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Working Memory Capacity and Semantic-Morphosyntactic Competition: A Comparison of L1 and L2 Sentence Processing

Mohammad Hadi Mahmoodi (Corresponding Author)

TEFL Department, Bu-Ali Sina University, Hamedan, Iran

mhmahmoodi@basu.ac.ir

Hamidreza Sheykholmoluki

TEFL Department, Bu-Ali Sina University, Hamedan, Iran

hsheykholmoluki@alumni.ut.ac.ir

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Abstract

This study explored the competition between semantic and morphosyntactic processing in L1 and L2. In addition, the relationship between working memory capacity (WMC) and L2 semantic-morphosyntactic processing was scrutinized. To this purpose, 73 Persian learners of English as a Foreign Language (EFL) participated in an offline grammaticality judgment test (GJT), an L1 as well as an L2 semantically-primed test, and a WMC test. The results showed that L1 morphosyntactic processing was not affected by semantic priming. But, L2 morphosyntactic parsing decisions, irrespective of the participants' WMC, was significantly influenced by semantic priming, indicating that L2 morphosyntactic knowledge in learners' interlanguage system might be shaky and subject to communicative aspects of input. Additionally, the findings revealed a significant relationship between the participants' WMC and their L2 semantic/morphosyntactic processing. The findings of the study provide some implications for foreign language teachers with regard to teaching morphosyntactic aspects of language and correcting morphosyntactic errors.

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1. Introduction

Language comprehension involves a process in which parsers make a simultaneous use of various informational resources such as lexical semantic, morphosyntactic, and prosodic information. Although such information is processed with ease in L1, research evidence suggests that L2 processing is more cognitively demanding and that L2 learners might resort to different strategies in the process of language comprehension compared with native speakers (e.g. Clahsen & Felser, 2006b; Dallas & Kaan, 2008). Effective processing in an L2 depends to some extent on learners’ sensitivity to grammar, which includes processing crucial information such as subject-verb agreement and plurality. Compared with native speakers, L2 learners might have different knowledge of (or access to) this grammar and resort to different strategies in analyzing that knowledge. These L2 phenomena may give rise to misinterpretations or processing difficulties, which might even impede L2 acquisition (O’Grady, 2005; Sharwood-Smith & Truscott, 2005; VanPatten, 2007). Therefore, it is crucial to gain insight into the factors that might influence L2 learners' sensitivity to morphosyntactic processing decisions.

Thus far, different approaches have been posed to explain why L2 learners face difficulties in processing L2 morphosyntax. For example, some models such as the Morphological Congruency Hypothesis (Jiang et. al. 2011) posit that acquisition of L2 morphemes depend on the influence of L1 features and properties. In addition, the Unified Competition Model (MacWhinney, 2005) claims that the influence of L1 is “pervasive in the arena of sentence interpretation” (p. 77). According to such models, the degree of similarity between L1 and L2 properties might determine the variation in L2 learners’ sensitivity to morphosyntax. If L1 features are to get in the way of L2 processing, different structures in L1 and L2 would be expected to engender more processing burden than those which are similar (Tolentino & Tokowicz, 2011). Likewise, MacWhinney (2005) claims that when L1 and L2 features are represented in the same way, these features will be positively transferred.

Not all models of L2 sentence processing attribute the variation in L2 morphosyntactic sensitivity to the influence of L1. Several L2 processing models such as the Shallow Structure Hypothesis (Clahsen & Felser, 2006) have argued that adult L2 learners resort to different processing mechanisms in learning some L2 aspects such as morphosyntactic relations because maturational constraints put nativelike morphosyntactic processing out of adult L2 learners' reach, especially for learners with lower proficiency levels (e.g., Clahsen & Felser 2006; Ullman 2005).

Other models have proposed that L2 learners cannot consistently integrate morphosyntactic information because it puts extra processing demands on their general cognitive and computational resources (e.g. Hopp 2010; McDonald 2006). In other words, since L2 processing is inherently more taxing for memory resources than L1 processing, differences between L1 and L2 processing might mirror qualitative differences in learners' memory capacities rather than essential differences in grammar (Hopp, 2014). Thus, capacity effects such as constraints on WMC have been put forth as another potential factor that might give rise to non-native-like L2 processing (Hopp, 2014). Within language, which is considered as one of the essential domains of human cognition, WMC has been shown to play a central role in many respects (Baddeley, 2017). Research evidence suggests that processing some L2 aspects such as morphosyntactic information, in particular, is affected by memory resource limitations, and primarily by limitations on WMC (Just & Carpenter, 1992). However, despite the identification of a close link between WM and language, the exact nature of the relationship between WM and language is still a yet-to-be-known area of investigation and this problem is even more acute primarily in Second Language Acquisition (SLA) literature.

Studies evaluating the predictive power of the afore-mentioned models have explored if learners process L2 syntactic information in the same way as native speakers would do. However, currently available findings in this line of research has remained inconclusive (e.g. Keating 2010; Omaki & Schulz, 2011; Witzel et al., 2012). The present study is an endeavor to explore whether the participants' L1 and L2 morphosyntactic parsing decisions are the same or different under semantic priming effect conditions for two typologically different languages with SOV (Persian) and SVO (English) word orders. In other words, the present study attempts to investigate the competition between syntax and semantics in L1 and L2 to shed more light on syntax-semantics interface. Moreover, the current study attempts to probe into the potential role played by WMC in processing semantic and morphosyntactic aspects of L2 input.

2. Literature review

One of the most well-known hypothesis in the domain of L2 learning is the Shallow Structure Hypothesis (SSH) proposed by Clahsen and Felser (2006). They argued that L1 processing children and adults are the same and any performance differences are attributable to cognitive developmental limitations. On the other hand, L2 performance differences are more qualitative rather than due to WM resource limitations, L1 transfer effect, or differences in parsers' processing speed. Based on the findings obtained from their study, Clahsen and Felser (2006) concluded that “the syntactic representations adult L2 learners compute for comprehension are shallower and less detailed than those of native speakers” (p. 32). This Hypothesis further assumes that "…late (adult) language learners rely to a greater extent on lexical-semantic and pragmatic information and do not compute syntactic structures in the same way as L1 learners" (Mitchell et al., 2013, p. 134). Based on this view, L2 learners resort more heavily to lexical semantics and plausibility information to interpret sentences and are thus less sensitive to syntactic constraints.

Another well-known cognitive model in SLA that aims to account for the internal mechanisms that learners employ to process sentences is VanPatten’s Input Processing (IP) model (2004a). Based on this model, L2 learners frequently encounter difficulty with processing some syntactic forms such as bound morphemes and ‘little’ words which convey syntactic information in the early stages of L2 development (Harrington, 2004). The model includes a set of principles and their corollaries that explain the processing strategies employed by learners and that predict which grammatical forms are processed more readily when cognitive resources are limited. More specifically, these principles explain the processing constraints that might get in the way of L2 learning (VanPatten, 2004), especially in the initial stages.

One of the notions that lies at the heart of the IP model is that the primary goal of sentence processing is extracting meaning from input and that processing grammatical forms occur fundamentally for communicative purposes. In other words, the model postulates that deriving meaning from the input has priority over deriving grammatical information. This notion is encapsulated in one of the fundamental principles of the IP model called the Primacy of Meaning Principle. The principle implies that learners' focus on meaning and communicative intent gives rise to the instances in which some forms—particularly morphosyntactic—are not processed with acquisitional intentions (VanPatten, 2004). Furthermore, the Primacy of Meaning Principle postulates that since comprehension plays a major role in communication and since there are constraints on parsers' cognitive resources (e.g., WMC), processing meaning is privileged over processing grammatical forms (VanPatten, 2004). This latter principle, referred to as the Availability of Resources Principle, postulates that to process meaningful/non-meaningful grammatical forms, the processing of meaning in the input stream must not drain parsers' processing resources. Therefore, constraints on parsers' processing capacities are one of the determining factors in selecting the grammatical forms in the input for processing (Harrington, 2004).

Evidence for the Availability of Resources Principle comes specifically from research exploring the relationship between WMC and L2 learning. A considerable body of research in this domain has demonstrated that individual differences in WMC accurately predict the process and products of L2 acquisition and processing (Grundy & Timmer, 2017; Li et al., 2019; Linck et al., 2014; Wen et al., 2015), speaking (Fortkamp, 2000; O'Brien et al., 2006), L2 reading comprehension (e.g., Daneman & Carpenter, 1980; Joseph et. al., 2015; Alptekin & Erçetin, 2009, 2015; Joh, 2015, Joh & Plakans, 2017), and writing (e.g., Adams & Guillot, 2008; Leeser, 2007) in particular. Numerous studies have also shown the involvement of cognitive resources in using syntactic information (e.g. Havik et al., 2009; Kim & Christianson, 2016). More specifically, the studies exploring the impact of WMC on resolving structurally ambiguous sentences (e.g. Harding et al., 2019; Hopp, 2014; James et al., 2018; Kim & Christianson, 2012, 2016; Payne et al., 2014) have provided support for the involvement of WMC in parsing such ambiguous sentences in both offline (e.g. Hopp, 2014; Kim, 2010; Mahmoodi et al., 2022; Swets et al., 2007) and online (e.g. Kim & Christianson, 2016; Marefat et al., 2015; Traxler, 2007) literature.

Processing L2 sentences, especially morphologically complex words, has been reported to depend less on grammatical information than L1 sentence processing (Clahsen & Felser, 2006a, 2006b; Ullman, 2005). Using grammaticality judgment and comprehension tasks, a number of previous studies have shown that L2 learners exhibit reduced sensitivity to morphosyntactic cues (e.g. Chen, et. al., 2007; Hahne, et. al., 2006; Keating, 2009; Ojima, et. al., 2005; Tokowicz & Warren, 2010). On the other hand, several other studies (e.g. Jackson, 2008; Jackson & Bobb, 2009; Jackson & Dussias, 2009) observed that highly proficient L2 learners exhibited nativelike sensitivity to case morphology. With respect to production, some recent studies have argued that L2 learners do show sensitivity to morphosyntactic information. For example, some longitudinal studies have reported that late L2 learners of German accurately used suppletive marked forms of auxiliaries, whereas regular inflectional affixes were either absent or incorrectly used (Dimroth, 2008; Parodi, 2000). Similarly, in an ERP study exploring subject-verb agreement violations in German, Tanner, et. al. (2009) observed that intermediate to advanced L2 learners of English showed qualitatively similar brain responses (P600) to ungrammaticalities. However, a number of other ERP studies have also reported differences between L1 and L2 morphosyntactic processing (e.g., de Diego-Balaguer, et al., 2005; Weber & Lavric, 2008). For instance, de Diego Balaguer et al. (2005) used a repetition-priming paradigm to investigate the acquisition of regular and irregular Spanish verbs among high-proficiency L2 Spanish learners. They found similar centro-parietal N400 priming effect for regular verbs in L1 and L2, whereas, irregular morphology elicited a reduced N400 priming effect for L2 learners. Therefore, differences in L1 and L2 processing were detected even among proficient early L2 learners for languages with very similar systems but some different structures. Because of such divergent findings with respect to processing morphosyntactic cues, there is an urgent need to explore how morphosyntactic information is processed in the L1 and the L2 and whether L2 learners are sensitive to morphosyntactic cues in the face of semantic priming effect or not. To explain the discrepant findings with regard to L2 learners' sensitivity to L2 morphosyntax, some researchers have claimed that L2 learners can process L2 stimuli in native-like way only when L1 and L2 morphosyntactic features are similar (Sabourin & Haverkort, 2003, Sabourin & Stowe, 2008), while others have argued that L2 structures are more easily acquired when L1 and L2 grammatical features are different (e.g., Foucart & Frenck-Mestre, 2011; 2012; Tokowicz & MacWhinney, 2005).

A gap in this body of research is that although an overwhelming majority of previous studies have explored participants' morphosyntactic knowledge or its lack thereof, the studies exploring the stability of L2 learners' morphosyntactic knowledge in their interlanguage system has remained underexplored. Therefore, the significance of the present study is that although the majority of previous studies have explored the breadth of L2 leaners' morphosyntactic knowledge, the present study investigated its depth. In other words, the present study will set out to investigate whether L2 learners' morphosyntactic knowledge remains stable and unaffected by semantic priming effects as a consequence of late L2 learning and memory resource limitations. Thus, the significance of the study is that the obtained findings will shed light on the syntax-semantics interface with implication for L2 age of onset and WMC.

3. Purpose of the study and research questions

The specific purpose of the current study was exploring the predictions of the IP model (VanPatten, 2004) and the Shallow Structure Hypothesis (Clahsen & Felser, 2006). In addition, the study aimed to explore parsers' abilities with different WMC levels in processing semantic and morphosyntactic information, to determine whether individual differences in WMC will affect learners' L2 semantic and morphosyntactic RC attachment processing behaviors. The study was, thus, guided by the following three questions:

1. Does the participants' L2 morphosyntactic performance remain stable as a consequence of semantic priming effect?
2. Is there any significant difference between the participants' L1 and L2 morphosyntactic processing as a consequence of semantic priming effect?
3. Is there any significant relationship between the participants' WMC and their L2 semantic/morphosyntactic processing performance?

Regarding the first research question, on the basis of the predictions of the Shallow Structure Hypothesis (Clahsen & Felser, 2006), it is hypothesized that the participants, being adult L2 learners of English, will resort to lexical-semantic information and thus show more morphosyntactic violations in the semantically-primed test as a consequence of semantic priming effect, attaching the RC toward the DPs to which the RCs are semantically biased. However, with respect to our second research question, since it is a rather uncharted area of inquiry, a null hypothesis is proposed. As to the third research question, consistent with the predictions of VanPatten's IP model (2004), it is predicted that low-capacity individuals will prioritize processing meaning over processing grammatical information, and thus will show more morphosyntactic violations, while it is predicted that high-capacity individuals will process both semantic and morphosyntactic information simultaneously and commit fewer morphosyntactic errors due to more processing resources that they have at their disposals.

4. Methodology

4-1. Participants

73 native speakers of Persian (31 males and 42 females) selected through purposive sampling procedure participated in this study. All the participants were BA students studying English Translation at a state University in Iran and their ages ranged from 18 to 24. The participants had all learned English in instructional settings and neither reported having the experience of travelling to or living in an English-speaking country. In order to control the confounding effect of language transfer, the participants who reported to know or be able to speak languages other than Persian and English were excluded from the study. The participants were naïve regarding the purpose of the study. Prior to conducting the study, they expressed their consent to participate in the study.

4-2. Instruments

4-2-1. WM Span Test

The participants' WMC was measured by means of a computer-based reading span task (RST). The overall design of the RST was similar to the Daneman and Carpenter's (1980) reading span test, with some modifications based on the guidelines by Ariji et al. (2003) and Omaki and Ariji (2003). The reading span task (RST), a complex verbal span task, has been widely used to investigate WM since the 1980s. To construct the test, first, a total of 70 nontechnical sentences with controlled length (between 20 and 30 syllables) were extracted from Persian textbooks and magazines (Appendix A). The sentences were unambiguous and unrelated and all the sentences were in active voice. To get feedback on the appropriateness of the sentences, two PhD experts in Persian literature from Bu-Ali Sina university, Hamedan, Iran subsequently viewed and validated the appropriateness of the sentences for the stated purpose. Additionally, the sentences were also viewed and validated by two PhD experts in TEFL from Bu-Ali Sina university. In order to make sure that the test would measure the processing component of WM, half of the sentences were made semantically or syntactically anomalous, each sentence followed by a grammaticality judgment YES/NO question. The rationale for including a grammaticality judgment YES/NO questions after each sentence was to ensure that the participants processed the sentences attentively. In addition, the first or the second word of every sentence (Ariji et al., 2003; Omaki & Ariji, 2003) was specified to be recalled after processing and judging the grammaticality of the sentences. The specified words were all concrete nouns with controlled length (between 1 and 3 syllables) and started with different sounds and letters in each trial. The words were specified to be recalled by underlining the word, picking up the word in bold, and distinguishing the word from the rest of the words of the sentence by the color green. The rationale behind specifying the first or the second word to be recalled was that WMC consists of both storage and processing components and these two components work simultaneously in normal speech. Asking the participants to recall the first or the second word while at the same time processing the rest of the sentence would guarantee the *simultaneous* measurement of both storage and processing components of WM (Ariji et al., 2003; Omaki & Ariji, 2003). All the sentences were assembled into a single test starting from two levels and continuing up to five levels, with each level being repeated five times, so that there was 70 (10+15+20+25) sentences in total.

The sentences were arranged in a way to be presented in a segment-by-segment fashion with each segment being timed. The duration of the segments of the sentences was based on the recommendations by Ariji et al. (2003) for native speakers, and was slightly modulated after the test was piloted with a sample of 50 participants similar to the target group prior to the main experiment. To calculate the participants' WMC scores, the number of correctly recalled words was counted only for the sentences whose grammaticality was accurately judged (Ariji et al., 2003; Chun & Payne, 2004; Joh & Plakans, 2017; Leeser, 2007; Swanson, 1994). This scoring system seeks to overcome the trade-off effect between the storage and processing components of WM. Thus, one point was assigned to each sentence only if the participants' performance was accurate on both acceptability and recall. The possible range of scores on the WM test was between 0 and 70. The α reliability of the test turned out to be .91, which is a high level of internal consistency.

4-2-2. GJT

A GJT consisting of 16 (grammatical and ungrammatical) sentences (Appendix B) interspersed with 32 (grammatical and ungrammatical) fillers (Appendix D), beginning with 5 practice sentences (Appendix E), to be rated on a scale from 1 (least acceptable) to 6 (most acceptable) was used to ensure that the participants were familiar with the target sentences, so that any subject-verb agreement violations in the semantically-primed test by the participants could be attributed to semantic priming effect only and not to their lack of familiarity with the construction of the target of stimuli. The construction in question was whether the verb in the relative clause agreed with the DP it modified in terms of number. The numbers "1" and "2", then, were interpreted as ungrammatical, and the numbers "5" and "6" were interpreted as grammatical. In addition, numbers "3" and "4" were interpreted as either "I don't know", or as a sign that the participants had answered haphazardly. The participants were told to choose the correct number by circling their choices. Two experts in TEFL subsequently viewed and validated the sentences for the stated purpose. Then, the sentences were interspersed with 32 (grammatical and ungrammatical) fillers so that the participants do not adopt any particular strategy in selecting the options. The test has a desirable level of internal consistency (α = .90).

4-2-3. Persian and English semantically-primed tests

A total of 41 English sentences, consisting of 5 practice, 16 experimental, and 20 fillers were used in the L2 semantic/morphosyntactic test to see whether the participant' morphosyntactic knowledge would remain stable and unaffected by sematic priming effect or not. The experimental sentences were made up of [DP1 of DP2 RC VP] construction and almost the same length. The genitive construction (i.e. *DP1 of DP2*) in each sentence was in the subject position and the following RCs were subject-modifying. Both DPs in the genitive construction were animate. One of the DPs was always in singular form and the other was in plural form so that the RC could be morphosyntactically biased toward one of the DPs through subject-verb agreement. In addition, the RC was only semantically biased toward the other DP, which was not morphosyntactically in agreement with the RC. Prior to pluralizing one of the DPs and when both DPs were in singular forms, the experimental stimuli were piloted with 20 readers. All the readers attributed the RCs to the DP toward which the RC was biased, confirming that the RC was semantically biased only for one of the DPs. In addition, prior to pluralizing one of the DPs, the experimental stimuli were viewed by two PhD experts in TEFL from Bu-Ali Sina university with the experience of teaching courses in TEFL and English translation and judged to be biased toward one of the DPs only. After ensuring that the RCs were semantically biased toward one of the DPs, the other DP was pluralized so that the RC could be morphosyntactically biased toward one of the DPs (either DP1 or DP2). In order to control the confounding effect of ordering, for half of the sentences, DP1 was in singular and DP2 was in plural forms, and for the other half DP1 was in plural and DP2 was in singular forms. Moreover, to further control the ordering effect, for half of the sentences, RCs were semantically biased toward DP1 and morphosyntactically biased toward DP2, and for the other half, the RCs were morphosyntactically biased toward DP1 and semantically biased toward DP2. Thus, the 16 experimental sentences were constructed across four experimental conditions (Appendix C), as presented in Table 1 below.

Table 1 *The Four Experimental Conditions for the Semantically-Biased Test*

	DP1	DP2	RC
Condition A	Singular	Plural	Semantically biased for DP1/Morphosyntactically biased for DP2
Condition B	Singular	Plural	Semantically biased for DP2/Morphosyntactically biased for DP1
Condition C	Plural	Singular	Semantically biased for DP1/Morphosyntactically biased for DP2
Condition D	Plural	Singular	Semantically biased for DP2/Morphosyntactically biased for DP1

In addition, to compare the participants' L2 with L1 processing, the participants' L1 morphosyntactic performance under semantic priming effect was also measured as baseline to see whether semantic priming would affect the participants' L1 processing or not. In order to reduce any bias in the data that might result from differences in the words used in the construction under investigation (Gilboy et al., 1995; Kim & Christianson, 2016), the L1 sentences were direct translations of the English sentences (Appendix C). Yet, two experts in Persian literature reviewed the Persian sentences to ensure the naturalness of the stimuli.

Each L1 and L2 experimental sentence was followed by two options. One option was about one of the DPs which was considered as a morphosyntactically possible site for the RC, and another option attributed the RC to the DP toward which it had been semantically biased, although it was morphosyntactically incorrect, to see if semantic bias would take readers' attention away from morphosyntactic information or not. The arrangement of the options was also randomized so that for half of the sentences the first option referred to DP1 and for the other half DP2 was the first option. A sample for the English and Persian experimental sentences in which DP1s are italicized, DP2s are underlined, and the RCs are enclosed in brackets along with their following options are illustrated in (1) and (2), respectively:

(1) *The unruly pupils* of <u>the teacher</u> [who listens to loud music in class] smiled at the principal.

A. The unruly pupils listen to loud music in class.

B. The teacher listens to loud music in class.

(2) *شاگردان شلوغ کار* <u>معلم</u> [که در کلاس با صدای بلند موسیقی گوش میدهد] به مدیر لبخند زدند.

(Shagerdane shulugh kare moallem ke dar kelas ba sedaye boland musighi gush midahad be modir labkhand zadand.)

الف) شاگردان شلوغ کار در کلاس با صدای بلند موسیقی گوش میدهند.

(Shagerdane sholugh kar dar kelas ba sedaye boland musighi gush midahand.)

ب) معلم در کلاس با صدای بلند موسیقی گوش میدهد.

Moalem dar kelas ba sedaye boland musighi gush midahad.)(

All the experimental sentences in each Persian and English set of stimuli were interspersed with 32 fillers (Appendix D), beginning with 5 practice sentences (Appendix E). (The Persian fillers and practice sentences were also direct translations of the English sentences). The practice and filler sentences were controlled for length to be similar to the experimental sentences and were followed by two options, which were in the form of statements about the truth value of the sentences, to not only conceal the purpose of the study, but also to ensure that the participants had chosen the options attentively. The practice sentences acted as warm-up. Two experts in TEFL subsequently viewed and validated the L1 and L2 target sentences for the stated purpose. All the stimuli were randomized across four lists, with a new randomization for each participant. Both the English and the Persian tests enjoyed a high level of internal consistency reliability (α = .86 for the English and α = .92 for the Persian test).

Two scoring systems for the L2 semantically-primed test were employed; one for calculating only the participants' L2 morphosyntactically accurate responses to be compared with their GJT scores and another for calculating both the participants' morphosyntactically accurate responses and their morphosyntactic violations. In the first condition, each morphosyntactically correct answer received a score of 1, while morphosyntactically incorrect responses were ignored. The minimum and the maximum possible scores for the test in this case were 0 and 16, respectively. In the second condition, for the simplicity of the calculation of the participants' morphosyntactic as well as their semantic processing decisions, the present study used the method employed by Kim and Christianson (2012). They assigned a score of one to each DP1 and a score of zero to each DP2 chosen by the participants. Then, they added up all the ones and zeroes and divided this number by all the ambiguous sentences. If the number was less than .5 and close to zero, the attachment preference was regarded as DP2 and if the number was more than .5 and close to one, the attachment preference was regarded as

DP1. Similarly, in this study each morphosyntactically-based parsing decision was assigned a score of 1 and each semantically-based parsing decision was assigned a score of 0. Then, all the numbers were added up and divided by the total number of experimental sentences (i.e. 16). If the number was close to 1, the parsing decision was considered to be morphosyntactically-based, and if the number was close to 0, the decision was considered to be semantically-based. The minimum and the maximum possible scores in this condition were 0 and 1, respectively. Therefore, in the first condition, in which DP1 was in singular form and the RC was semantically biased toward DP1 and morphosyntactically biased toward DP2 (condition A), as well as in the third condition, in which DP1 was in plural form and the RC was semantically biased toward DP1 and morphosyntactically biased toward DP2 (condition C), the greater rate of DP1 RC attachment preference by readers would indicate a more semantically oriented processing preference, overshadowing readers' morphosyntactic processing ability. On the other hand, in the second condition, in which DP1 was in singular form and the RC was semantically biased toward DP2 and morphosyntactically biased toward DP1 (condition B), as well as in the fourth condition, in which DP1 was in plural form and the RC was semantically biased toward DP2 and morphosyntactically biased toward DP1 (condition D), a lower rate of DP1 RC attachment preference would indicate a more semantically oriented processing preference, to the detriment of readers' morphosyntactic processing ability.

4-3. Procedure

First, the participants took the WM span test individually lasting approximately 15 minutes for each participant. The experiment was carried out in a quiet room. The participants were seated in front of a laptop screen. Prior to conducting the test, all the necessary directions were clearly spelled out by one of the experimenters. Then, each participant was presented with 3 warm-up trials. After the warm-up phase, they took the WM span test. The stimuli were presented to the participants visually on a laptop screen. The sentences were presented from 2- to 5-sentence conditions; each condition being repeated five times. All the sentences were presented in a non-cumulative segment-by-segment fashion. In the 2-sentence condition, first two sentences were presented, presenting one sentence at a time. Immediately after the presentation of the last segment of each sentence, the participants were presented with the cue *"Grammatical?"* on a separate slide to judge the grammaticality of the sentence by saying "YES" or "NO". Then, the participants saw the cue "WORDS" on the next slide to recall the specified words. This condition was repeated five times so that the number of words required to be recalled added up to 10 in the 2-sentence condition. All the responses by the participants were expressed orally, while one of the experimenters marked the participants' responses on a pre-developed answer sheet. The 3-sentence, 4-sentence and 5-sentence conditions were also presented this way. Thus, there were 10 sentences in the first, 15 sentences in the second, 20 sentences in the third, and 25 sentences in the fifth condition, so that the total added up to 70 sentences.

Then, at the next meeting, the participants took the GJT, lasting approximately 20 minutes. To control for any test effect, the Persian semantically primed test was administered two weeks after the administration of the GJT, and the English semantically-primed test was administered two weeks after the administration of the Persian version of the semantically-primed test. With regard to the GJT and the Persian and English semantically-primed tests, the stimuli were presented on a laptop screen. All the sentences in three tests were presented in a self-paced segment-by-segment non-cumulative fashion. As for the GJT, each sentence was followed by a slide asking the participants to rate the acceptability of the sentences on a 1-6 scale. The participants responded orally while one of the experimenters marked their answers on a pre-developed answer sheet. For the Persian and English semantically-primed tests, each sentence was followed by a question on the next slide, asking whether the semantically-biased RC following the *DP1 of DP2* construction modified DP1 or DP2. As in the GJT, the participants responded orally but in these tests by saying either A or B, while one of the experimenters marked their responses on a pre-developed answer sheet. In order to ensure that the participants responded attentively, the answers to the fillers were subsequently checked for accuracy. Finally, the LBQ was administered at the fourth meeting with a one-week interval between the third and the forth administrations. The participants completed the LBQ in almost 15 minutes.

5. Results

5-1. Descriptive statistics

In order to summarize the participants' scores on the measures, descriptive statistics for the GJT, the Persian and English semantically primed tests along with their fillers, and the WM span test are displayed in Table 2.

Table 2 *Descriptive Statistics of the Variables (N = 73)*

Variables	Min	Max	Mean	SD
GJT	15	16	15.72	.44
Fillers in the GJT	31	32	31.54	.50
English semantically-primed test (with two scoring systems)	1 (.06)	16 (1)	10.46 (.65)	5.30 (.33)
Fillers in the English semantically-primed test	31	32	31.60	.49
Persian semantically-primed test	.87	1	.99	.02
Fillers in the Persian semantically-primed test	31	32	31.91	.27
WM test	25	67	50.05	11.32

As Table 2 indicates, a comparison of the participants' mean scores for the GJT and the English semantically-primed tests shows that there is a notable decline in the participants' morphosyntactic accuracy, suggesting that the semantic priming effect might have affected the participants' L2 morphosyntactic processing accuracy. Moreover, as can be seen in Table 2, the participants' mean score for the Persian semantically-primed test is .99, which shows that the participants' L1 processing was highly morphosyntactically oriented because it is too close to 1, indicating that the semantic priming effect had only a negligible and almost no impact on the participants' L1 morphosyntactic processing accuracy. Thus, a comparison of the L1 and L2 morphosyntactic processing under semantic priming effect conditions shows that the semantic priming effect had a substantially more noticeable impact on the participants' L2 rather than their L1 morphosyntactic processing.

5-2. RQ1

In order to examine whether the participants' L2 morphosyntactic performance would remain stable and unaffected by semantic priming effects and to see if the difference between the two conditions was significant, a paired sample T-test was conducted, the results of which are summarized in Table 3.

Table 3 *Paired Sample T-Test for the Difference between the GJT and the English Semantically Primed Test*

		Paired Differences								
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)	Effect size
Pair 1	Morphosyntax - GJT	5.26	5.30	.62	4.02	6.49	8.47	72	.00	.99

As Table 3 indicates, the results showed that there was a significant difference between the participants' GJT scores and their morphosyntactic test scores (t (72) = 8.477, p=.00, effect size=.99). Therefore, it can be understood that semantic priming effect significantly influenced the participants' morphosyntactic performance.

5-3. RQ2

In order to examine whether there is any significant difference between the participants' L1 and L2 morphosyntactic processing as a consequence of semantic priming effect, a paired sample T-test was conducted, the results of which are summarized in Table 4.

Table 4 *Paired Sample T-test for the Difference between the Persian and English Semantically-Primed Tests*

		Paired Differences								
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)	Effect size
Pair 1	Persian semantically primed – English semantically primed	.34	.33	.03	.26	.41	8.85	72	.00	1.03

As Table 4 demonstrates, the results revealed that there was a significant difference between the participants' L1 and L2 semantically-primed test scores (t (72) = 8.85, p=.00, effect size=.99), suggesting that semantic priming effect influenced the participants' L1 and L2 morphosyntactic processing in a significantly different way.

5-4. RQ3

To examine if there is any significant relationship between the participants' WMCs and their L2 semantic/morphosyntactic processing abilities, the data were subjected to Pearson Correlation. Table 5 shows the results of the correlation between the WMC and the participants' morphosyntactic processing abilities.

Table 5 *Pearson Correlation between the Participants' WMC and L2 Morphosyntactic Processing (N = 73)*

		Morphosyntactic processing	Effect size
WMC	Pearson Correlation	.89*	.79
	Sig. (2-tailed)	.00	
	N	73	

**. Correlation is significant at the 0.01 level (2-tailed).

As demonstrated in Table 5, the results of the correlation between WMC and morphosyntactic processing shows that there is a significant correlation between WMC and morphosyntactic processing ability ($r = .89$, $p = 0.01 < 0.05$, effect size=.79). This implies that the participants with higher WMCs had lower morphosyntactic violations, while the lower capacity individuals had higher morphosyntactic errors as a consequence of semantic priming effect.

5-5. Post-hoc power analysis

In addition, a statistical power analysis was performed using GPower 3.1 (Faul et al., 2009) to examine whether the sample size in the present study was sufficiently large to potentially detect an individual differences effect. The expected effect size was set at .5, considered to be large using Cohen's (1988) criteria. With an alpha level of .05 and sample size of 73, the statistical power with this effect size was .98 for our analyses, which is much higher than the desired level of .80. This implies that there is a 98% probability that we have not committed type II error. Thus, our sample size of 73 appears to have been more than adequate for the purpose of this study.

6. Discussion

The present study investigated the impact of semantic priming effect on EFL learners' L1 and L2 morphosyntactic processing decisions. The relationship between WMC and semantic/morphosyntactic processing behaviors was also explored.

Our first research question explored whether the participants' L2 morphosyntactic performance would remain stable as a consequence of semantic priming effect, for which we hypothesized that the participants' morphosyntactic knowledge would be significantly affected by semantic priming effect. In line with the predictions of our hypothesis, the findings of the study showed that the participants' morphosyntactic processing ability was significantly affected by semantic priming effect, confirming our predictions.

The second research question investigated whether there was any significant difference between the participants' L1 and their L2 morphosyntactic processing as a consequence of semantic priming effect, for which a null hypothesis was proposed. Results revealed that there was a significant difference between the participants L1 and their L2 morphosyntactic processing as a consequence of semantic priming effect. Taken together, the findings obtained from the first and the second research questions provide further support for the predictions of the Shallow Structure Hypothesis (Clahsen & Felsera, 2006), which holds that “the syntactic representations adult L2 learners compute for comprehension are shallower and less detailed than those of native speakers” (Clahsen & Felser, 2006a, p. 32).

The third research question of the study explored the relationship between the participants' WMC and their L2 semantic/morphosyntactic processing decisions. For this, we hypothesized that there would be a significant relationship between the participants' WMC and their semantic/morphosyntactic processing decisions. Confirming the predictions of our hypothesis, the findings showed a significant correlation between the participants' WMC and their semantic/morphosyntactic processing decisions. Regarding the significant relationship between WMC and semantic/morphosyntactic processing decisions found in this study, the findings are consistent with a number of previous studies such as Hopp (2014), Kim (2010), Kim and Christianson (2016), Payne et al. (2014), Swets, et. al. (2007), and Traxler (2007), who found different L2 processing behaviors between high-capacity and low-capacity individuals. This finding provides further evidence for the predictions of vanPatten's IP model (VanPatten, 2004), which states that deriving meaning from input has priority over deriving grammatical information, especially for individuals with lower WM resources.

The finding of the present study corroborates the predictions of Good Enough Processing approach (Ferreira et al., 2002; Ferreira & Patson, 2007) which postulates that although it is not impossible for parsers to compute syntactic analyses, they do not always employ the full syntactic parse for comprehension. Misinterpretations occur when there is a conflict between analyzing syntactic and lexical-semantic information. Therefore, based on the findings of the present study, it seems that only L2 learners, but not L1 speakers, might resort to a "good-enough processing strategy" that hinders them form using full syntactic analyses during L2 comprehension.

The findings obtained from the present study could also be interpreted in light of Dynamic System Theory (DST) of SLA according to which second language learning is a complex and dynamic process and not a static or linear skill (Jessner, 2008). There is a tendency in applied linguistics to use static linear models for evaluating the outcome of second language learning (Dornyei, 2009). But, as revealed by the findings of the present study, a one-shot linear analysis of the dynamic and complex system of language does not mirror the reality of second language learning. This was manifested in the participants' L2 morphosyntactic performances at two different points in time in the current study. Accordingly, DST is mainly concerned with examining changes in L2 learning over time, and in so doing, it analyzes the complex and dynamic nature of L2 learning process and the variables that affect this process. Moreover, according to DST, the variables that get in the way of second language learning are highly interlinked so that changes in one variable (WMC and semantic load of the input in this study) will influence all other variables (morphosyntactic decision in this study) being part of the system (de Bot et al., 2007). That is why de Bot et al. (2007, pp. 7) suggest that 'Dynamic System Theory is proposed as a candidate for an overall theory of language development'.

The findings of the present study contribute to the field of research in L1 and L2 processing in that the results extend the findings of previous studies on the L2 morphosyntactic processing to a comparison of L1 and L2 morphosyntactic processing under semantic priming conditions. The methodology employed in this study allowed us to probe deeper into the processing strategies employed by Persian FL learners of English and gave us a unique opportunity to explore the semantic and morphosyntactic processing behaviors of the same group serving simultaneously as L1 speakers and L2 learners with a rage of WMC levels, and thus provided us with a deeper understanding of the similarities and differences not only between L1 and L2 processing but also between low-capacity and high-capacity individuals. Thanks to the methodology employed in the study, we were able to delve deeper into learners' interlanguage systems and show how L2 morphosyntactic knowledge in FL learners' interlanguage systems are in a state of flux and subject to semantic manipulation. In a nutshell, the findings obtained from the present study allowed us to examine the competition between syntax and semantics and thus provided us with some insight into syntax-semantics interface.

7. Conclusion and implications

As revealed by the findings of the present study, L2 morphosyntactic processing ability in FL learners' interlanguage systems might be influenced by factors such as the semantic load of the stimuli and thus could be prone to restructuring. Additionally, parsers' cognitive capacity might be a factor that comes into play in L2 morphosyntactic processing. With respect to the impact of WMC on L2 morphosyntactic processing, it could be concluded that the more parsers' memory resources are drained by holding lexical-semantic information in WM, the more it is possible that parsers commit morphosyntactic violations. In conclusion, the findings of the current study provided further evidence for the involvement of a linguistic factor (i.e. semantic priming effects) and a cognitive factor (i.e. WMC) in L2 sentence processing.

Therefore, as for our first and second research questions, the implication of the study is that since overreliance on lexical-semantic information in the input might take learners' attention away from noticing L2 morphosyntactic information, and thus prevent morphosyntactically-based input to be converted into intake, FL teachers are suggested to consider implementing tasks for practicing more morphosyntactic aspects of an L2, especially through meaning-focused communicative tasks which require leaners to simultaneously focus on both conveying meaning as well as employing L2 morphosyntactic devices for conveying those meanings. The trade-off effect between processing semantic and syntactic information might gradually be overcome through practice as participants' L2 morphosyntactic knowledge is gradually proceduralized and automatized.

As for the third research questions, as far as the relationship between WMC and morphosyntactic processing ability is concerned, the implication of the present study is that teachers in FL contexts are recommended to take learners' cognitive capacity into serious account while teaching an L2. One occasion in which this consideration can be manifested is in error correction. FL teachers should beware of the fact that leaners' errors, especially morphosyntactic ones, might be rooted in their lack of sufficient cognitive resources. By taking this variable into account, teachers can go a long way toward reacting appropriately to learners' morphosyntactic errors, and thus provide the type of feedback which is commensurate with leaners' cognitive processing abilities.

In closing, since the present study was carried out in an FL setting, it should be acknowledged that the findings obtained from the study might probably be generalizable to instructed settings only and not to SL contexts. Whether the same findings are obtained in SL contexts or not is a mission that future studies are to investigate. Thus, it is highly recommended that psycholinguistic researchers conduct similar studies in SL contexts as well to explore whether the findings obtained in instructed settings are also replicated in SL contexts or not.

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