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Structural Priming as Implicit Learning: Evidence from EFL Learners' Production of the Relative Clause Structure

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Abstract

This study focused on the pedagogical application of priming in an EFL context. Structural priming refers to the speakers' tendency to produce the structure they encountered in recent discourse in subsequent production compared to an alternative form. Given the limited number of studies in the literature with a focus on the application of priming in L2 teaching and the problems that L2 learners face during speech production, the present study aimed at investigating whether the implication of priming leads to a more frequent oral and written production of the relative clause (RC) structure compared to adjectival modification of nouns (AN) in long- and short-terms as an instance of implicit learning. Participants consisted of 60 EFL female L2 learners, aged between 18-25 years old. Two experimental and 1 control groups were defined and 20 participants were allocated to each group. By applying a pretest, a treatment, an immediate posttest, a delayed posttest design, a picture description task, and a grammaticality judgment test (GJT), the data were gathered. Results of the descriptive and inferential analyses revealed that the implication of priming led to an improvement in the rate of the RC construction when the participants were involved in the written production of the L2, as compared to oral modality. Results are discussed based on structural complexity and procedures involved in L2 production. Theoretical and practical implications of the study are considered, too.

Keywords: Implicit Learning, Language Processing, Oral Production, Priming, Relative Clause (RC) Structure, Written Production

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1. Introduction

Being able to express ideas and thoughts in an L2 is one of the most fundamental aims of L2 learners throughout the world (Lambert et al., 2020). One of the cornerstones of L2 speech production is productivity which implies an ability to produce and generate an unlimited number of sentences by the use of finite rules. However, a certain number of factors are claimed to have an influence on the processes involved in L2 speech production, including memory limitations (Bernolet et al., 2016), distractibility (Chomsky, 1965), the effect of L1 (Jackson & Ruf, 2017), and the distance between L1 and L2 (Hopp, 2010). This study was an attempt to investigate the impact of another factor, which is not directly stated in the literature, but researchers (e.g., Corney & Mendez, 2015; Shin & Christianson, 2012) have shown that it has an influence on L2 speech production: That factor is the speaker's tendency to reuse the same syntactic structure across successive sentences (Kaan & Chun, 2017; McDonough & Fulga, 2015).

The speakers' tendency to echo the same construction that they heard or produced in a recent discourse in subsequent production compared to an alternative form (Jackson, 2018) is called *priming*. For instance, it is more probable that a speaker produces a double object dative (DO) construction after hearing a sentence like *Mary sent her sister a gift* than produce an alternative construction (i.e., a prepositional dative [PO]), like *Mary sent a gift to her sister* (Pickering et al., 2013). Within the priming framework, the initial sentence that is heard by the speaker is called priming and the subsequent sentence that is produced is called the target sentence (Leonard, 2010). Structural priming is

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mostly applied for the study of parallel structures like active vs. passive, direct object vs. prepositional object, phrasal verbs, direct vs. indirect speech, and so on (e.g., Branigan & MacLean, 2016; Segaert et al., 2016; Shin & Christianson, 2012). Based on the priming paradigm, the increasing probability of the repetition of an old structure in subsequent production is due to the processes that are strengthened and activated by frequent and repeated use (Heyselaar & Segaert, 2021). Based on this view, priming leads to implicit learning (Dell & Chang, 2014; Kaschak et al., 2011a; Kaschak etal., 2014). In this regard, learning is viewed as a shift from the choice of one construction in the linguistic representation network to the choice of another construction during sentence production.

During the past years, the priming paradigm has been applied for the study of bilingualism (Bernolet et al., 2013), child language development (Branigan & McLean, 2016), L1 speakers (Kaan & Chun, 2017), L2 learners (Kinoshita et al., 2019), L2 production (Hartsuiker & Bernolet, 2017), and comprehension (Pickering et al., 2013). This wide range of observations suggests that this concept needs to be extracted from the psycholinguistic and cognitive fields of studies and applied for L2 teaching and applied linguistics. Recently, a few number of studies (e.g., Conroy & Mendez, 2015; Shin & Christianson, 2012) have tried to exercise priming in an EFL context to investigate L2 production and learning.

However, the findings are quite mixed, controversial, and contradictory. For example, the long- lasting effect of structural priming, as a sign of implicit learning, is not completely convincing yet. Contrary to the studies (e.g., Branigan & Messenger, 2016; Corney & Mendez, 2015; Dell & Chang, 2014; Kaschak, et al., 2011a) which displayed the long-lasting effect of structural priming as a form of implicit learning, there are ample other pieces of evidence that showed that priming had no effect on L2 learning and use (see Bernolet et al., 2013, for evidence that structural priming is not always so long-lasting). Besides, an in-depth review of the literature clearly indicates that most experiments about

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structural priming center on a few number of constructions like DO and PO structures (Kaschaket al., 2011b; Kutta et al., 2017), *wh*-question development (McDonough & Chaikitmongkol, 2010), dative structure (Hartsuiker & Bernolet, 2017), passive construction (Ameri-Golestan & Nezakat-Alhossaini, 2012), transitive structure (Hardy et al., 2020), and indirect questions and requests (Biria et al., 2010). The number of studies with a focus on relative clause (RC) construction as an embedded complex construction has been quite rare. Just the few experiments that centered on RCs were with a focus on interlinguistic priming between L1 and L2 to address the shared syntax hypothesis (Bernolet et al., 2013), the impact of priming on RC processing (Cheng et al., 2018), and object RC comprehension among L2 learners (Nitschke et al., 2014). However, almost no study, to the best of researchers' current knowledge, has investigated the impact of priming on RC production. Studies on the RC structure are of paramount importance. Previous research on L1 (e.g., Kirjavainen et al., 2016) and L2 contexts (e.g., Tanaka et al., 2019) has shown that, as an embedded clause, the RC structure shows a complicated syntactic behavior (Xu, 2014). As such, the strategy that most L2 learners employ when facing difficulties in the RC production is the avoidance strategy (Phoocharoensil & Simargool, 2010) or the overgeneralization of parallel structures (e.g., Erdogan, 2005). However, because the main function of the RC structure is to express an idea about the referent of its head noun and because this function is integral to communicative needs of L2 learners, mastery in the use of these clauses is vital for L2 learners.

Taken together, if the main concern of priming is how L2 speakers learn, internalize, and remember linguistic materials and so is L2 teaching, it is natural to ask whether or not priming relates to L2 learning and development. This study sought to investigate the role of priming on the RC production among Iranian intermediate EFL learners, immediately after the treatment and after a course of a week. The difficulties that L2 learners experience during L2 speech production has been examined from different perspectives, and different plausible

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explanations have been proposed. For example, in usage-based approaches to L2 teaching, it is proposed that difficulties in L2 speech production might stem, in part, from either a lack of automaticity or implicit knowledge in production (Segalowitz & Hulstijn, 2005) or a lack of well-embedded abstract syntactic knowledge (Ellis, 2005). Different approaches have been implemented in EFL/ESL contexts to increase automaticity and to strengthen linguistic knowledge. However, the present was an attempt to draw on an innovative paradigm like priming, which has been shown to be influential in both the development of abstract syntactic knowledge and in the improvement of implicit, procedural knowledge (Dell & Chang, 2014). Because it is shown that priming gradually strengthens linguistics representations (Leonard, 2010), it is not unreasonable to ask if the natural occurrence of priming in the context of learning may lead to a long-lasting adjustment of L2 learners' linguistic behaviors as the function of experience.

The parallel structures that were chosen for the purpose of the current study were the RC and adjectival modification of nouns (AN). In English, a noun can be modified by an adjective in two ways: Either the adjective is placed before the noun like *the busy street* or the noun is followed by an RC containing the adjective like *the street that is busy*. It is shown (Taghavipoor, 2005) that, compared to the RC structure, the AN construction is a simpler, more useful, and more frequent structure that mostly replaces the RC construction (Hartsuiker & Westenberg, 2000). Following previous studies (e.g., Kutta et al., 2017), this study hypothesized that after receiving priming intervention, accessing the RC construction, as a recently activated structure, is much easier for L2 speakers than producing and activating a thoroughly new structure, and L2 speakers might prefer to adjust their speech production to their recent experience with their L2. Besides, it was hypothesized that L2 speakers might be able to generalize the same structure to new utterances without any explicit attention to the form of the priming sentences. The goal of the priming intervention in the current study was

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to assess the improvement that the participants manifested on the immediate/delayed posttest after the treatment had been given to them, as compared to the results from the pretest that was administered before receiving any treatment.

As to the significance of the study, speaking in an L2 is the primary concern of most L2 programs. Yet, little is known about the nature of L2 production. Not only do studies on L2 production aid in understanding and evaluation of L2 competence (Lennon, 1990), but they also help in gaining a better insight about the theoretical and pedagogical perspectives of how this prominent objective can be achieved within L2 classrooms. Practically, L2 production is poorly taught, learnt, realized, and evaluated; this is mainly due to the fact that the processes and factors involved in L2 production are not easily accessible (Bock, 1986). Yet, this study tried to address one of underlying factors shown to have influence on L2 production, namely priming to examine whether the implication of priming in a picture description task leads to automatic and unconscious grammatical encoding of messages in a long run.

2. Literature Review

2.1. Theoretical Background

This study draws on implicit learning (Bock & Griffin, 2000; Chang et al., 2006; Hartsuiker et al., 2008) account of priming. Based on implicit learning account, priming effect is not the consequence of residual activation of the surface structure of a previous sentence on subsequent production, a phenomenon which mostly happens in explicit memory and remains active temporarily. In fact, this account claims that the effects of structural priming lasts over a long period of time, at least a week (Hartsuiker at al., 2011a). Thus, it is not regarded as a production-related phenomenon. Based on this account, the increasing probability of the repetition of an old structure in subsequent production is due to the processes that are strengthened and activated by frequent and repeated use (Bock,

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1986) which, finally, affect subsequent cognitive processes. This view holds that structural priming is a process of strengthening the links between syntactic representations. Ferreira and Bock (2006), clearly account how structural priming leads to L2 learning. They claim that when L2 speakers gain a mastery of how unrelated linguistic representations pertain into one another, they will be able to produce and comprehend language. For instance, for comprehending and generating a passive construction, an L2 speaker must have gained the knowledge that specific meaning relations (patient and agent relationship) relates to particular functional aspects (oblique objects and subject), which relates to linearization of words (how noun phrases and verb phrases are ordered), and so on. They suggest that structural priming provide a condition whereby linguistic experience and, in turn, mechanism of L2 development progresses. Therefore, based on this view, priming touches cognitive processes rather than syntactic representations. In addition, people in this group argue that since syntactic processing normally occurs outside of awareness in the assembly of sentences (Bock, 1982) and the tendency to repeat syntactic structure is procedural and unintentional (Bock & Griffin, 2000), structural priming meets the criteria of procedural knowledge construction of implicit learning.

Based on Levelt's (1989) speech production model, converting a message into a series of sentences and sounds occurs in three main stages: (1) The conceptualization stage in which the ideas and thoughts that the speaker wishes to convey are specified, (2) the formulation stage in which the messages are converted into linguistic representations, and (3) the articulation stage in which linguistic representations are articulated by motor movements. In this study, the researchers focused on the formulation stage and the linear construction of syntactic sentences. Based on Bock (1986), there is an independent level of syntactic representation. This stage deals solely with the choice of grammatical structures and is totally independent of their sounds and meanings. During sentence production, the constituent structures which are about to be produced

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have to be specified from the L2 learners' linguistic schemata. Recent studies have shown that accessing a recently activated structure is much easier for L2 speakers than producing and activating a thoroughly new structure, and L2 speakers prefer to adjust their speech production to the recent experience with their L2 (Chang et al., 2006). The present study proposes that, within the formulation stage of production, the online processor might refer to recent sentences that are heard and activated through priming. Generally, it is proposed that one mechanism of the acquisition of L2 syntax might be through changes in the activation levels of syntactic representations.

2.2. Empirical Evidence

The implicit learning account of structural priming is based on empirical evidence that showed that the priming effect lasts over 20 min (Jackson & Ruf, 2016), or after a week (Shin & Christianson, 2012). Based on the findings of the above studies, if the target structure had been produced in the absence of prime sentences after 20 min, a day, or a week, implicit learning in L2 use had taken effect. Nonetheless, the findings around the implicit learning account are inconsistent and contradictory. For example, Ameri and Alhossaini (2012) found large and significant priming effects for passives for L1 Persian-speaking EFL learners. Also, they identified a positive relationship between priming and the use of passive constructions and between priming effects and the participants' level of proficiency. In a similar vein, Kaan and Chun's findings (2017) showed the beneficial role of priming equally for the Korean L2 learners of English and native speakers. Even the persistence of structural priming has been reported in comprehension, as well (e.g., Ziegler & Snedeker, 2019). For example, in a study by Wei et al. (2019) on Chinese learners of English, it was shown that the priming paradigm was influential in comprehending reduced RCs both when priming and target sentences were adjacent and when some filler sentences intervened between them. In general, these studies showed that recent experience with a given

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structure can have a long-lasting facilitative role on the language processing mechanism among L2 learners (see Jackson, 2018, for a complete review).

Also, Biria and Ameri-Golestan (2010) investigated the impact of priming on Iranian EFL learners' production of indirect questions and requests. The main aim of their study was to investigate whether the L2 learners could transfer the priming effect from the speaking modality to the writing modality. Their results showed that because of the change in task modality, the number of the target sentences which were produced in the written sentence fragment task was significantly smaller than the oral picture description task. However, contrary to this study, the results of the study by Kaschak (2007) indicated that the effect of the cumulative priming implemented in the oral picture description task was observable in the written stem completion task. Similarly, Kaschak et al.'s (2014) data gained from a set of six experiments through picture description and written sentence completion tasks showed that cumulative structural priming effects carry in both directions: from written to oral tasks and vice versa only if the priming and posttests are run in a single experimental session. They did not observe any more cumulative priming effects after a course of a week in the case of task modality change. Completely in line with this finding, Kaschak et al. (2011a) exhibited long-term priming effects when the tasks used in all the phases of the study were alike. This might be explainable through the methodology that these studies employed. Through cumulative priming, the number of the prime sentences introduced to L2 learners increases, that is, L2 learners are bombarded with input flood. As such, the priming effect is likely transferred between tasks.

2.3. This Study

Although most previous studies have focused on the role of priming on L2 production, no almost study, to the best of the present researchers' knowledge, have focused on the role of priming on oral and written L2 production in a single study. Each modality has been addressed separately in different distinct studies

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(Kaan & Chun, 2017; Kaschak et al., 2011b; Kaschak et al., 2014; Kutta et al., 2017), and various contradictory results have been gained. The importance of focusing on different oral and written modalities in a single study lies behind the fact that after the retrieval of information from memory, the conditions that dominate the encoding process have shown to affect production operations (Kaschak, 2014). As Levelt and Kelter (1982) claims, actual speech production is inherently limited by cognitive and psycholinguistic resources, and the processes involved in L2 speech production require procedural procedures; this explains why during the online processing of speech production, L2 learners suffer from a gap in their production.

The present study hypothesized that by the implementation of priming before L2 production, certain deficiencies in processing might be managed. However, by comparing the L2 production in oral and written modalities, it becomes clearer whether or not the priming effect or manifestation has been under the influence of cognitive, linguistic, and psycholinguistic shortcomings. Thus, the question of interest is if L2 learners' experience during the priming phase alters their choice of construction after a course of a week, and that how much priming effect is under the influence of production processes that are drawn in during sentence generation. As such, the study came to the following research questions:

1. Does priming intervention have any significant effect on the oral production of the RC structure by EFL learners after a course of a week?
2. Does priming intervention have any significant effect on the oral production of the RC structure by EFL learners immediately after the treatment?
3. Does priming intervention have any significant effect on the written production of the RC structure by EFL learners after a course of a week?

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4. Does priming intervention have any significant effect on the written production of the RC structure by EFL learners immediately after the treatment?

3. Method

3.1. Design and Context of the Study

The current study utilized an explanatory sequential mixed methods research design to answer the research questions. Through the incorporation of a control group, random sampling, and random implementation of the treatment on the participants, a true experimental design was designed to investigate the (possible) effect of priming on L2 production. In the quantitative phase of the experiment, the research comprised a pretest, a treatment phase, an immediate posttest, and a delayed posttest administered one week later. At the end of the study, in the qualitative phase of the study, the participants answered some oral questions in the form of a semi-structured interview about their familiarity with the RC structure and why they did not produce the structure on the immediate/delayed posttests. All the data were gathered through a grammaticality judgment test (GJT) and a picture description task, the details of which are described in the following sections.

The study was conducted in an EFL context where the English language is not the dominant and official language of the mainstream. Besides, the participants were late L2 learners who had not learnt Persian and English simultaneously. All the participants had learned English after age 12 and lived in a Persian-dominant environment, speaking Persian at home and at school. The participants were divided into three groups: two experimental and one control. Both the first (G1) and the second group (G2) received priming for their treatment. All the prime sentences for both experimental groups were presented visually in the written form below the prime pictures in red, as discussed in detail in the Data Collection Procedure subsection. Thus, prime sentences were not

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designed in a way that, apart from the written presentation, a speaker read the prime sentences aloud to the participants. However, the only difference between the two experimental groups was in the type of modality that the participants used to describe the target pictures during the pretest and the posttest. That is, after receiving the priming intervention, G1 described the target pictures orally, whereas G2 did it in the written form. G3 was the control group.

3.2. Participants

Seven language institutes which were located in different districts of the city were chosen through–convenience sampling from which the original pool of 80 L2 learners was randomly selected. An English proficiency test (i.e., Oxford Quick Placement Test [UCLES, 2001]) was administered to the participants to ensure their homogeneity as intermediate EFL learners. Besides, a GJT was administered to the participants to measure their linguistic knowledge about RCs because it is shown that priming works when L2 learners are familiar with the concepts and functions of the given structures (McDonough & Fulga, 2015).

Those participants whose proficiency scores fell within the range of 17-27 were considered to be at the intermediate level based on the test direction, and those whose GJT scores fell within the minimum of 4 and maximum of 10 out of 12 were selected for the purpose of the study. Sixty participants who met both the GJT and proficiency scores criteria were selected for the purpose of the study, out of which 40 were randomly allocated to the two experimental groups. Twenty participants were assigned to the control group, as well. The participants were all female L2 learners, with an average age of 18-25 years old (see Table 1):

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Table 1. *Demographic Background of the Participants*

No. of Participants	60 Intermediate L2 Learners
Gender	Female
Native Language	Persian
Institutes	Randomly Selected From Some Language Institutes of Isfahan, Iran
Age	18-25 Years Old

3.3. Instruments

There were three instruments applied in the study, which are explained in below:

2.3.1. Picture Description Task: Using a Google image search, 118 freely available pictures from the Internet were sourced and based on the contents/concepts behind them, they served as the filler pictures, prime pictures, and target pictures. From among the total number of pictures selected for the purpose of the present study, 47 pictures were used as the fillers, 12 pictures as the primes, and 52 pictures were applied to elicit the target structures during the pretest, the treatment, and the immediate/delayed posttests.

The pictures were ordered in a way that, first, the prime pictures; then, two or three filler pictures; and finally, the target pictures were presented to the participants. The filler pictures were applied to conceal the purpose of the study in a way that, under each filler picture, a sentence with a structure different (structures like passive construction, impersonal constructions, etc.) from the ones that were at the main focal point of the study was presented. Below the prime pictures, the prime sentences were presented in the red color. Finally, the target pictures were presented to the participants: The target pictures were semantically unrelated to the prime pictures and could be described using one of two alternative constructions of the RC or AN structures. Thus, when the participants saw each target picture, they had to describe it with the adjective provided below

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the target picture using the first construction that came into their minds. This enabled the researchers to measure how often the syntactic structure of the target sentences produced by the participants matched with the RC constructions presented in the prime sentences. Therefore, whereas the target pictures acted as the testing materials in each testing session (i.e., the pretest, the immediate posttest, and the delayed posttest), the prime pictures acted as the treatment materials.

The researchers tried to choose pictures that represented the content of the prime sentences. Besides, the pictures of the target sentences were chosen in a way that matched with the semantic concept that the participants had to produce in completing the target sentences using the adjective provided for them. The face and content validities of the task were checked by three experts in the field and three statisticians. Besides, after the pilot study, the researchers asked the participants of the pilot study about the degree of match between the pictures and the prime sentences, about the degree of go togetherness that the sematic concept of the target pictures inspired to them and the target sentences that they had to produce using the adjectives provided to them, about the linguistic level of the prime sentences and the target sentences, about any possible distractions in the content of the pictures, etc. Finally, some pictures that were not suitable for the purpose of study were replaced.

All the pretest and posttest pictures were counterbalanced across the participants so that each participant saw each picture either on the pretest and the immediate or delayed posttests—but not on all. In order to check the reliability and validity of the pictures for picture description task, a pilot study was done prior to the main study.

2.3.2. Grammaticality Judgment Test (GJT): The second instrument applied for the purpose of the study was a GJT. This test was designed by the researchers for the purpose of the current study. The justification behind the use of the GJT was that the effectiveness of priming depends on the existence of the linguistic

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competence of the given structures in the participants' minds (Kaan & Chun, 2017; McDonough & Fulga, 2015). The GJT was piloted before being employed in the study. (The participants were different from those participating in the main body of the experiment). The maximum number of the items on the GJT was 50, out of which 12 measured the participants' knowledge about the RC structure. The reliability of the GJT was checked through Cronbach's alpha, which turned out to be .78. The participants were required to indicate/mark whether each sentence was grammatical or ungrammatical. In the piloting stage of the development of this instrument, a differential-groups design (Brown, 2005) was also used to check the construct validity of the test; in fact, the participants in the pilot study were divided into two groups of masters and non-masters (with masters having a working knowledge of RCs and non-masters struggling with RCs). The results of comparing the RC scores of the two groups indicated that masters significantly outperformed non-masters on the GJT, $t(28) = 7.30$, $p = .000$, which led to the confirmation of the construct validity of the test. In terms of content validity, three professors, expert in SLA issues and language testing were consulted and after they manipulated and rectified the wording of a few sentences, they approved of the content validity of the test.

2.3.3. Proficiency Test: Finally, an Oxford Quick Placement Test (UCLES, 2001) was administered to measure the participants' level of proficiency and ensure their homogeneity as intermediate L2 learners. This test is widely used by L2 researchers as a placement test (Berthold, 2011). Although the test has gone under Cambridge ESOL quality control procedures (Geranpaye, 2003), its reliability for the present study was assessed through Cronbach's alpha, which turned out to be .79.

3.4. Data Collection Procedures

The data collection was carried out independent of the participants' class hours. The participants were asked to assign a time to participate in the experiment, but

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they were not told that they were taking part in the experiment, so they were not aware of the nature of the study. Instead, they were informed that the institutes were interested in how well they could make use of their English proficiency in some tasks. One of the current researchers of this study was not their teacher.

Initially, the GJT and the language proficiency test were administered to the participants. As to the experiment, it was individually conducted in a quiet classroom of the language institutes in front of a laptop using E-prime Program. The data collection was carried out under the supervision of one of the researchers. However, the participants did not know that the other person in front of the laptop was one of the researchers. The study was undertaken over 3 consecutive weeks with the pretest in the first week, the treatment and the immediate posttest in the following week, and the delayed posttest in the third week (see Bernolet et al., 2013; Kaschak et al., 2011b, for a similar procedure).

In the pretest session, the participants performed the picture description task for approximately 10 min. Prior to the task completion, a brief instruction regarding what they were required to do with the pictures was provided by one of the researchers. During this phase, some pictures were presented to the participants, and they were asked to describe them with the first structure that came into their minds. No prime was presented to them during this phase.

In the treatment sessions, the participants experienced 12 trials (see Figure 1 as an example of a trial). Each trial was started with a filler sentence, which was written in the black color, and the participants had to read it. Then, they were instructed to press the arrow key to move to the next picture in which they saw the prime picture and a red-colored sentence beneath it, which they had to read and repeat (see Jackson & Ruf, 2016). The sentences that appeared below the prime pictures contained the RC structures and were designed to implicitly activate the participants' linguistic knowledge about the RC structures. The repetition task was designed to trigger structural priming (Jackson & Ruf, 2017) and to increase activation of target syntactic representations (Kim & McDonough, 2016). After

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the priming, some more filler sentences appeared on the screen for the participants. The function of the filler sentences was to reduce the effect of explicit memory on the part of the participants. That is, if the prime and target sentences appeared immediately one after the other, the production of the RC structures could be attributed to explicit memory. By the use of the filler sentences, the impact of explicit memory decreased and the production of the RC structures after a short delay between the prime pictures and the target pictures could not be attributed to memory factors.

Finally, the target pictures were presented to the participants with some incomplete sentences below them in the black color that had to be described and completed as quickly as possible by one of the two alternate structures: the RC or AN structure. In fact, the AN structure might be used as a parallel format of the RC structure as a simpler structure (Leonard, 2010). In addition, the justification behind the use of sentence starters (*we saw* as in Figure 1) was to decrease the variability in the participants' production (e.g., Conroy & Méndez, 2015; McDonough & Trofimovich, 2009). Without the use of the sentence starters, the participants started to create random sentences, most of which were unrelated to the study, impacting on the practicality of much of the data. The existence of the sentence starters could increase the ease of the sentence production burden for the participants, as well. Besides, an adjective was presented below each target picture. The participants were instructed that they had to use the adjective in their descriptions. For example, a picture with an incomplete sentence like *our store is located* ... and with the adjective *busy* could be described in either form of *our store is located on a street which is very busy* or *our store is located on a very busy street.* All the prime, filler, and target sentences were presented visually and separately on different slides.

G1 participants were required to describe the target pictures orally. Their speech was recorded on a high-quality voice recorder for orthographic transcription on a separate device. They were informed about the experiment and

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their voice recording after the experiment. The experiment was self-paced. Therefore, the time of the data collection procedure varied slightly between each individual participant. G2 participants were told that they would automatically flip into an appropriate box on the computer screen onto which they had to type their descriptions, and by pressing the Esc button, they returned to the prime presentation. And, the control group saw all of the test target pictures, but these pictures were not preceded by any of the test prime sentences or pictures. Instead, each target picture was preceded by one of the filler sentences/pictures from the priming set. In other words, the control group saw all of the target pictures, but these were not preceded by any of the experimental prime sentences or pictures.

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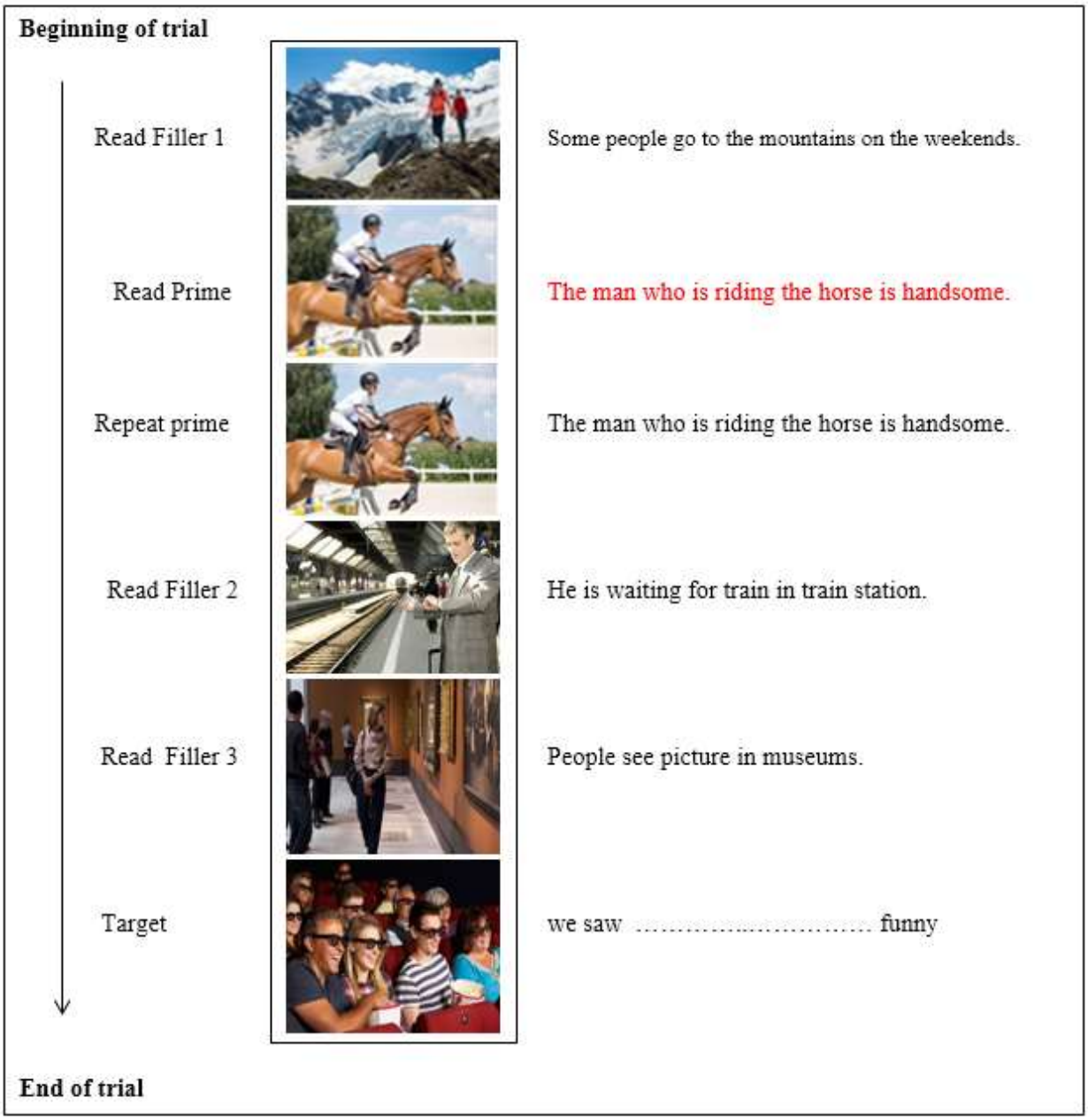

Figure 1. *An example of a trail in a priming intervention.*

The immediate posttest was taken in the final session of the treatment. After a week (Kutta et al., 2011; Kutta et al., 2014), the delayed posttest was implemented and it took 10 min. Like the pretest session, the pictures displayed on the immediate and delayed posttests were used to elicit the structures that were

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not preceded by any prime pictures. Also, some filler pictures were presented on the immediate and delayed posttests. It is noteworthy to mention that based on the implicit learning account (Branigan & Messenger, 2016; Dell & Chang, 2014; Shin & Christianson, 2012), the scores of the immediate posttest could not be regarded as an instance of learning because the immediate manifestation of the prime sentences in the participants' speech were just residual temporary activation of the surface structures of syntactical constructions. Nonetheless, an immediate posttest was included in the design of the study to examine whether or not the participants detected the stimuli among the mainstream of the input they received from the pictures. Only the constructions noticed by the participants are could be primed (Mcdonough & Fulga, 2015). Thus, the scores of the immediate posttest could reveal whether or not the priming stimuli was recognized in the first place on the part of the participants. On the other hand, the scores of the delayed posttest were taken as an instance of learning. If the implicit learning account presupposes that we store abstract structural representations of structural priming for a long time (Tooly & Traxler, 2010), it raises the possibility that the absence of priming in a long time (i.e., the scores on the posttest sessions) suggests the absence of learning. In fact, implicit learning was operationalized in this study as the enduring effects of priming after a week, as measured through the delayed posttest.

Finally, at the end of the experiment, the participants answered some questions orally in the form of a brief semistructured interview. The researchers were interested to know if they had learnt the RC structures previously, if they had any difficulties comprehending and processing the RC structures, if they thought they had sufficient mastery in producing the RC structures, if they often produced them in their spontaneous L2 use, and why they did or did not produce the RC structures during the picture description task.

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3.5. Data Analysis Procedure

In order to analyze the data, the participants' voices (produced during the pretest and the immediate/delayed posttests) for G1 were transcribed. G2 written descriptions were corrected, as well. Then, scoring was conducted for both groups and for all phases of the study. The scoring procedure was exactly alike for both groups. In a way that each sentence with the RC structure was scored as "target = 1," AN structure as "alternate = 0," and all other responses (i.e., incomplete utterances and sentences that did not strictly incorporate the sentence starters) were coded as "other = 0." Besides, the errors related to articles, tense, and agreement in the participants' production were ignored. There were three raters who were Ph.D. TEFL holders., and the maximum score was 12 because there were only 12 pictures that the participants had to describe. Interrater reliability was calculated through Cronbach's alpha, which turned out to be 94.

The items of the GJT were scored as "correct" or "incorrect," measuring the accuracy of each response. Out of the 50 test items included on the GJT, just the scores of the 12 test items that directly measured the knowledge of the RC structures were included in the data analysis. As such, the maximum possible score was 12 for this test, too. The reliability measure of the test after piloting was calculated and it turned out to be .84.

In order to analyze the effect of priming on the participants' production of the RC structures, descriptive statistics as well as inferential statistics including one-way ANOVA, multiple comparison tests (i.e., the Scheffé test), and paired and independent samples *t* tests were run.

4. Results

The main purpose of the study was to investigate the production of the RC structures both in oral and written modalities among Iranian EFL learners after priming intervention. The results are presented in three subsections: (1) the results of the GJT, (2) the results of within-group's comparison of the mean

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values from the pretest to the immediate and delayed posttests, and the (3) results of the comparisons of the mean values between the two experimental groups and the control group.

4.1. Results of the Grammaticality Judgment Test (GJT)

Table 2 shows the descriptive statistics of the GJT. The justification behind the use of the GJT was that the effectiveness of priming depends on the existence of the linguistic competence of the given structures in the participants' minds (Kaan & Chun, 2017; McDonough & Fulga, 2015). As Table 2 reveals, the mean scores for the three groups were M_{G1} = 6.90, *SD* = 1.29, M_{G2} = 7.35, *SD* = 1.53, and M_{G3} = 6.75, *SD* = 1.33, respectively, which show that the participants possessed an acceptable level of knowledge about the RC structures as a prerequisite for priming to happen:

Table 2. *Descriptive Statistics for the Grammaticality Judgment Test*

	N	Mean	*SD*	95% Confidence Interval for Mean		Min.	Max.
				Lower Bound	Upper Bound		
G1	20	6.90	1.29	6.29	7.50	5.00	9.00
G2	20	7.35	1.53	6.63	8.06	4.00	10.00
G3	20	6.75	1.33	6.12	7.37	4.00	9.00
Total	60	7.00	1.39	6.64	7.35	4.00	10.00

As the scores differed in some points around their mean scores, one-way ANOVA was run to see if the mean differences were statistically significant (see Table 3). The significance value of the *F* test in Table 3 is greater than .05 for the GJT. Thus, the average assessment scores for the GJT was equal across the three groups at the beginning of the study, $F_{\text{grammaticality judgment}}$ (2, 57) = 1.010, p = .371 > .05:

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Table 3. *ANOVA for the Grammaticality Judgment Test*

	Grammaticality Judgment Test				
	Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Between Groups	3.900	2	1.950	1.010	.371
Within Groups	110.100	57	1.932		
Total	114.000	59			

4.2. Results of the Comparisons of Mean Values Within Groups

Table 4 presents the descriptive statistics of the participants' performance for the oral modality (G1), the written modality (G2), and the control group (G3) in all phases of the study:

Table 4. *Results of the Descriptive Statistics*

		N	Mean	*SD*	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Pretest	G1	20	1.25	.96	.21	.80	1.70	0	3
	G2	20	1.10	.78	.17	.73	1.47	0	3
	G3	20	1.20	1.05	.23	.71	1.69	0	3
	Total	60	1.18	.84	.10	.95	1.39	0	3
Immediate	G1	20	1.50	1.00	.22	1.03	1.79	0	3
Posttest	G2	20	2.05	.68	.21	.91	2.37	1	3
	G3	20	1.35	.93	.19	.94	1.76	0	3
	Total	60	1.63	.90	.11	1.40	1.87	0	3
Delayed	G1	20	1.35	.98	.22	.89	1.81	0	3
Posttest	G2	20	1.95	.68	.15	1.63	2.27	1	3
	G3	20	1.25	1.02	.23	.77	1.73	0	3
	Total	60	1.51	.89	.11	1.24	1.70	0	3

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As Table 4 indicates, the pretest scores (G1: 1.25 ± 0.96, G2: 1.10 ± 0.68, and G3: 1.20 ± 1.05) clearly demonstrate that the mean performance of the participants before receiving the treatment were almost desirably identical and at a low level, but it improved later on after receiving the treatment. In the case of the immediate posttest, an increase in the mean of the RC production due to the intervention that the participants had received is observable, and the highest mean score is related to G2 (M = 2.05, SD = .68) that produced the RC structure in the written form. When it comes to the delayed posttest, like the immediate posttest, the mean difference of G1 (M = 1.35; SD = .98) and G2 (M = 1.95; SD = .68) is expectedly higher than G3 (i.e., the control group) in a way that G2 outperformed the other two groups (i.e., G1 and G3).

Besides, a test of homogeneity of variance was run, and no significant difference was seen in terms of the variances on the pretest and posttest scores (see Table 5):

Table 5. *Test of Homogeneity of Variances*

	Levene's Statistic	*df1*	*df2*	*Sig.*
Pretest	2.029	2	57	.141
Immediate Posttest	3.139	2	57	.051
Delayed Posttest	3.142	2	57	.051

Moreover, the results of the paired samples t test showed that G1 mean improved from M_{pretest} = 1.25 on the pretest to $M_{\text{posttest 1}}$ = 1.50 on the immediate posttest. G2 mean improved from M_{pretest} = 1.10) on the pretest to $M_{\text{posttest 1}}$ = 2.05 on the immediate posttest. The results of the analyses suggested that the progress within the groups for the two experimental groups that underwent the priming treatment was higher than that for the group that received no instruction. This improvement was noticeably more observable for G2 that was involved in the written production of the RC structures. When it comes to the delayed posttest,

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some degrees of retrogression in the production of the RC structures in the groups were observable (see Table 6):

Table 6. *Paired Samples Statistics*

Groups			Mean	N	Std. Deviation	Std. Error Mean
G1	Pair 1	Pretest	1.25	20	.967	.216
		Immediate	1.50	20	1.000	.224
	Pair 2	Immediate	1.50	20	1.000	.224
		Delayed	1.35	20	.988	.221
G2	Pair 1	Pretest	1.10	20	.788	.176
		Immediate	2.05	20	.686	.153
	Pair 2	Immediate	2.05	20	.686	.153
		Delayed	1.95	20	.686	.153
G3	Pair 1	Pretest	1.20	20	1.05	.236
		Immediate	1.35	20	.93	.209
	Pair 2	Immediate	1.35	20	.93	.209
		Delayed	1.25	20	1.02	.128

Next, paired samples *t* test was run to examine whether or not the mean differences within the groups were statistically significant. Overall, *the mean differences for the pretest and the immediate posttest as well as the immediate posttest and the delayed posttest revealed that producing* the *RC structures and the retention* rate to use the RC structures in the long run was higher for G2 that was involved in written speech production than the other two groups. There were statistically significant differences between the pretest and *immediate* mean scores of the *two experimental groups:* t_{G1} (19) = 2.51, $p < .05$; t_{G2} (19) = 4.79, $p < .05$. Similarly, there were not any statistically significant differences between the immediate and *retention* mean scores of the *two experimental groups on the delayed posttest:* t_{G1} (19) = 1.83, $p > .05$; t_{G2} (19) = 1.45, $p > .05$. However, G2

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proved to be *more* efficient *than* G1 in the retention and reuse of the RC structures (see Table 7):

Table 7. *Paired Samples Statistics for the Pretest and the Posttests*

Groups			Mean	*SD*	Paired Differences 95% Confidence Interval of the Difference Lower	Upper	*t*	*df*	*Sig.* (2-tailed)
G1	Pair 1	Pretest - Immediate	-.250	.44	-.45	-.04	-2.51	19	.021
	Pair 2	Immediate - Delayed	.150	.36	-.02	.32	1.83	19	.083
G2	Pair 1	Pretest- Immediate	-.950	.88	-1.36	-.53	-4.79	19	.000
	Pair 2	Immediate - Delayed	.100	.30	-.04	.24	1.45	19	.163
G3	Pair 1	Pretest- Immediate	-.100	.308	-.244	.44	-1.453	19	.163
	Pair 2	Immediate - Delayed	.150	.366	.082	-.021	.321	19	.083

4.3. Results of the Comparisons of Mean Values Between the Groups

One-way ANOVA was used in order to analyze the variance of the three groups at the beginning of the study. The test results of the one-way ANOVA indicated that there was no statistically significant difference among the mean scores of the pretest results with respect to the use of the RC structures: $F(2,57) = .158$, $p > .05$. This indicates that the three groups were homogeneous regarding their use of the RC structures at the beginning of the study (see Table 8):

Table 8. *One-Way ANOVA for the Pretest Scores*

		Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Pretest	Between Groups	.233	2	.117	.158	.854
	Within Groups	42.100	57	.739		
	Total	42.333	59			
	Total	46.933	59			

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Finally, the test results of the one-way ANOVA for the immediate posttest indicate that there was a statistically significant difference among the mean scores of the three groups: $F(2, 57) = 3.644$, $p < .05$. And, the test results of the one-way ANOVA for the delayed posttest manifest that there was a statistically significant difference among the mean scores in the three groups: $F(2, 57) = 5.536$, $p < .05$ (see Table 9):

Table 9. *One-Way ANOVA for the Immediate and Delayed Posttest Scores*

		Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Immediate Posttest	Between Groups	5.433	2	2.717	3.644	.032
	Within Groups	42.500	57	.746		
	Total	47.933	59			
Delayed Posttest	Between Groups	7.633	2	3.817	5.536	.006
	Within Groups	39.300	57	.689		
	Total	46.933	59			

To see the mean differences among the three groups on the posttests, the Scheffé test was conducted. For the immediate posttest, the highest mean difference was reported between G2 and G3: mean difference = .700; $p \leq .05$. However, the differences between the two experimental groups were not statistically significant: mean difference = .550; $p \geq .05$. In addition, the results of the Scheffé test revealed that for the delayed posttest, the differences between the mean score of G3 differed significantly from the mean score reported for G2. In contrast, the difference between the two experimental groups were not statistically significant: mean difference = *.600;* $p \geq .05$ (see Table 10):

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Table 10. *The Scheffé Test for the Posttest Scores*

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	*Sig.*	95% Confidence Interval	
					Lower Bound	Upper Bound
Immediate Posttest	G1	G2	-.550	.141	-1.24	.14
		G3	.150	.860	-.54	.84
	G2	G1	.550	.141	-.14	1.24
		G3	.700*	.045	.01	1.39
	G3	G1	-.150	.860	-.84	.54
		G2	-.700*	.045	-1.39	-.01
Delayed Posttest	G1	G2	-.600	.082	-1.26	.06
		G3	.250	.638	-.41	.91
	G2	G1	.600	.082	-.06	1.26
		G2	.850*	.008	.19	1.51
	G3	G1	-.100	.638	-.91	.41
		G2	-.700*	.008	-1.51	-.19

*The mean difference is significant at the 0.05 level.

5. Discussion

The present study aimed to investigate if the implicit presentation of the RC structure through structural priming leads to the production of that construction in the long run as an instance of implicit learning. The first research question investigated if priming had any significant effect on the oral production of the RC structure in the long run. The results of the statistical analyses including paired samples *t* test revealed that the participants' production of the RC structures in G1 improved on the immediate posttest, implying that priming helped the participants significantly to do better on the immediate oral test in terms of producing the RC structure. Besides, the results of the statistical analysis for the delayed posttest administered after a week showed that there was *a drop in the mean score of the delayed posttest, but the drop* in the mean scores from the immediate posttest to

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the delayed posttest was not statistically significant. In fact, the *delayed posttest* results *show*ed that the participants had retrieved successfully the RC structures in their long-term memory. These findings are consistent with the findings of studies conducted by Corney and Mendez (2015) that showed that the L2 speakers' oral production of prepositions enhanced when the priming paradigm was employed.

Also, the findings of the current study are similar to those reported by Kaschak et al. (2011) who found that the effects of structural priming persist for, at least, a week. The positive effect of priming on L2 production might be due to the claim that by Bock (1986), according to whom the processing of a stimulus facilitates the processing of another one. Based on this point of view, priming plays a facilitatory role by smoothing the production of the subsequent sentence. In fact, Bock (1986) claims that besides targeting linguistic representation, priming taps specific processes involved in the production and comprehension of an L2. Bernolet et al. (2013) tried to account how priming leads to implicit learning of certain structures. They believe that concurrently with the processes of sentences introduced to L2 speakers through priming, they implicitly learn syntactical rules that, in the long run, leads to structural persistence. Thus, priming not only targets linguistic information in syntactic representation of L2 learners' minds, but it also aims to trigger certain aspects of processing procedures (i.e., those involved in describing a picture from the point of displaying the images to articulating the descriptions) that are drawn on to handle information and to formulate messages.

The second research question investigated if priming had any significant effect on the written production of the RC structure in the long run. *The results of the descriptive and inferential statistics showed that G2 showed* a higher *mean* score on both the immediate and delayed *posttests, as compared to G1*. In fact, the comparison between the performance of the two experimental groups on the delayed test revealed that G2 was more successful than G1 in improving the long-term use of the RC structures. This finding is in alignment with the findings of

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Kaschak et al. (2014) that manifested that the effect of priming in an oral picture description task aroused in a written stem completion task. Similarly, Kaschak et al. (2014) displayed that the priming effects transferred in both directions: from oral to written and from written to oral modalities. Earlier, Kaschak et al. (2011b) showed that the long-term priming effects persisted when the tasks used in all phases of the study were alike. What these studies considered as the cornerstone of the persistence of the priming effect was a matched condition between priming and the other phases of the studies. Kaschak et al. (2011b) argued that the more there would be a match between all phases of the study, the more the probability of the memory retrieval of the construction. Besides, it is argued that the match between encoding and retrieval conditions becomes more critical when the interval time between the phases of the study increases (Craik, 2003). In essence, it is argued that the longer the distance between priming and retrieval, the more essential a matching condition.

However, the findings of this study do not support the above claims. Although the participants in both experimental groups of this study received priming in an oral modality, G2 that had to produce the target sentences in written modality displayed a better performance. Although there is not a definite answer to this issue, the following speculation is possible: The contrast between written and oral production relies on the fundamental differences in processing. Whereas in the course of the oral production, L2 learners experience a time pressure, the written production provides a place for planning before L2 production. It is probably the case that due to the limitations in the processing capacity of humans (Ellis, 2005), during the online processing, the participants failed to entirely attend to all aspects of production and they preferred to articulate the AN structure, over which they had a better mastery and with which they were more familiar. After the experiment, during the oral interview, in response to the questions which asked about the participants' mastery in comprehension and production of the RC structure, they confirmed that the AN structure was a simple

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and frequent construction that was well-embedded in their linguistic representation, as compared to the RC structure. This is in line with Swain's (1992) claim that the adjectival modification of a noun is one of the simple, useful, and frequent structures taught to EFL/ESL learners within the elementary, basic levels of the L2 learning process. Seventy-five percent the participants came to the belief that the first structures taught to them were the simplest and more useful ones and the latter ones were mainly complex constructions that could be employed in speech production just for L2 variability. They believed that when there was a possibility to express a concept with a simpler, shorter, and more frequent concept that they had experienced in different contexts, there was no need to make an explicit attention to produce a complex structure in the L2.

Besides, most participants asserted that the production of the AN structure was simpler for them probably because the length of this structure is more than adjectival constructions—it puts too much cognitive burden on them to produce this structure. This reminds us of what Chomsky (1965) called the economy of derivation in which he claimed that some processes are cheaper or preferred over others. The RC structures belong to the syntactic category labeled as Complementizer Phrase (CP) and are embedded in a complex nominal expression (i.e., Determiner Phrase [DP), whereas adjectives are embedded in Noun Phrase (NP) and modify the whole construction that they govern. It seems the difference in the structural type of the above two structures leads to cognitive complexity which, in turn, has been shown to have an influence on the priming effect in the oral mode where L2 learners are under time pressure (Shin & Christianson, 2012).

Taken together, it seems that because of the complexity of the RC structure and L2 learners' imbalanced preference in the choice of the RC or AN structures as well as the cognitive/psychological limitations in the appointment of attention during oral production, the priming effect apparently displays its impact in the written modality more clearly than the oral mode. Baddeley (2003) argues that during the written production, L2 producers are not under any time pressure and

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can keep their eyes thoroughly to the formulation and heuristic constituent ordering of the structures prior and during the production. Above all, contrary to previous studies (e.g., Bock et al., 2007) that claimed that the priming effects are robust enough that can endure despite changes in the demands of modality and production, these findings point towards this predominant conclusion that the priming effects might be compelled by factors other than adaptations to purely linguistic representations.

6. Conclusion

The current study investigated the effects of the priming paradigm on Iranian EFL learners' production of the RC structures as an instance of implicit learning. By applying a pretest, a treatment, an immediate posttest, and a delayed posttest design, the present study was an attempt to find answers for the research questions raised in this study. The results of the descriptive and inferential measures showed that priming could have a beneficial impact on the participants' production ability. Moreover, by comparing the two experimental groups, it was found that the priming effect manifested itself significantly in the written production of the participants. Although most previous studies have oriented around the cognitive and linguistic mechanism in L2 learning, priming can be employed in a certain challenging, but interesting, area of research that investigates how L2 learners extract, internalize, and subsequently, produce various aspects of the L2.

From a theoretical perspective, a major implication of studies like the one reported here is that it shows that grammatical representation is not a fixed entity within the linguistic schemata of L2 learners. The findings of the current study corroborate Bybee and Hopper's (2001) claim that L2 learners' grammatical preference is variable and subject to probabilistic changes. However, this adjustment for the participants of the present study and for the structure under study (i.e., the RC construction) primarily happened when they were under no time pressure for the online processing of L2 production. What this finding

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inspires is that priming might be introduced for intermediate L2 learners within written tasks or when engaged in pre-task planning procedures.

Besides, the major implication of the findings of the present study is that the results showed that the effects that are observed by the priming paradigm are the aftereffect of implicit learning. Thus, this concept possesses an implicit learning component and, as such, is applicable whenever implicit or procedural knowledge is at the main focal of an L2 educational program. The experience of a structure with completely new lexical items in a different context lends a hand in knowledge automaticity in which, as discussed in DeKeyser's (1995) cognitive-psychological view of L2 learning, automaticity is an unconscious, effortless, and fast mechanism that is of vital importance for L2 learners.

Practically, priming activities that provide the primes of only one structure may be more useful in L2 classroom contexts if an instructor's goal is to help his or her students to produce a difficult or infrequent structure. For example, even at advanced levels, L2 speakers may struggle with the spontaneous use of a construction. In this context, an instructor might create priming activities that present only that construction because the goal is to elicit the structure that the students have difficulty with, rather than to practice a structure they have already acquired and use frequently.

Besides, priming can be incorporated into interactional activities through which L2 speakers develop their competence through interaction with more developmentally advanced L2 speakers (e.g., native speakers/instructors or more advanced L2 speakers), who would prime L2 learners to produce the more advanced forms. Moreover, the priming intervention provides a situation in which L2 learners can practice grammatical structures by substituting different lexical items into a single grammatical frame. Most importantly, the co-occurrence of priming with tasks like picture description tasks causes the structural priming to be a meaningful and purposeful task. Therefore, contrary to earlier pattern drills, L2 learners through structural priming will be able to concentrate on the meanings

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of utterances, rather than being completely attracted by form. Thus, when L2 instructors face difficulty in designing activities that provide their students with opportunities for the production of grammatical structures in which the primary focus remains on meaning, the priming activities described in the current study can serve a variety of pedagogical functions by exposing L2 learners to large amounts of positive input. However, how to implement it within the syllabus design needs to be investigated further.

As to the limitations of the study, the RC and AN structures were the only constructions that were under the focus of the study. If two other alternative structures had been added to the present ones, the effect of structural complexity on the priming effect, as discussed in Discussion part, would have become more evident. Thus, it should be kept in mind that these conclusions are only applicable to the RC construction and the intermediate-level Iranian EFL learners. The data were gathered individually out of the classroom setting, demanding further research to be carried out in a natural classroom-based setting because natural conversation does not occur in isolated sentences, rather in a connected discourse and context-dependent setting.

Although many studies have investigated the impact of priming on L2 production from different perspectives, there are still some aspects of the concept that require further investigation. Future studies can examine the (possible) effects of priming on L2 learners' production by a focus on other structures. Besides, instead of conducting the priming research individually, as is the main stream in the psycholinguistic field of study, other studies can implement it within the classroom setting both in EFL and ESL contexts. In addition, the role of individual differences and their openness to linguistic variability should be considered more thoroughly.

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