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Structural priming effects during the oral production of English as L2

Efeitos de priming *estrutural na produção oral de inglês como L2*

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ABSTRACT

Structural priming effects in L1 oral production are associated with the automatic nature of processing and implicit knowledge. In L2, however, these effects are not well known. The present study investigated syntactic processing in the oral production of Brazilian Portuguese late learners of English as L2 to determine if structural priming effects can be detected within the L2. To do so, participants performed an oral sentence production task in English within four experimental conditions in which the use of active and passive voices with and without repetition of the main verb was manipulated. Participants also performed an oral sentence production task in the active and passive voice that served as a baseline to detect their individual preferences in the use of verbal voices. Results demonstrated a complex interaction between structural priming effects and the individual tendency to reuse the syntactic structure in L2. Results also showed a greater production of the passive voice structure in the experimental conditions in comparison to the baseline. Furthermore, the effects of structural priming were mainly found in conditions 3 and 4, which were both related to the passive voice, the less frequent structure. The results in condition 3 indicated an interaction of structural priming effects and the repetition of the head of the structure (i.e., the verb), meaning that verb repetition boosted these effects when structure (i.e., the passive voice) and verb were repeated (*lexical boost*). Taken together, these findings provide evidence for structural priming in English as L2 during oral production, mainly in the passive voice structure.
KEYWORDS: Structural priming L2. Syntactic processing.

RESUMO

Os efeitos do *priming* estrutural na produção oral da L1 estão associados à natureza automática do processamento e ao conhecimento implícito. Em L2, no entanto, esses efeitos são pouco conhecidos. O presente estudo investigou o processamento sintático na produção oral de aprendizes tardios de inglês como L2, falantes de português brasileiro como L1, para determinar se os efeitos de *priming* sintático podem ser detectados na L2. Para tanto, os participantes realizaram uma tarefa de produção oral de sentenças em inglês em quatro condições experimentais nas quais o uso das vozes ativa e passiva com e sem repetição do verbo principal foi manipulado. Os participantes também realizaram uma tarefa de produção de sentenças orais na voz ativa e passiva que serviu *baseline* para detectar suas preferências individuais no uso de vozes verbais. Os resultados demonstraram uma interação complexa entre os efeitos de *priming* estrutural e a tendência individual de reutilizar a estrutura sintática em L2. Os resultados também mostraram uma maior produção da estrutura da voz passiva nas condições experimentais em comparação com a linha de base. Além disso, os efeitos do *priming* estrutural foram encontrados principalmente nas condições 3 e 4, ambas relacionadas à voz passiva, a estrutura menos frequente. Os resultados na condição 3 mostraram uma interação entre efeitos de *priming* estrutural e a repetição do núcleo da estrutura (i.e., o verbo), indicando que a repetição do verbo

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aumentou os efeitos quando a estrutura (voz passiva) e o verbo foram repetidos (impulso lexical). Sendo assim, esses resultados fornecem evidência para o *priming* estrutural em inglês como L2 durante a produção oral, principalmente na estrutura da voz passiva.
PALAVRAS-CHAVE: *Priming* estrutural. L2. Processamento sintático.

Introduction

In the domain of acquisition and processing of syntax in L2 by late learners, one central inquiry revolves around the nature and organization of syntactic knowledge in a brain that stores multiple linguistic systems: are the syntactic representations related to these various systems shared among languages or are they kept separate, despite potential interaction?

Hartsuiker et al (2016) explain that there are two main views regarding syntactic representation in L2. In the shared syntax view, syntactic representations, as well as the processes operating on these representations, are shared between the learner's languages when the syntactic structures are sufficiently similar. In their lexicalist model of shared syntax, Hartsuiker et al (2004) posit the integration of the lexicon and syntax of an individual's multiple languages. In this model, each language of a bilingual or multilingual speaker comprises distinct lexical representations. These representations encompass both conceptual and combinatorial linguistic information that is shared across the languages, resulting in a single representation that, when activated in one language, is also activated in the other. In recent versions of the model (e.g., BERNOLET; HARTSUIKER, 2018), the sharing of syntactic information is the final state of acquisition. In the initial stages of learning, however, the syntactic representations of languages remain separate, gradually converging throughout the learning process due to language exposure. Non-lexicalist views on syntactic representation, such as that proposed by Chang, Dell, and Bock (2006), also argue in favor of shared syntax among languages.

In the separate syntax view, on the other hand, the syntactic representations of languages interact but are organized independently, within distinct linguistic systems. Production or comprehension processes of a sentence in one language, for instance, remain qualitatively separate from those in the other language, and this is largely due to the critical period for language acquisition. While representations and processes can interact, this interaction also relies on the typological proximity between languages and proficiency in L2. One model that posits the separation of syntactic representations and processes in late bilinguals is the Declarative Procedural Model (ULLMAN, 2001)

According to the Declarative/Procedural (DP) model Ullman (2001) learning, storing, and using language lay on two memory systems: the *declarative memory system* and the *procedural memory system*. The declarative memory system is responsible for learning and retrieving lexical and semantic information, which is considered to be at least partly explicit; the procedural memory system is responsible for learning and retrieving rules and sequences, as well as motor and cognitive skills, all of which consist of implicit knowledge (ULLMAN, 2001). The DP model is well established and makes predictions for how these systems are enhanced in L2 learning. Yet, the precise engagement of these memory systems in L2 perception, comprehension, and production remains unclear.

One way to approach the debate on whether L2 syntax is shared or independent in bilinguals and multilinguals is through structural priming. Structural priming is a cognitive phenomenon in which speakers tend to reuse syntactic structures they have been previously exposed to (BOCK, 1986) and in which there is facilitation in the processing of a syntactic structure following exposure to a similar structure (PICKERING; FERREIRA, 2008; TOOLEY; TRAXLER, 2010). Structural priming can occur in both language comprehension or production, in the L1 and L2 (or Ln). Due to its potential to shed light on the status of syntactic representations (whether shared or independent, whether related to the lexicon or not), thus determining the constraints applied to structure processing in both production and comprehension, the phenomenon of structural priming is considered a window into understanding the syntactic system of bilinguals and multilinguals. In the last two decades, structural priming has been observed in L2 users within and across languages (for a review, see Jackson, 2018), in a wide age range, and in a wide variety of languages, in the case of cross-language structural priming.

In the present study, we aim at contributing to the discussion on the nature of syntactic representations in L2 late learners, speakers of Brazilian Portuguese (L1) and English (L2). The main objective of the present study was to investigate whether there were structural priming effects during sentence production within the L2. For doing so, three research questions were pursued:

Research Question 1: Are there structural priming effects during the oral production of sentences in English as L2? If so, which syntactic structure may benefit from structural priming: the active voice or the passive voice structure?

Research Question 2: If structural priming effects are found during the production of sentences, are these effects related to verb repetition?

Research Question 3: Is syntactic processing independent of lexical repetition?

In order to answer the research questions presented above and supported by the literature of structural priming (e.g, BOCK, 1986; PICKERING; BRANIGAN, 1999; HARTSUIKER et al, 2016) the following predictions were addressed:

Prediction 1: There are structural priming effects on the oral production of sentences in English as L2. These effects will be stronger for the passive voice structure than for the active voice.

Evidence shows that structural priming effects can be detected in both L1 and L2. For instance, Segaert et al. (2011) showed that in L1, structural priming effects are enhanced in less frequent structures during production. Likewise, Biria and Golestan (2013) showed that in L2, structural priming may increase the production of less frequent structures. Based on Branigan, Pickering, Stewart, & McLean (2000) and Schoonbaert et al. (2007), we expect to find evidence of structural priming within English L2 during production. In addition, based on Segaert et al. (2011), we expect to find stronger structural priming effects in the two passive voice conditions: Condition 3, which consists of a passive prime with verb repetition in the target and Condition 4, in which the structure is repeated between prime and target, without verb repetition (see table 2).

Prediction 2: Structural priming effects during the production of sentences in the passive voice in English as L2 are related to verb repetition.

According to the residual activation theory, structural priming effects are boosted when the head of the construction is repeated (i.e., verb, noun). In this study, the head of the construction is a verb. In line with this, Branigan et al. (2000), based on Levelt et al. (1999) model of combinatorial nodes, suggested that structural priming depends on the activation of syntactic representations, which are stored in combinatorial nodes that are once again activated in the processing of a subsequent structure if considered relevant. This assumption may enhance structural priming due to cognitive economy. Thus, we assume that after a passive voice prime with the head of the construction (i.e., verb) repeated, it is more likely that the activation of the recent used structure (i.e., passive) in combination with the verb repetition would boost the production of this structure. Therefore, we expect to find syntactic priming effects in condition 3, which consists of a passive prime with verb repetition in the target.

Prediction 3: Syntactic processing is independent of lexical repetition.

Some studies (PICKERING; BRANIGAN, 1998; HARTSUIKER et al., 2004) have shown that participants produced more target structures when prime and target have identical lexical items due to the lexical boost. On the other hand, McDounough and Mackey (2008) found that structural priming was stronger when participants produced the target structure with new lexical items in the L2. Likewise, Ferreira and Bock (2006) reported that structural priming may occur even when an initial prime and a target sentence share the same syntactic structure, however, have different heads (i.e., verb). If so, the two conditions with no lexical repetition (that is, condition 2 and condition 4) may also benefit from structural priming effects. To appraise the objectives of this study, a behavioral experiment was conducted with a group of Brazilian Portuguese (BP) speakers of English as L2. Participants' profile is described in the following subsection.

1. Method

1.1. Participants

In this study, a structural priming oral production task was conducted with 31 participants (10 males), aged between 18 to 52 years (M_{age} = 24.4 years; SD = 7.32). Participants completed a biographical and language experience questionnaire and underwent a proficiency test to confirm their eligibility for the study. The level of proficiency in English required for participation was advanced C1 or C2, as outlined by the Common European Framework of Reference for Languages (CEFR).

According to the information participants provided in the biographical and language experience questionnaire, with respect to education, 17 participants were undergraduate students from the Federal University of Santa Catarina (UFSC), 11 of them reported having finished undergraduate studies and 3 of them were graduate students at UFSC. Regarding instruction in their L2, the mean age participants reported starting learning English as L2 was around 10 years of age and most of them considered themselves proficient in English around the age of 18 years. They reported using English occasionally in the university or at work; they also reported a minimum of 2 hours of daily exposure to the L2 throughout movies, TV series, among others.

Regarding proficiency, all participants were required to take the online level test Exam English, which demonstrated their proficiency in English was equivalent to C1 and C2 (CEFR). Participants also provided self-evaluation concerning proficiency and most of them reported being very good at speaking. In relation to experience abroad, 8 participants reported having lived more than 3 months in an English-speaking country. Information regarding participants' profile is summarized in table 1.

Table 1: General information regarding participants' profile

Participant	Age	Gender	Level of English	Starting age of L2 learning	Reported time living abroad	Average daily timing exposure to the L2
01	26	F	C1	15	0	2
02	24	M	C2	14	0	3
03	23	F	C1	11	0	5
04	18	F	C2	8	0	5
05	19	F	C2	8	3 years	5
06	23	F	C2	14	1 year	3
07	22	M	C1	10	0	5
08	19	M	C1	16	6 months	3
09	25	F	C2	7	0	6
10	25	F	C2	6	0	1
11	18	M	C2	6	0	8
12	37	M	C2	14	6 months	2
13	19	M	C1	11	0	5
14	23	F	C2	14	0	6
15	23	M	C1	19	5 months	4
16	22	F	C2	6	0	2
17	29	F	C2	10	1 year	1
18	19	F	C2	6	1 year	3
19	18	M	C2	6	0	2
20	42	F	C2	10	0	1
21	20	F	C1	13	0	5
22	28	F	C2	7	0	4
23	23	F	C2	11	0	6
24	33	M	C2	12	0	6
25	22	F	C1	14	0	5
26	18	F	C2	10	0	4
27	52	F	C2	10	2 years	2
28	23	F	C1	12	0	2
29	26	F	C2	12	0	4
30	19	F	C2	12	0	3
31	21	F	C2	7	0	5
N:31	**M= 24,41 (SD= 7,32)**	**Number of males 10.**	**C1 level: 9; C2 level:22**	**M=10,53 (SD=3,38)**	**8 lived abroad**	**M= 3,8 (SD=1,77)**

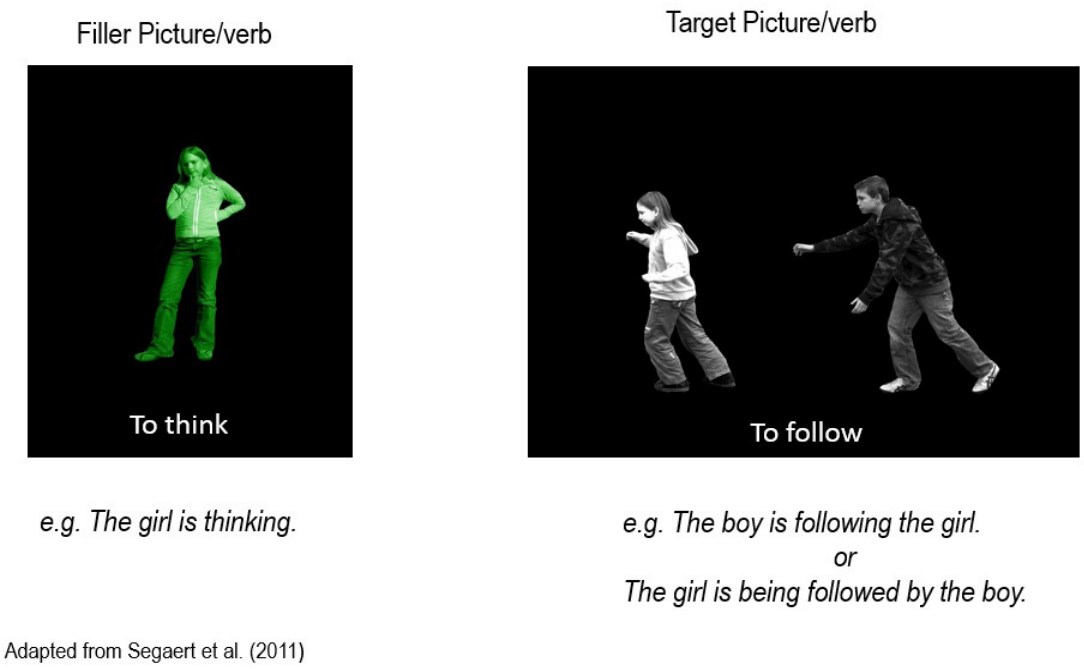
Source: by the authors

1.2. The syntactic priming oral production task

This experiment aimed at investigating structural priming effects in English L2 during an oral sentence production task, using a picture description paradigm. In the task, transitive verbs and pictures were manipulated in two target structures: the passive voice and the active voice. This was done to assess whether the production of a prime structure would enhance the production of a subsequent sentence with the same structure. This experiment was adapted from Segaert et al.'s (2011) to be conducted in a population of BP speakers of English as L2.

The structural priming oral production task consisted of two parts: a baseline and a syntactic priming part. The baseline part consisted of 48 pairs of trials. Each trial consisted of a filler and an experimental stimulus. There were 48 colored pictures with intransitive filler verbs, which showed one actor performing an action and a given intransitive verb to describe the action. These pictures were intercepted with 48 grayscale pictures with 48 transitive verbs, which depicted two actors performing an action and a given transitive verb to describe the action. In the baseline part, participants were instructed to describe the pictures with the verbs given by naming both actors in the pictures where two actors were shown. In this part of the task participants did not receive instructions to use a specific structure since this part of the task served to measure participants' natural preference for active or passive voice structure. In the baseline, each participant produced 96 sentences. Figure 1 shows an example of a trial in the baseline part and possible outcomes.

Figure 1: Baseline trial with possible outcome responses produced by participants



Source: by the authors

The structural priming part of the task consisted of 313 pictures with verbs, with 80 pairs of experimental trials. Each trial consisted of a prime picture followed by a target picture. Primes were pictures where actors (which could be a man or a woman and could be on the right or left side in the picture) were color-coded. Participants were instructed to start the sentence with the person colored in green, which may require either a passive or active voice sentence according to stimuli manipulation. For instance, if the verb given was *to pay* and the picture shows a woman in green receiving money and a man in red giving her the money, the elicited answer would be: *'The woman is being paid by the man*'. Targets were pictures in which actors were depicted in grayscale. In this case, participants could produce a transitive sentence in the preferred structure, which could be either a passive or an active voice sentence.

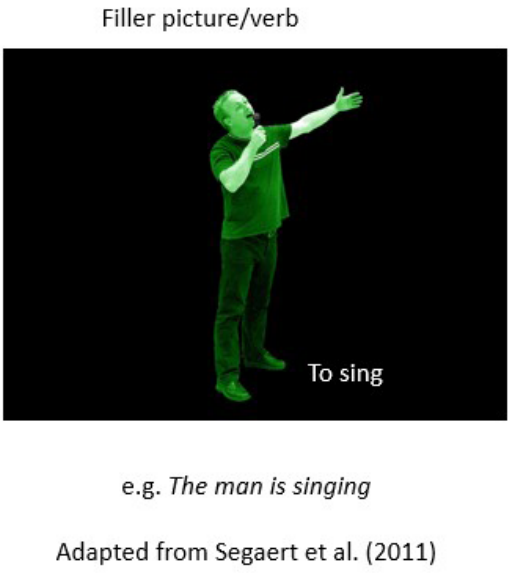
There were 160 pictures containing transitive verbs, 80 of which were prime pictures. These prime pictures portrayed one actor in green and one in red. The pictures were arranged to manipulate for the order of precedence in the sentence in two target structures: 40 pictures elicited sentences in the passive voice and 40 pictures elicited sentences in the active voice. The other 80 pictures were target pictures depicting two actors in grayscale. Therefore, participants could produce either an active or a passive sentence. The other 153 pictures contained intransitive verbs, which served as fillers. Each trial was intercepted with fillers that varied from 1 to 3 intransitive verbs and pictures (colored in green, red or grayscale) containing one actor performing an action. For instance, if the given verb was to *sing* and the picture showed a boy, a possible outcome would be: '*The boy is singing'*. In the structural priming part, each participant produced 313 (153 filler and 160 experimental) sentences. Figure 2 portrays an example of a trial in the structural priming part and possible outcomes and figure 3 illustrates an example of a filler.

Figure 2: Syntactic priming trial

Adapted from Segaert et al. (2011)

Source: by the authors

Figure 3: Filler picture



Source: by the authors

The structural priming part of the task consisted of 4 conditions and 80 experimental trials. Each condition consisted of 20 trials. Each trial consisted of a prime followed by a target. Prime pictures were color-coded to elicit either an active voice structure or a passive voice structure according to the condition. As can be seen in table 2, Condition 1 consisted of 20 trials with prime pictures eliciting active voice sentences and verb repetition in the target picture. Condition 2 consisted of 20 trials with prime pictures eliciting active voice sentences and no verb repetition in the target picture. Condition 3 consisted of 20 trials with prime pictures eliciting passive voice sentences and verb repetition in the target picture. Condition 4 consisted of 20 trials with prime pictures eliciting passive voice sentences and no verb repetition in the target picture. Table 2 presents examples of prime-target pairs in each condition.

Table 2: Examples of all experimental conditions

Condition 1	**Prime**	Active voice	Verb repetition	To lift
	Target	Active voice	Verb repetition	To lift
Condition 2	**Prime**	Active voice	No verb repetition	To help
	Target	Active voice	Verb repetition	To feed
Condition 3	**Prime**	Passive voice	Verb repetition	To pay
	Target	Passive voice	Verb repetition	To pay
Condition 4	**Prime**	Passive voice	No verb repetition	To follow
	Target	Passive voice	No verb repetition	To draw

Source: by the authors

Each condition consisted of 20 trials. Conditions and items were randomized[3] across the experiment, resulting in 80 trials interspersed by 153 fillers. Thus, participants saw the 4 conditions randomized and counterbalanced with filler pictures, ranging from 1 to 3 fillers across the experiment. As a result, each participant was asked to produce 96 sentences in the baseline part and 313 sentences in the structural priming part. A single list of stimuli presentation was created, thus all participants saw the stimuli in the same order. Table 3 illustrates an instance of the sequence of verb presentation in the baseline and table 4 displays an instance of the sequence of verb presentation in the structural priming part of the task.

Table 3: Baseline verb presentation

Intransitive verb	To dance
Transitive verb	To comfort
Intransitive verb	To drive
Transitive verb	To follow

Source: by the authors

Table 4: Example of a structural priming verb presentation trial

Prime	**Condition 2**	Transitive verb	To lift
Target	**Condition 2**	Transitive verb	To wet
Filler	**Filler**	Intransitive verb	To sneeze
Filler	**Filler**	Intransitive verb	To drink
Prime	**Condition 4**	Transitive verb	To assist
Target	**Condition 4**	Transitive verb	To transport

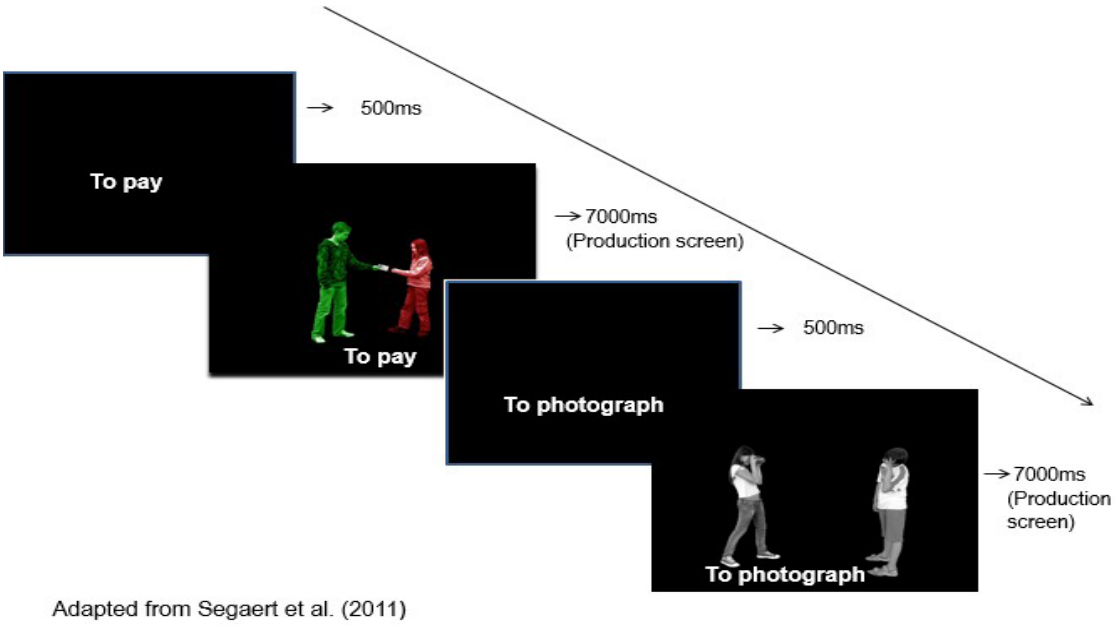
Source: by the authors

Participants were required to describe the pictures in one sentence. If actors were colored, participants were asked to start the sentence mentioning the person colored in green. If actors were not depicted in color, participants could start the sentence as they preferred. The sequence of the task consisted of the presentation of an English language transitive verb in the infinitive, with the font in white, in the center of a black screen for 500 ms. After that, participants saw two actors (a man and a woman or a boy and a girl) performing the action represented by the verb given and the

[3] Conditions and items were randomized using the online resource of https://www.random.org/lists/.

verb was presented again on the same screen for 7000 ms. Participants had to produce the sentence while the picture was shown on the screen, that is, they had 7000 ms to produce their sentence. If participants did not produce their sentence during the time given, the software would advance for the next frame and this sentence would not be taken into account for analysis. After producing a sentence, participants could press the space bar on the keyboard so that the next stimuli could appear allowing participants to perform the task quicker. Figure 4 illustrates the sequence of presentation of a trial.

Figure 4: Presentation of a trial without verb repetition



Source: by the authors

The stimuli used in this study were gently provided by Katrien Segaert. The syntactic priming oral production task was programmed in E-*prime 2.0* software (Psychology Software Tools, Pittsburgh, PA). The stimuli (verb followed by a picture) were shown on a DELL XPS 8700 computer with a DELL 23-inch widescreen monitor. First, participants were shown a verb in the middle of the screen for 500 ms. After that, a picture with the same verb previously shown was presented for 7000 ms. On the same screen participants produced sentences orally while the verb and the picture were on the frame. Participants used an HM-6 microphone to perform the task. Participants' responses were recorded by means of E-*prime 2.0* data collection.

1.3. Procedures

The experiment took place at an experimental cabin at the Laboratory of Language and Cognitive Processes (LabLing) at UFSC in one individual session per participant. The study was approved by the Committee for Ethics in Research at UFSC. Before starting the experiment, participants were asked to read and sign the consent form. Then, the participants filled in the biographical questionnaire

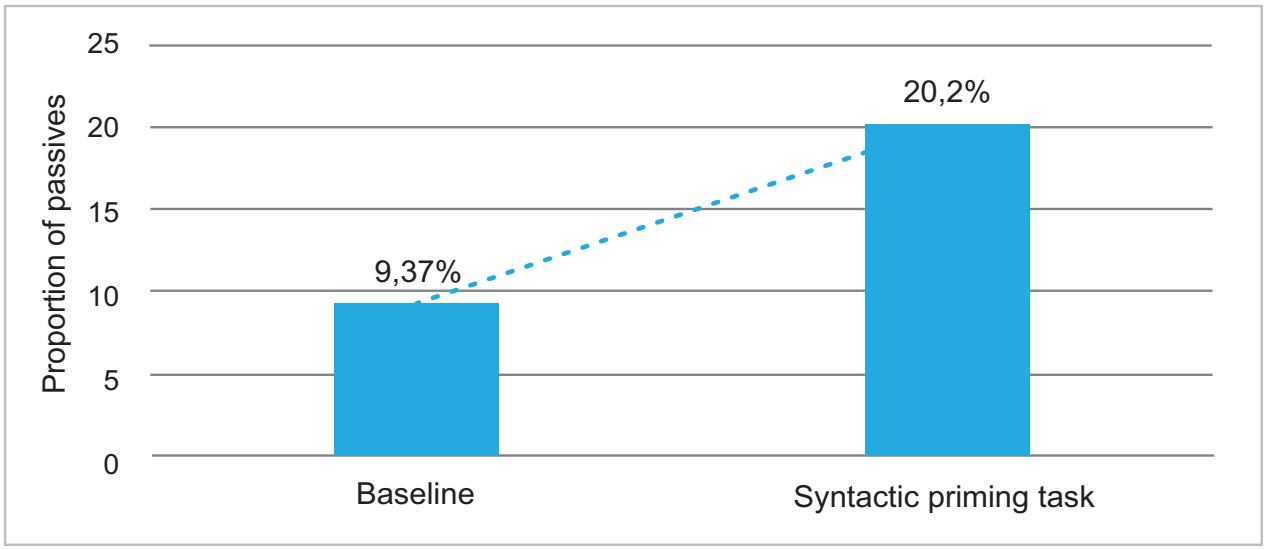
and language experience questionnaire. After that, they were required to take the online proficiency test and next, to perform the structural priming oral production task. Upon the beginning of the task, participants received oral and written instructions about how to perform the task. To make sure that participants were familiar with the task, a practice session, consisting of 6 trials, was provided before the experimental session.

After the practice session was finished, participants were left alone to conduct the experimental session, which was divided in two parts: the baseline part, which took between 10 to 15 minutes and the structural priming task, which took between 25 to 30 minutes. Between the two parts of the task, participants were given a short break, which varied from 2 to 4 minutes. In total, each session lasted between 45 to 60 minutes per participant, divided as follows: 15 minutes for the consent form, questionnaire and proficiency test, and 35 to 45 minutes for the structural priming oral production task.

2. Results

The baseline contained 1462 target answers (sentences). Of these, 1325 were in the active voice and 137 were in the passive voice. These results show participants' tendency to use the active voice more frequently than the passive voice. These numbers change significantly after the structural priming task, in which the total number of target sentences was 2465, with 1967 sentences in the active voice and 498 in the passive voice. Figure 5 displays the comparison of passive voice in the baseline and the syntactic priming task. The X-axis shows the baseline and the syntactic priming task, whereas Y-axis displays the proportion in percentages of passive voice sentences in the target.

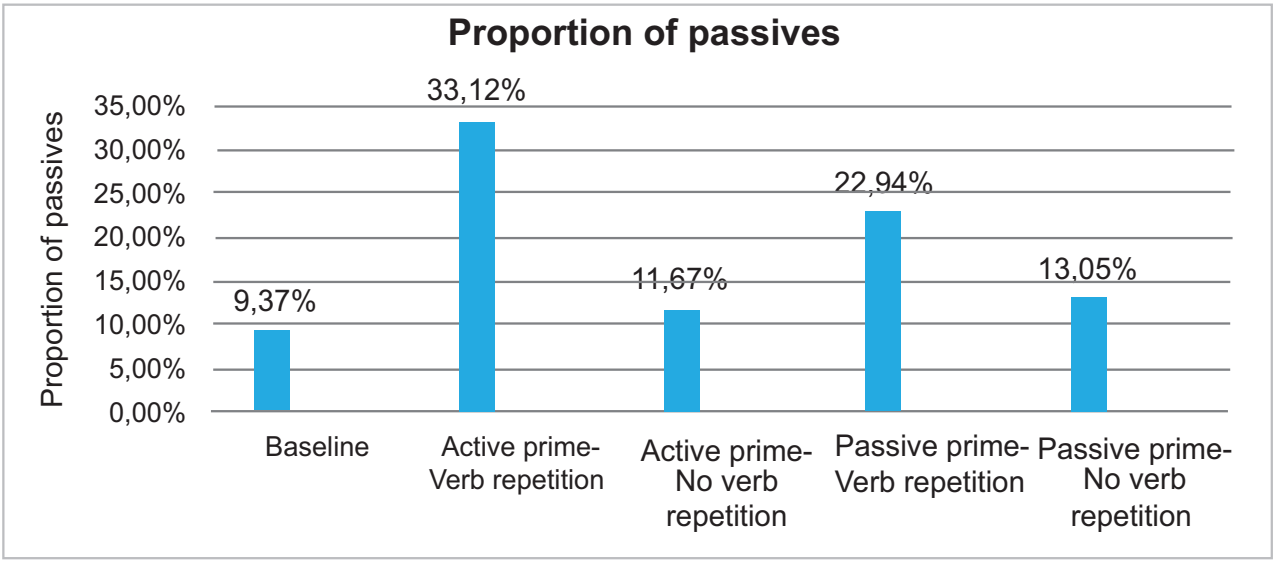
Figure 5: Comparison of responses from baseline to syntactic priming task



Source: by the authors

As illustrated above in figure 5, the number of passive voice responses in the syntactic priming task (20.20%) was generally higher than in the baseline (9.37%). Likewise, the number of passive voice constructions in each condition of the syntactic priming task was higher than in the baseline. Figure 5 illustrates the proportion of passive voice responses in comparison to the baseline per condition. The X-axis displays the baseline on the left as well as each of the four conditions, labeled with their respective type of prime, whereas the Y- axis shows the proportion of passives in each condition. Figure 6 displays the proportion of passive voice responses per condition in comparison to the baseline and demonstrates that the number of passive voice constructions was higher in all conditions than in the baseline.

Figure 6: Response tendency results: the proportion of passive sentences per condition



Source: by the authors

In order to answer research question 1 (RQ1), which asked: "are there syntactic priming effects during the oral production of sentences in English as L2? And if so, which syntactic structure may benefit from syntactic priming effects: active voice or passive voice structure?", the generalized linear-mixed model fit by maximum likelihood (Laplace Approximation) in R- package was employed. For that, several models[4] were tested in order to see the most suitable model to analyze the data. Two models were suited for the data and the one with less experimental noise was considered the best-fitted model. Table 5 summarizes the results of response tendencies according to the statistical analysis in R, including items and participants as random effects as well as the baseline as the intercept.

[4] Several models were employed taking into account as many as possible variables. However, some of them failed to converge the data of this study.

Table 5: Summary of fixed effects in the mixed logit model with the baseline as intercept

Predictor	Estimate	Standard error (SE)	*Z- value*	*P- value*
Intercept (Baseline)	-2.87	0.26	-10.72	<.001***
Active prime- Word repetition	1.88	0.14	13.06	<.001***
Active prime- No word repetition	0.22	0.16	1.37	=1
Passive prime- Word repetition	1.22	0.14	8.32	<.001***
Passive prime- No word repetition	0.45	0.16	2.81	<.01**

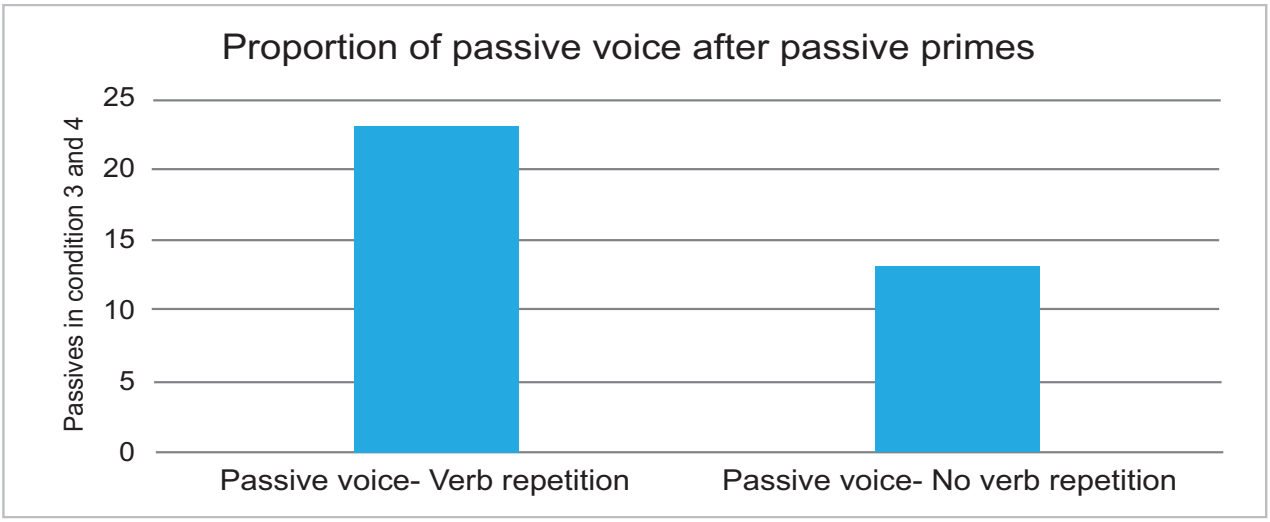
Source: by the authors

In table 5, the levels of statistical significance are represented as *p*-values. The intercept (baseline) value was statistically significant (<.001) as well as Condition 1 (p = <.001), Condition 3 (p = <.001) and Condition 4 (p = <.01). Only Condition 2 (active prime- No word repetition) was not statistically significant ($p = 1$). With respect to the active voice, Condition 2 ($p = 1$) was the most unlikely Condition to demonstrate results. Nonetheless, Condition 1 (active prime- word repetition) demonstrated a high number of passive voice constructions, which was statistically significant (p = <.001). Contrary to what was expected, this result shows that active primes did not affect the response tendencies when the verb was repeated from prime to target in comparison to the baseline. Concerning Condition 3 (passive prime- word repetition), the number of passive voice constructions was statistically significant (p = <.001), which was expected since primes were in the passive voice and the verb was repeated. This result demonstrates that passive primes affected the response tendencies when the verb was repeated from prime to target in comparison to the baseline. Last, considering Condition 4 (passive prime- no word repetition), the number of passive voice constructions was statistically significant (p = <.01) in comparison to the baseline, although in a lower number than in Condition 3. This result shows that passive primes did affect the response tendencies, even when the verb was not the same from prime to target.

Thus, the above presented results support prediction 1, which predicted that there would be structural priming effects in the oral production of sentences in English as L2 and that the structure that would benefit from the syntactic priming would be the passive voice. Hence, the results reported above show that when comparing the results of the syntactic priming task with the baseline results, there was a greater production of passive voice sentences in the experimental conditions, which were mainly found in Conditions 3 and 4, both related to the passive voice. These results are in line with Segaert et al. (2011) who claimed for a larger effect of syntactic priming in less frequent structures (i.e., the passive voice).

Research question 2 (RQ2) asked: "If syntactic priming effects are found during the production of sentences, are these effects related to verb repetition?". In order to answer this question, the same analysis reported above was used. Likewise, figure 7 displays a comparison between Condition 3 (passive prime- word repetition) and Condition 4 (passive prime- no word repetition).

Figure 7: Comparison of the proportion of passive sentences in Conditions 3 and 4



Source: by the authors

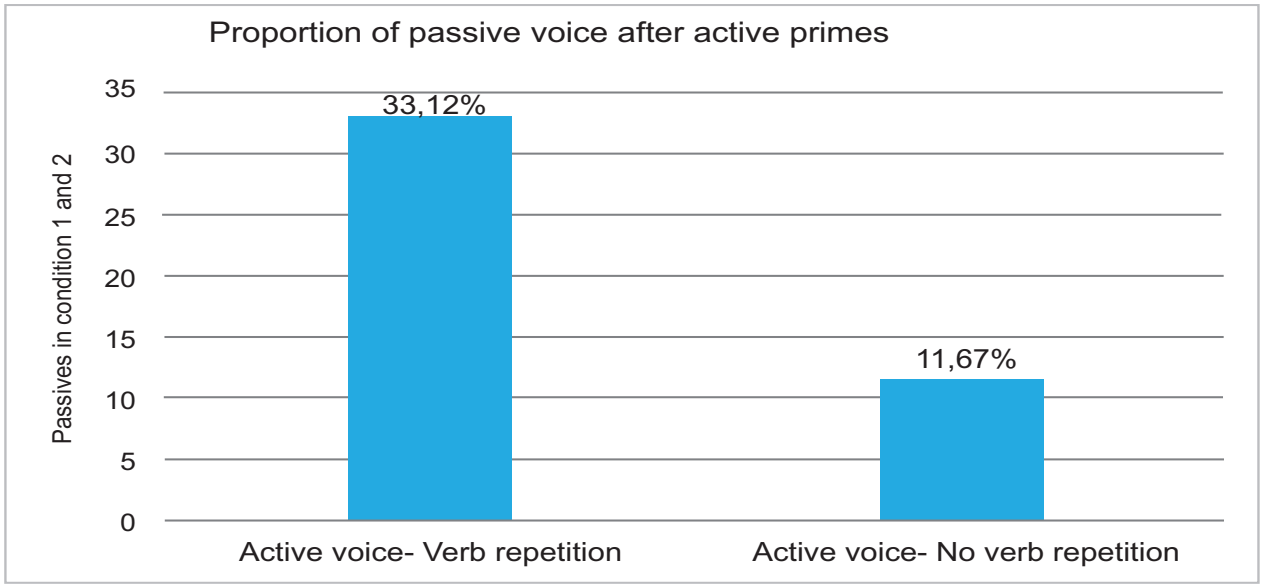
As illustrated in figure 7 and confirmed by means of the linear-mixed models analysis previously presented, structural priming effects were stronger in Condition 3 than in Condition 4. In this sense, prediction 2 is supported by the results. Hence, considering that there was a significant result in Condition 3, in which there was a verb repetition between prime and target, it is possible to state that structural priming effects are more robust when there is a repetition of structure and verb. The results of Condition 3 are in line with previous studies in L1 (e.g., BRANIGAN et al., 2000; CLELAND; PICKERING, 2006) that claim that syntactic priming effects benefit from lexical repetition between prime and target. These results also support Segaert et al. (2011) and Bernolet, Hartsuiker and Pickering (2013) findings for structural priming effects on responses tendencies when the head of the structure (i.e. the verb) is repeated.

Concerning research question 3 (RQ3), which asked "Is syntactic processing independent of lexical repetition?", the results previously reported by means of linear-mixed models partially confirm prediction 3, which stated that syntactic processing is independent of lexical repetition. Results of Condition 4, in which the syntactic structure, but not the verb, was shared between prime and target, were statistically significant (p= <.01). This is in line with previous studies (e.g. SEGAERT et al. 2011) which demonstrate that the magnitude of syntactic priming may appear even when it is not helped by lexical repetition between prime and target, that is, without the influence of lexical access. However, as figure 9 displayed the proportion of passives in Condition 3, in which there was repetition

of the verb and the syntactic structure, participants' tendency to produce a passive was higher than in Condition 4, in which there was structure repetition only. These results demonstrate that structural priming in L2 are more likely to occur when the less frequent structure is repeated as well as the head of the construction (i.e. verb).

On the other hand, a close look on the results is needed in order to raise other issues regarding this assumption. Hence, figure 8 displays a comparison of passive voice responses in the conditions with active primes: Condition 1 (active prime- Verb repetition) and Condition 2 (active prime- No verb repetition).

Figure 8: Comparison of the proportion of passive sentences in condition 1 and 2



Source: by the authors

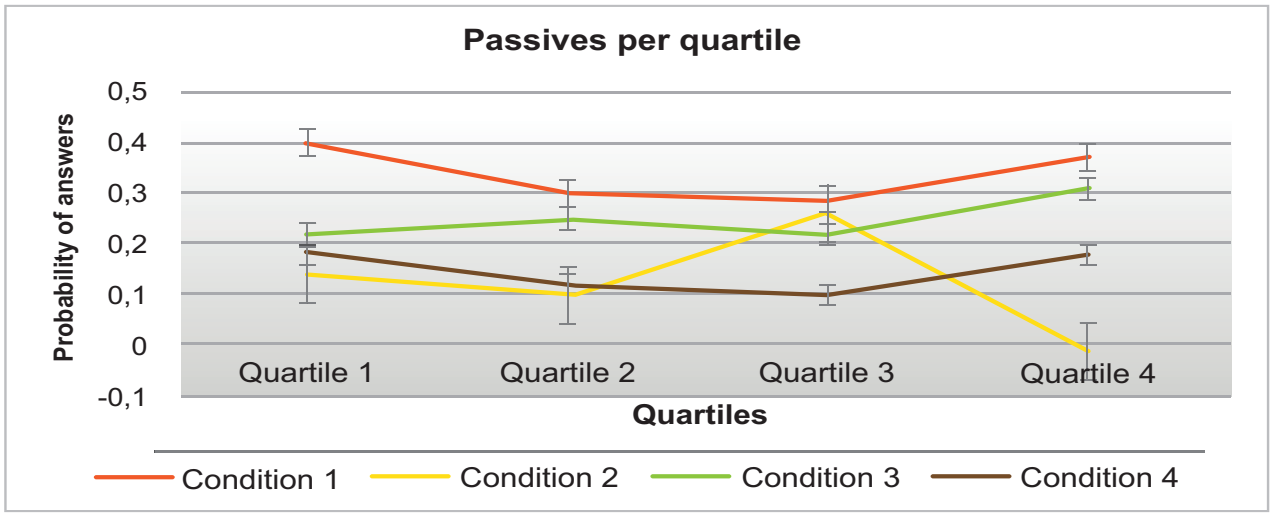
As illustrated on figure 8, Condition 1, in which the active voice and the verb were repeated from prime to target, showed a strong degree of preference for the passive voice in participants' responses when compared to Condition 2, in which the active voice was repeated, but the verb was not repeated from prime to target. This can be interpreted as evidence that the repetition of verb and structure in Condition 1 boosted the more complex structure, the passive voice. In addition, with respect to actives, the results of Condition 1 also support previous findings (SEGAERT et al., 2011) that show a ceiling effect for the active voice.

In Condition 2, participants' preferences were higher for the active voice, which was expected, considering that switching structure and verb from prime instances to targets can be more cognitively demanding for L2 speakers. According to Levelt and Kelter (1982), syntactic persistence, that is, the use of the same structure, reduces processing costs for the speaker, which might be the case here since the active voice triggered results in Condition 2.

Nonetheless, a question remains concerning the results found in Condition 1. First, these results can be taken as support for prediction 3 (syntactic processing is independent of lexical repetition) because there was no lexical boost between prime and target in Condition 1, as we can see in figure 08. Besides, these results are in line with prediction 1 (the structure that would benefit from the structural priming is the passive voice and not the active voice), since the active voice did not influence participants' responses on targets, when there was repetition of the active voice and the same verb from prime to target. In order to better explore the results reported in this study, a second analysis with linear-mixed model was run.

In context 2 a second analysis was carried out per quartile. That is, the experiment was divided into 4 quartiles and the baseline was not considered for the analysis, since this model aimed at testing the conditions only, as well as to determine if the high number of passive voice responses in Condition 1 could mean a cumulative syntactic priming effect in the course of the experiment. Thus, the experiment was divided into 4 quartiles and the statistical model run for this analysis considered participants and items as random effects in the generalized linear-mixed model fit by maximum likelihood (Laplace Approximation) in R- package. Figure 9 displays the probability of passive answers per quartile in each condition.

Figure 9: Response tendency results: the proportion of passive sentences per quartile in each condition



Source: by the authors

As can be seen in figure 9, Condition 1 had a high proportion of passive responses starting in the first quartile of the experiment. Thus, the assumption that there were cumulative syntactic priming effects throughout the experiment that affected Condition 1 does not hold. Furthermore, this analysis showed an intriguing result considering Condition 2, because from quartile 2 to quartile 3 of the experiment, the number of passive responses increased significantly, which did not occur in the other conditions. Table 8 shows the p-value of each condition per quartile.

Table 6: Summary of linear mixed model: p- value per quartile

Predictor	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Condition 1	p<0.053.	p>0.436	p>0.859	Intercept
Condition 2	p<0.063.	p< 0.015 *	p< 0.016 *	Intercept
Condition 3	p>0.859	p> 0.234	p>0.821	Intercept
Condition 4	p>0.58	p>0.13	p>025	Intercept

Source: by the authors

As displayed in table 6, when considering the quartiles of the experiment, condition 2 had significant results in the 3 first quartiles. Condition 1 had significant results in the first quartile. Since these results raised another question regarding an effect of order of stimulus in the experiment, another analysis was run considering order of items as a factor.

In context 3, an analysis was carried out considering only the conditions and including the order of items as a factor, to further investigate if this factor could influence the results. Again, linear-mixed models were employed to compare the conditions with order as a factor. The results of the analysis of fixed effects in the mixed model including order as a factor are summarized in table 7.

Table 7: Summary of fixed effects in the mixed model including order as a factor

Predictor	Estimate	SE	*dt*	*t- value*	*Pr(>|t|)*
Condition 1	0.111	0.172	39.274	0.647	> 0.521
Condition 2	-0.238	0.088	112.347	-2.703	< 0.007 ***
Condition 3	-0.171	0.170	40.573	-1.007	> 0.319
Condition 4	-0.407	0.099	88.191	-4.089	< 0.001***

Source: by the authors

This analysis demonstrated that order was statically significant only for Condition 2 (p< 0.007) and Condition 4 (p< 0.001). Therefore, in order to understand the result of Condition 2 the same model was run including items (verbs) as fixed effects. In this analysis, order was considered as intercept. Table 8 summarizes results including only the verbs that reached statistical significance (*draw, feed, and follow)*.

Table 8: Summary of fixed effects in the mixed logit model including items as a factor

Predictor	Estimate	SE	*Z-value*	*P-value*
Intercept	-1.49	3.33	-4.47	<0.001
Verb *to draw*	-2.60	1.06	-2.44	<0.01
Verb *to feed*	1.034	4.23	2.44	<0.01
Verb *to follow*	8.488	3.98	2.12	<0.03

Source: by the authors

The results displayed in table 8 show that order was significant ($p<0.001$). Therefore, it was necessary to examine, in the experimental design, the conditions in which the verbs (*draw, feed* and *follow*) with significant results were found in targets. It was noticed that these 3 verbs significantly motivated responses in the passive voice. Surprisingly, the verbs *feed* and *follow* were allocated in Condition 1 in the first quartile. In addition, the verbs *draw* and *follow* were placed in Condition 2 in the third quartile. These findings might suggest that these verbs are more likely to be used in passive instances in comparison with the other verbs of the experiment. These results might be the reason for the high number of passives in Condition 2 and might partially explain the high number of passives in Condition 1 in the first quartile. It is important to state that even though items were counterbalanced and randomized, the experimental design did not control for showing all items in all experimental conditions. In addition, in fact, some items could be naturally more common in the passive voice, which might be the case for the items mentioned above. All findings of this study are further discussed within the theoretical framework in the next section.

3. Discussion

In this study, we investigated syntactic priming effects during sentence production in English as L2. In this section, we discuss the results previously reported by readdressing the research questions and hypotheses that were pursued in the present study. In addition, we contrast the findings of this study with the theoretical framework.

RQ1: Are there structural priming effects during the oral production of sentences in English as L2? If so, which syntactic structure may benefit from structural priming: the active voice or the passive voice structure? Prediction 1: There are structural priming effects on the oral production of sentences in English as L2. These effects will be stronger for the passive voice structure than for the active voice.

Prediction 1 was supported by the results of the present study. The comparison of the results of the syntactic priming task with the baseline results shows that there was a greater production of passive voice sentences in the experimental conditions. Likewise, the effects of structural priming in oral sentence production in L2 were mainly found in Conditions 3 and 4, which were both related to the passive voice. These findings are in line with Segaert et al. (2011), who claimed for a larger effect of structural priming in less frequent structures (i.e. the passive voice).

RQ2: If structural priming effects are found during the production of sentences, are these effects related to verb repetition? Prediction 2: Structural priming effects during the production of sentences in the passive voice in English as L2 are related to verb repetition.

The results of the structural priming experiment support prediction 2. There was a statistically significant structural priming effect in Condition 3, in which the verb was repeated between prime and target. By that it is possible to state that the effects are more robust when there is a repetition of syntactic structure and verb. The results of Condition 3 are in line with previous studies in L1 (e.g.,

BRANIGAN et al., 2000; CLELAND; PICKERING, 2006) that claim that structural priming effects benefit from lexical repetition between prime and target. These results also support Segaert et al. (2011) findings for structural priming effects on response tendencies when the head of the structure (i.e. the verb) is repeated. Concerning the L2, these findings are in line with Hartsuiker et al. (2004) who demonstrated that syntactic priming is more likely to occur when two languages have the same translation equivalents, as predicted by the shared syntax account.

RQ3: Is syntactic processing independent of lexical repetition? Prediction 3: Syntactic processing is independent of lexical repetition.

Prediction 3 was also supported by the results of the present study. In Condition 4, the syntactic structure was shared between prime and target without verb repetition between prime and target. Our results show that structural priming can be observed even when it is not boosted by lexical repetition between prime and target. These results are in line with Segaert et al. (2011).

Concerning Condition 1 the experimental results found were unexpected. However, few assumptions can be made by looking closely at the results and thinking about the theories related to structural priming in bilinguals. Overall, the results of this condition demonstrate that there is no structural priming effects for actives when there is lexical repetition. These results can be interpreted in different ways.

First, the active voice is a very frequent structure in the language and, according to Pickering and Branigan (1999), skilled language speakers, as is the case of the population of this study, "might be less susceptible to syntactic priming effects, since they have more computational resources available" (PICKERING; BRANIGAN, 1999, p. 141). Most participants in the study reported using their second language frequently for a sort of different activities. Therefore, for these participants, the representation of the active voice in English as L2 may be well integrated in their syntactic procedural knowledge in a way that prevents them from being affected by structural priming within this syntactic construction and by verb repetition.

Second, the results in Condition 1 can also be interpreted considering the experimental design of the study, in which half of the experimental items were in the passive voice, which significantly increased the exposure to a structure that is assumed to be less frequent in English as L2. Thus, the participants of the present study, advanced speakers of English as L2, might have benefited from the exposure to the passive and implicitly learned throughout the experimental session. According to Ferreira and Bock (2006), implicit learning reflects "the incidental tuning or adjustment of the tendencies of a processing as a function of experience" (FERREIRA; BOCK, 2006, p. 3), and this might have been the case for the results in this condition.

Moreover, the results of Condition 1 also allow inferences concerning the inverse-preference theory (FERREIRA; BOCK, 2006) related to syntactic priming effects. This theory states that structures that are in general less preferred, such as the passive voice, demonstrate more structural priming effects, whereas the generally more preferred structure, such as the active voice, evokes less

of these effects. According to Ferreira and Bock (2006) when something is already known (i.e. active voice) it does not reflect learning. On the other hand, when something is poorly known it may enable greater learning.

The results of Condition 1 may also reflect individual differences because some participants demonstrated a natural tendency to produce more passive voice sentences than others in the baseline part of the task, in which there was no stimuli manipulation. According to Jackson (2018), the magnitude of syntactic priming may vary across individuals, meaning that not all L2 speakers are primed under the same conditions. This variation may also be related to individual differences in other cognitive resources, such as attention or working memory capacity.

Summarizing, the results of this research show that structural priming within the L2 during oral sentence production was more likely to occur in the less frequent structure (i.e. passive voice), which is in line with Segaert et al. (2011) in L1. Structural priming occurred when prime and target shared the same syntactic structure and verb, which may be in line with the residual activation theory (PICKERING; BRANIGAN, 1998), since the effects were boosted when the head of the construction was repeated (i.e. verb). However, structural priming was also demonstrated without verb repetition in the less frequent structure, which may suggest that priming may occur even when there is no verb repetition. This is in line with McDounough and Mackey (2008), who showed that structural priming was stronger when participants produced the target structure with new lexical items.

Final remarks

The main objective of the present study was to investigate within language structural priming during sentence production in the L2. These are the main findings of the present study:

1. The present results show that there are structural priming effects during the production of sentences in the passive voice in English as L2 by native speakers of Brazilian Portuguese. Structural priming effects during oral production in L2 are stronger in less frequent syntactic structures in the language, such as the passive voice, than in frequent syntactic structures, such as the active voice.

2. When comparing target sentences preceded by active primes with target sentences preceded by passive primes, it was found that there was a lexical boost effect for target passives only. Active primes with target verb repetition boosted the production of passives and not actives.

3. Although the results showed that structural priming was more likely to occur when there was both verb and structure repetition, structural priming occurred even when there was structure repetition only.

4. It is not possible to state that the effects found in this study are cumulative/residual because not all verbs were shown in all conditions.

Taken together, our results can be interpreted as evidence for the *inverse-preference* theory (FERREIRA; BOCK, 2006) in a nonnative language. In addition, our findings show that structural priming enhanced the production of the less frequent structure (i.e. passive voice) in the L2.

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