4 macro-cognitive processes demanded by L2 speech production: (1) activation of information of the L1 and L2; (2) suppression of irrelevant information of the L1; (3) search and serial retrieval of L2 items; and (4) monitoring of performance either to avoid or to correct errors. The researcher's 2000 study suggests (and strengthens the 1999 study) that there is a relationship between learners' working memory capacity and fluency, accuracy, complexity, and lexical density in L2 oral performance.

In the area of L2 acquisition, other researchers (e.g., HARRINGTON, 1992; MIYAKE and FRIEDMAN, 1998) claim that working memory could be a constraint on the expansion of interlanguages. For instance, Miyake and Friedman (1998) show that L2 acquisition processes pose greater demands on working memory than L1 processes. In this sense, according to Miyake and Friedman (1998), an extra load in the system affects the quality and speed of acquisition.

As suggested by Ellis and Sinclair (1996), one of the complex cognitive tasks in the learning of an L2 is to deal with the abstraction and application of rules, since a great amount of attention has to be attributed to the suppression of the learner's L1 rule system. Ellis and Sinclair (1996) were able to demonstrate that individuals with deficits in working memory show restriction in the acquisition of syntax not only in L1 but also in L2. These researchers report that individuals who were prevented from rehearsing L2 phrases while doing a working memory test were less efficient in using metacognitive knowledge of syntactic rules and in abstracting grammatical regularities from sentences. These individuals were also more predisposed to making mistakes. In the same train of thought, Harrington and Sawyer's (1992) findings show that individuals with higher L2 reading spans were more successful in the grammar and vocabulary sections of the TOEFL than those with lower L2 reading spans.

Taken together, the studies reviewed above show that individual differences in working memory capacity seem to be related to L2 speech production and L2 acquisition of grammar. However, if assume, like Unsworth and Engle (2007) propose, that working memory as a system is necessary only in those tasks where there is a conflict between automatized and non (or less) automatized processes, then we need to ask where, both in L2 speech production and L2 grammar acquisition, this conflict is. It is to this issue that we now turn.

The most comprehensible psycholinguistic model of speech production was proposed by Levelt (1989). In his model, Levelt (1989) suggests that speech production processes are organized into four main components. The first component, the *conceptualizer*, generates the pre-verbal message by means of two kinds of conceptual planning: (1) *macro-planning*, which consists of selecting a particular information content and choosing levels of directness and politeness to speak by bearing in mind some communicative goals and sub-goals and by retrieving information in order to achieve such goals; and (2) *micro-planning*, which consists of bringing information into perspective by assigning issue and focus and of making decisions about the right form of the message.

The pre-verbal message is the content of the second component of the model, the *formulator*, in which it is translated into a linguistic structure by means of grammatical encoding and phonological encoding. The former consists of accessing lemmas (semantic information) and building a syntactic structure for the message by means of syntactic procedures. The latter, phonological encoding, consists of building a phonological and phonetic plan for the message. The product of the formulator is internal speech. *The articulator*, the third processing component, executes the phonetic plan as over speech. The last processing component, the *Speech-Comprehension System*, is responsible for monitoring the speaker's internal and overt speech. Monitoring, which may take place at all phases of the speech production process, allows speakers to contrast what they have intended to say to what they linguistically executed.

De Bot (1992) has adapted Levelt's model (1989) to explain L2 speech production and has made adjustments only where necessary. He hypothesizes that the speaker needs to choose what language to use before actually starting to encode the message. De Bot (1992) suggests that this decision takes place in the conceptualizer and assumes that macro-planning is language-specific and micro-planning is language-independent. De Bot (1992) also assumes that L1 and L2 grammatical encoding and phonological encoding take place through different procedures (DE BOT, 1992). In his adaptation, De Bot suggests that L1 and L2 lexical items are part of the same conceptual network, though they are stored in different subsets. Finally, De Bot assumes that the articulator is language-independent, which means it contains syllable programs and patterns for the L1 and L2.

With De Bot's (1992) proposal, one can see that it is in the formulator – where the message is given a linguistic structure – that L1 and L2 speech production will critically

differ. In L1 speaking, the procedures involved in grammatical and phonological encoding are highly automatized and, as such, require little attentional resources on the part of the speaker. Given that the knowledge base of the L2 speaker is incomplete – as compared to his/her L1 knowledge – it is plausible to assume that the procedures involved in L2 grammatical and phonological encoding are not as automatic, which implies that the L2 speaker has to devote a good amount of his/her attentional resources to the processing of grammatical and phonological information. In fact, L2 speech production, when compared to L1 speaking, is slower, more hesitant and, most times, displays lexicogrammatical deviations. These features of L2 speaking are believed to reflect the lack of automaticity of the processes that take place in the formulator.

Skehan (e.g. 1998) has shown that there is a conflict between fluency, accuracy, and grammatical complexity in L2 speaking. For him, the attentional resources of the speaker have to be shared among these three aspects of production, but more attention to one of the aspects penalizes production in the others. In particular, fluency (rate of speech) and accuracy (error-free speech) seem to be in constant competition, so much so that gains in fluency generally take place at the cost of losses in accuracy (and vice-versa).

It seems reasonable to argue that the conflict between fluency and accuracy results from the learner's difficulty in regulating attention for fluency and formal aspects at the same time (Skehan, 1998). In this sense, the *Noticing Hypothesis*, as proposed by Schmidt (1990, 1995) could be elucidative, since it proposes that the acquisition of L2 formal aspects depends on the degree of attention that the learner dispenses to these aspects during the acquisition process. For Schmidt (1990, 1995), when learners notice (i.e., pay attention consciously to) L2 formal aspects, they acquire them. It is through noticing, Schmidt (1990, 1995) argues, that L2 forms become part of interlanguage and can be accessed and retrieved for automatic use. For Schmidt (1990, 1995), noticing is a necessary condition for the acquisition of L2 grammatical aspects to take place.

Empirical studies suggest that noticing formal aspects of the L2 can bring benefits for individuals' accuracy in oral and/or written production. Leow (1997), for instance, examined the relationship between awareness and written production. His study investigated the human attentional system and its effects on L2 behavior, showing that differences in learning could be accounted for in terms of different levels of awareness. Leow (1997) concluded that the higher the level of awareness, the better the processing, which enhances recognition and accuracy in written production.

Concerning speaking, Bergsleithner and Fortkamp's (2005) study investigated the relationship between noticing and L2 speech production. After receiving instruction of some L2 formal aspects, participants were interviewed and asked to verbalize rules as well as produce two sentences orally by using the rule they were taught. Thus, noticing was measured by means of verbalization of rules (ROBINSON, 2001) and by the accuracy of the sentences participants produced. Participants were required to perform a picture description task in which the use of the target form taught was necessary. The results indicated that learners who paid more attention to the L2 formal aspects taught could also perform the L2 oral task more accurately.

Taking into consideration that learners differ in their working memory capacity and that these differences are related to performance in various cognitive tasks, it is possible to argue for a relationship between working memory capacity and noticing. Ellis (1994) and Schmidt (1992) claim that noticing, and our attentional resources in general, are commanded by a central executive and constrained by limitations. The basic claim of the Noticing Hypothesis is that the way in which learners acquire L2 rules and grammatical constructions is related to the amount of attention they deliver to input. Obviously, different learners will notice different things when receiving language input: one learner may notice form, another may

notice phonological aspects, a third may notice vocabulary, and a fourth may notice form, meaning, and function relationships (Schmidt, 1990, 1995). This difference in noticing can be related to learners' motivation, interest or grammatical sensitivity (Schmidt, 1995). However, and this is our contention in the present study, this difference can also be associated to a more cognitive aspect: individual differences in working memory capacity and in attentional resources mechanisms.

3 METHOD

3.1 OBJECTIVE, RESEARCH QUESTION, AND HYPOTHESIS

The general objective of this study was to investigate the relationship between working memory capacity, noticing, and L2 speech production. The present study pursued the following research question: *Is there a relationship between working memory capacity, noticing, and L2 speech production?*

From this research question, the following hypothesis was generated: *There is a statistically significant relationship among learners' working memory capacity, noticing of L2 forms, L2 oral performance.*

3.2 PARTICIPANTS

This study was carried out with a group of 18 pre-intermediate learners from an extracurricular English language course offered by a major federal university in the south of Brazil. The choice for pre-intermediate learners was based on the fact that, as Selinker (1972) pointed out, it is at the intermediate level of language learning that a great number of changes in interlanguage take place.

3.3 PROCEDURES

The data collection for this study was divided into three phases: (1) the pre-testing phase, (2) the treatment, and (3) the post-testing phase. In the pre-testing phase, the participants were required to perform a speaking span test (DANEMAN and GREEN, 1986) and a picture description oral task in which a grammatical structure (the use of "need" + gerund or participle) was necessary. The treatment consisted of the instruction of the structure "need" + gerund or participle. The third phase – *the post-testing phase* - was divided into two sub-phases: (1) *immediate*, directly after the grammatical treatment and (2) *delayed*, one week after the treatment. The immediate sub-phase consisted of an oral protocol collection about the target structure. In the protocol the participants were required to verbalize the target rule and produce sentences by using the rule taught in the treatment. In the delayed phase, one week after the treatment and the immediate phase, participants were required to describe a new picture by using the rule taught in the grammatical treatment.

3.4 MATERIALS

3.4.1 THE SPEAKING SPAN TEST - SST

In order to assess the participants' working memory capacity, the *Speaking Span Test* (Daneman, 1991) was applied. This test was proposed by Daneman (1991) for L1 studies and adapted by Fortkamp (1999) for L2 studies. This test consisted of 60 unrelated words,

organized in sets of two to six words, which were silently read by the participants. These words were individually presented for one second on the center of a computer screen. At the end of each set, participants were required to produce orally a sentence for each word presented, in the form and order the word was presented. A participant's speaking span was determined by the number of correct sentences produced, the maximum being 60.

3.4.2 THE SPEECH PRODUCTION TASKS

In the pre-testing phase, participants were required to describe a picture. The adequate description of the picture requires the use of the grammatical structure "need" + gerund or participle. Participants recorded their speeches individually on tapes at the university language laboratory. Participants' speeches were transcribed and analyzed in order to verify whether the participants had used the grammatical structure in focus. The analysis of the transcriptions showed that participants did not properly know how to use the target structure.

In the delayed post-testing phase, a new recording was carried out in the laboratory, one week after the grammatical treatment and the oral protocol. For this recording, a new picture was used in order to minimize the effects of task repetition on the participants' oral production, following Bygate (2001). The participants were required to use the grammatical structure taught in the treatment so that we could verify whether the accuracy of the sentences they produced was maintained from the immediate (produced in the oral protocols) to the delayed phase.

3.4.3 THE ORAL PROTOCOLS

The interview aimed at measuring the participants' noticing through oral protocols about the grammatical structure they received instruction on. For that, we used Robinson's (1995) framework as a guide to elaborate the questions for the elicitation of the protocols. Basically, questions such as whether the participants noticed any rules, looked for rules, and verbalized rules (Robinson, 1995) were posed. We also asked the participants to produce two oral sentences using the rule. Noticing was measured by means of the accuracy of the participants' sentences.

3.5 MEASURES OF ACCURACY

For the picture description tasks, a general measure of accuracy in oral performance was adopted. Accuracy was measured in terms of number of errors per 100 words. In each participant's speech, the number of errors was divided by the number of words they produced. Then, the resulting figure was multiplied by 100 in order to express percentages (Fortkamp, 2000). As the focus of this pilot study was to analyze only accuracy in L2 oral production, errors in pronunciation and intonation were not included in the data analysis.

3.6 THE GRAMMATICAL TREATMENT

In the present study, we adopted a pedagogic intervention that has been the target of extensive research in the L2 area - *Focus on Form*. The idea of Focus on Form pedagogy was first proposed by Long (1991). For him, this kind of pedagogic intervention has as its objective to foster learners' awareness and noticing of L2 formal aspects. He proposed a reactive decision for focus on form, in which teachers should focus on form, meaning, and

function relationships during interaction when clarifying students' doubts about grammar, as well as when giving them feedback in communicative settings. However, the kind of focus on form chosen for the present study was the one known as *prospective decision*, as suggested by Robinson (2001). Focus on form through by means of *prospective decision* implies that the teacher decides what to teach according to either the syllabus or the learners' needs (DOUGHTY, 2001; ROBINSON, 2001). We found that, for the purposes of the present study, focus on form based on prospective decision was more effective than Long's (1991) proposal for a *reactive decision* of focus on form which, within an interactional perspective, is related to the teacher reaction to learners' mistakes and doubts by means of feedback and support (DOUGHTY, 2001; ROBINSON, 2001) in communicative settings. Although this kind of focus on form is considered to be beneficial to L2 teaching/learning, our study was not conducted in a classroom environment. In addition, the choice for the grammatical structure we focused on was due to the fact that the structure was part of the official syllabus of the course participants were taking. For the purposes of the present study, the treatment consisted of two classes of one-hour and a half, each.

3.7 DATA ANALYSIS

Data was analyzed predominantly through statistical treatment. Pearson's correlations were used in order to measure the relationship among working memory capacity – as measured by the Speaking Span Test (SST) – noticing, and L2 speech production. Comparisons between performance before and after the treatment were made through T-tests. We used an alpha level of .05 for all statistical tests.

4 RESULTS AND DISCUSSION

Figure 1 shows the relationship between working memory capacity, as measured by the speaking span test (SST), and the oral production task performed in the pre-testing phase. As can be seen, the results show a tendency by lower spans to produce a higher number of errors, while higher spans tended to produce a smaller number of errors. However, there was no statistically significant correlation between the two variables ($r(18) = -.375, p = .125$).

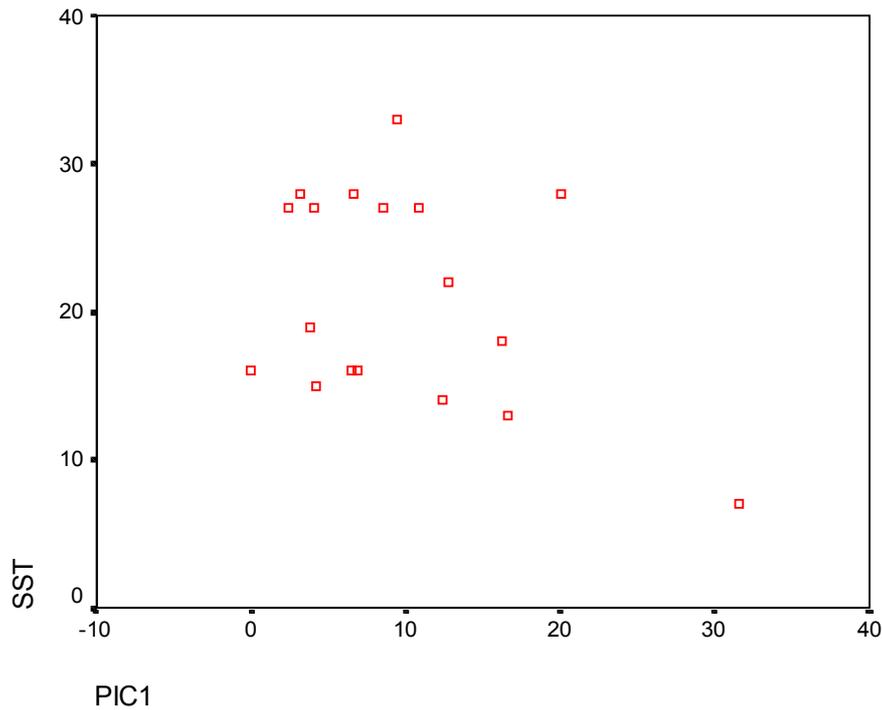


Figure 1: Results of the SST and oral production 1

As for the relationship between working memory capacity, as measured by the SST, and noticing, as measured by the accuracy of the utterances in the oral protocol after the grammatical treatment, Figure 2 shows that both higher spans and lower spans produced most of the sentences correctly. No statistically significant relationship between working memory capacity and noticing was found ($r(18) = .026, p = .918$). This lack of relationship can be explained by the effect of formal instruction, which might have favored both higher and lower spans, provoking noticing in the two groups (ROBINSON, 1995; 2001) and also by the lack of challenge in the task, which might have favored lower spans.

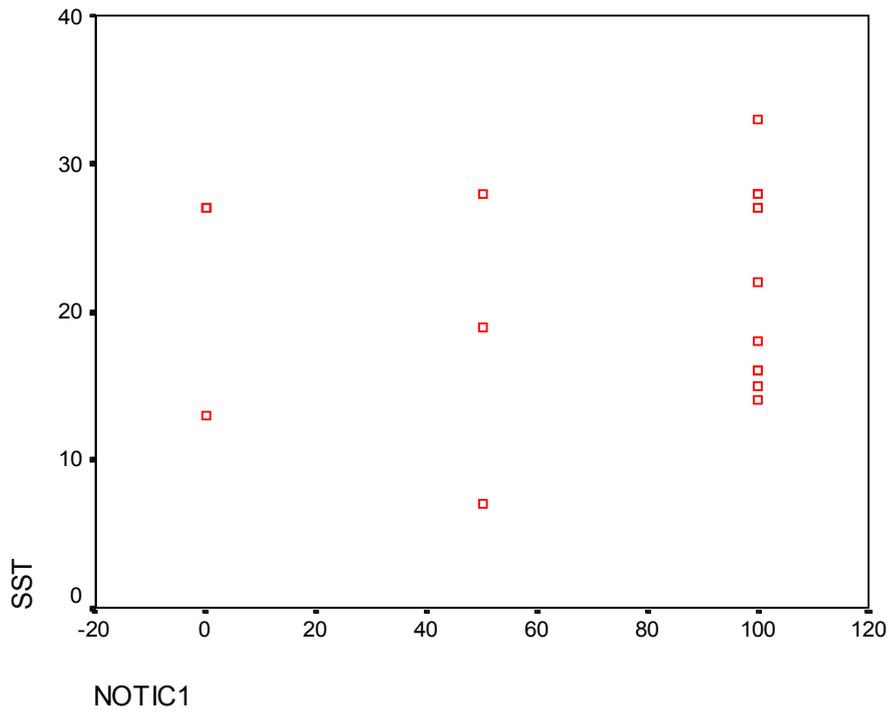


Figure 2: Results of the SST and the oral protocol

Figure 3 shows that, although there seems to be a relationship between noticing of the target form (“need” + gerund or participle) and accurate performance in the delayed oral task, this relationship is not statistically significant ($r(18) = .277, p = .281$).

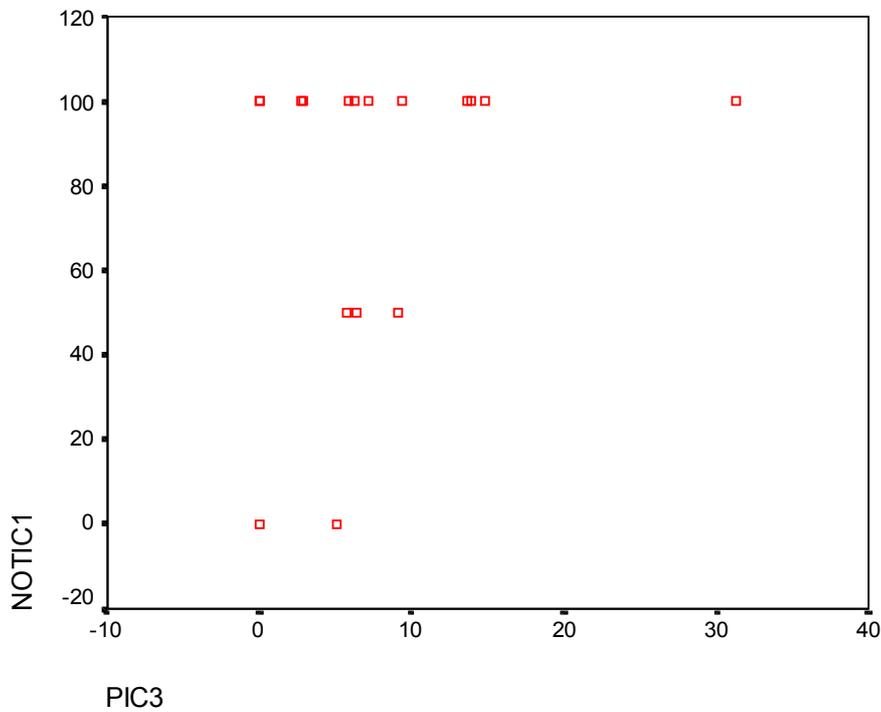


Figure 3: Results of the oral protocol and oral production in the delayed post-testing phase

Results of Pearson correlations show that there is a statistically significant relationship between working memory capacity and accurate performance in the delayed oral task, as can be seen in Figure 4 ($r(18)=-.652, p=.003$).

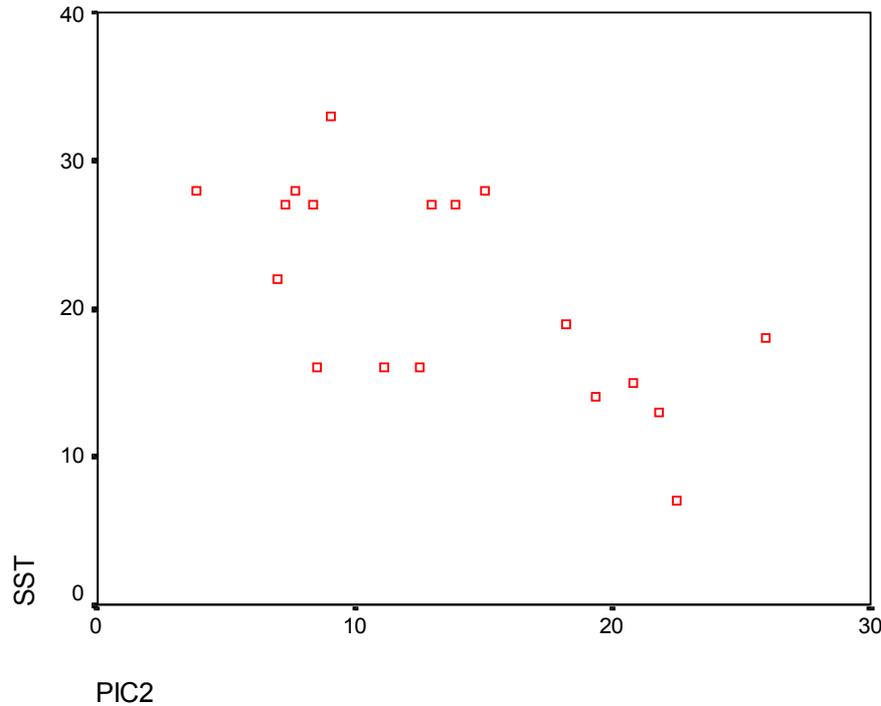


Figure 4: Results of the SST and the delayed oral task

These results might be taken as evidence that individuals with a larger working memory capacity are more prone to speaking accurately.

When comparing the participants' performance in the picture description task in the post-testing phase and their performance in the delayed picture description task, the results of a paired-sample T-test show that there was a significant reduction in the number of errors produced by the participants in the delayed task ($t(18) = 5.3, p < .001$), as Figure 5 shows. This might be an indication that the participants could notice the formal aspects of the target grammatical structure and were able to use the structure more accurately in the delayed task.

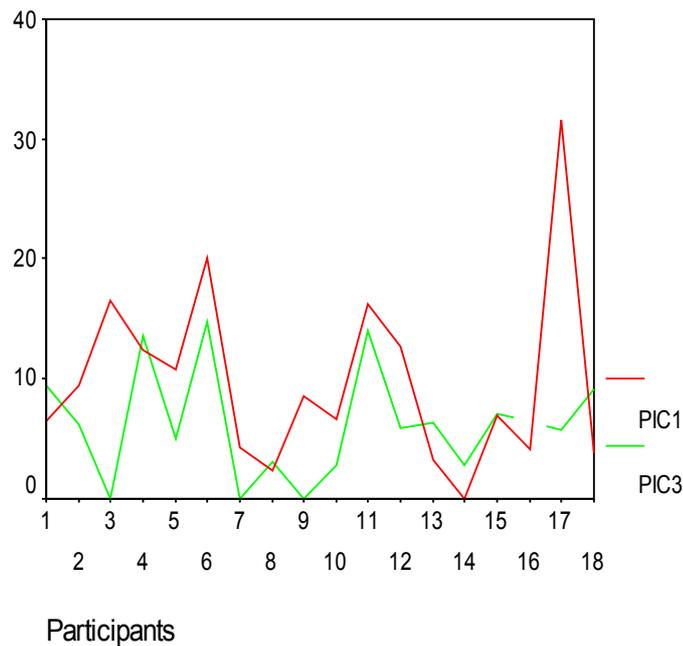


Figure 5: Results of the picture description task in the pre- and post-testing phases

The present study aimed at investigating the relationship among working memory capacity, noticing of L2 formal aspects, and L2 speech production. Pearson Product-Moment Coefficient of Correlation was used in order to analyze the data. Together, our findings can be interpreted as an indication that individuals with a larger working memory capacity tend to speak more accurately and that opportunities for noticing L2 forms tend to improve accuracy in L2 speech production. However, we did not find evidence for a relationship between working memory capacity and noticing. As a result, the hypothesis we investigated in the present study was not supported.

Contemporary models of working memory advance the proposal that differences in the capacity of the system will appear in tasks that require the control of attention in the face of interference, distraction, and conflict in task goals related to highly automatic responses (KANE, CONWAY, HAMBRICK, and ENGLE, 2007). Given the cognitive demands posed by L2 speech production processes and by the task of consciously perceiving L2 formal aspects (in which the L2 learner has to deliberately devote attention to input), it is unlikely that individual differences in working memory capacity, noticing, and L2 speech production are not related, as our results seem to suggest. Therefore, we offer an alternative explanation for the lack of strong evidence for a relationship among these three cognitive variables which has to do with problems in the method we adopted for assessing noticing and accurate use of the target structure.

First, the picture used in the delayed oral task produced a ceiling effect and led the participants to use the target grammar structure without much elaboration. The degree of difficulty of the cognitive task is an important factor in the study of working memory capacity. As Unsworth and Engle (2007) claim, tasks that do not require maintenance of new and novel information in a high level of activation are unlikely to tax working memory capacity. The statistically significant relationship we found between working memory capacity and accuracy in the oral tasks does not invalidate this argument since, as explained in the method section, the measure of accuracy we used in these tasks was a general one and was determined by number of errors per 100 words. This might have masked the relationship. Percentage was not a good method because, among other reasons, the lower spans produced

fewer sentences with the target structure and, therefore, made fewer mistakes. A look at the speech samples of higher spans shows that those were the participants that took more risks, producing more sentences with the target structure. We acknowledge that the picture should have been more challenging in order to tax participants' working memory capacity more heavily in the use of the target structure.

The second drawback is related to the assessment of noticing. Capturing the cognitive processing involved in the use of consciousness in learning is not an easy task. For the purposes of the present study, we considered the accuracy of the two sentences produced in the oral protocols as evidence of noticing. This is certainly a very general measure that, among other problems, does not reveal the cognitive processing that working memory is responsible for. It could also be that the very task of producing two sentences containing the target structure right after the treatment did not even tax working memory capacity.

In all, our results are encouraging in the sense that, given the relevance of a cognitive system such as working memory to the performance of complex cognitive tasks, more research is need in the L2 area to adjust methods of assessment of cognitive behavior. We hope to be able to contribute to that in the near future.

Note

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RESUMO

A memória de trabalho é o sistema cognitivo responsável pelo processamento e armazenamento simultâneos e temporários da informação necessária para o desempenho de tarefas cognitivas complexas. Uma longa tradição de pesquisa mostra que diferenças individuais na capacidade desse sistema estão relacionadas com níveis de desempenho nessas tarefas. Neste estudo, investigamos a relação entre capacidade da memória de trabalho, percepção consciente e produção oral em L2. Os resultados obtidos sugerem que a capacidade da memória de trabalho se relaciona com a acurácia do desempenho oral em L2, mas não com a capacidade do indivíduo de perceber conscientemente os aspectos formais do insumo.

Palavras-chave: Capacidade da memória de trabalho. Produção oral em L2. Percepção consciente.