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L2 Relative Clause Processing: Evidence from Self-Paced Reading

Abdolnoor Khaleghi *
Postgraduate student, Lund University, Sweden

Abstract
This study investigates how non-native readers and native speakers of English process subject relative clauses (RCs) when reading temporarily ambiguous sentences. The main objective of this research is to probe how antecedents accompanied by structural variables such as noun type, RC length, and RC type or position would possibly influence online RC parsing. Eighteen L2 learners (Persian) and fifteen English native speakers participated in a questionnaire study (offline) and a non-cumulative self-paced reading experiment (online). The findings revealed that the Persian learners and the native speakers did not read similarly, in the offline task, providing different attachment preferences (NP1 or NP2). The impact of experimental conditions on participants' online RC processing was not significant except in region 4, where extraposed RCs were located, but significant effects of the group were yielded. Both groups processed sentences containing definite short non-extraposed RCs (region 2) faster, however, the Persian learners showed longer reading times overall, regardless of RC position. Therefore, online behavior and attachment choices are modulated to some extent by group effects. Moreover, L1 influence may account for Persian learners' preferences for high attachment over low attachment in RC ambiguity resolution.
Keywords: ambiguous sentences, self-paced reading, subject RC processing, attachment preference

INTRODUCTION

It is widely assumed, in the psycholinguistic literature, that human sentence processing involves different parsing strategies, some of these have been claimed to be subject to cross-linguistic differences (Jacob, 2009; Malakooti et al., 2020), some others being subject to parametric variation (Frazier and Rayner, 1988; Mazuka, 1998) as well as to individual differences, for example, in proficiency (Karimi et al. 2021), age, exposure or working memory span (Omaki, 2005; Engelhardt et al., 2017).

Relative clause (RC) as one of the most extensively studied ambiguous structures has received much attention in second language (L2) processing research. A construction with syntactic and semantic ambiguities in sentences as in (1) where one constituent, the relative pronoun (who), can attach to two potential antecedent noun phrases (NPs).

* **Correspondence:** Abdolnoor Khaleghi, Email: a.khaleghi.ling@gmail.com

(1) The reporter interviewed *the nurse* of *the patient* **who** was smiling.

These temporary ambiguities are extensively used to identify parsing procedures and explore the connection between comprehension and memory capacity (Rah, 2009). Languages vary depending on whether the RC is attached to the first noun phrase *the nurse*, or to the second noun phrase *the patient* when reading the temporarily ambiguous sentences. In other words, two potential hosts exist, in such constructions, for the critical RC (who was smiling), including (a) NP1 (high attachment) and (b) NP2 (low attachment) (Scheepers, 2003).

Several studies have examined the so-called RC attachment ambiguity and revealed that native English-speaking adults prefer attaching the RC to NP2 *the patient* (or low attachment) in both explicit judgment (offline) and implicit online tasks (Dussias, 2001; Hopp 2015; MacDonald & Christiansen, 2002), while high attachment choice *the nurse* (or NP1) is observed in speakers of languages with free word order, which includes Spanish (Dussias & Sagarra, 2007), Dutch (Jackson & Roberts, 2010), and German (Felser et al., 2003).

Drawing from the related literature on L1 and L2 processing and cross-linguistic differences in sentence parsing, it was revealed that variables such as definite/indefinite NPs, short/long RCs, and RC initial/final positions are assumed to affect participants' parsing performance. These variables are thus manipulated to test whether NP1 or NP2 bears the processing costs, whether they are definite or indefinite, and whether RC length or RC positions might cause processing difficulty.

This study therefore tends to explore the Persian learners' behavior in RC processing and their attachment choice when parsing ambiguous sentences in which there are no disambiguating cues to help the parser decide upon potential NPs for RCs to attach to. The objective of the current research is also to investigate sentence processing strategies in L2 Persian learners and English natives, and how structurally manipulated variables might influence the processing. This is carried out by measuring the time-course of sentence comprehension focusing on critical regions, where potential effects might occur, in real-time interpretation as well as in an offline task, that is, a task without time measures.

LITERATURE REVIEW

Sentence Processing Mechanism

Language comprehension employs a set of analyses to recall words from the mental dictionary and place them into syntactic structures utilizing grammatical rules to express the full meaning of the structure and achieve sentence comprehension (Ferreira et al., 2002). Furthermore, sentence parsing is assumed to be incrementally proceeded (Cole & Reitter, 2019). In other words, the parser is constantly updating its interpretation by processing the string from left to right (Start, 2004), as new information enters the previous input as soon as they appear (Hopp, 2016).

Findings from experimental data shed light on how the human parser processes language when being exposed to L2 sentences online. Processing temporarily ambiguous sentences during which initial analysis is selected by the parser can lead to erroneous analysis and the so-called garden path effect (Rah, 2009) by which human parser might encounter reading difficulty or interruption and processing involves more reanalysis or revision to understand the sentence. Psycholinguistic techniques such as self-paced reading (SPR) can be employed to experimentally measure such effects.

Relative Clause Extraposition

Manninen (2002:1) proposed that extraposition is a syntactic transfer in which "the noun of a relative clause gets to be isolated from the rest of the sentence by other items". RC extraposition happens when a relative clause is transposed from its initial canonical position adjacent to the head to the final position of the clause, as exemplified in (10).

(10) [A pretty woman] left the meeting [who was smiling].

The extraposed RC is restrictive and acts as a subject complement as in (10), but in non-restrictive RCs, it is a full DP as in (11) or (12).

(11) Marlon Brando, who was born in 1924, was a famous actor and movie star.
(12) [A pretty woman who was smiling] left the meeting.

Manninen (2002) argues that extraposition is typically permissible when the noun is indefinite as in (10) as compared to the definite noun as in (13), suggesting that heads in indefinite and definite conditions might affect significantly differently online L2 RC attachment resolution, reflected in reaction time patterns.

(13) [The pretty woman] left the meeting [who was smiling].

RC extraposition may have no syntactic motive, however functional factors such as information structure, RC length, verb repetition in RC, and verb type are involved (Moulai Kohbanani et al., 2016). Among these factors, RC length appears to have the greatest impact on RC extraposition. This is backed up by the principle of domain minimization (Hawkins, 2004), claiming that heavy materials are more inclined to be transposed to the final position of the sentence. RC extraposition, in both old and modern Persian (Moulai Kohbanani et al., 2016), frequently appears to lower parsing difficulties by transferring the cumbersome unit to the final position of the sentence (Hawkins, 2004), although any syntactic transfer that violates word order is regarded costly-processed (Fukui, 1993).

While some studies report a clear preference for high attachment among Persian L2 learners and Persian-speaking monolinguals in both offline and online tasks (Marefat & Meraji, 2005), Persian L2 learners have been evidenced to behave occasionally native-like when reading sentences online (Marefat & Farzizadeh, 2018). Earlier research has reported that L1 Persian speakers show high attachment preference (Arabmofrad &

Marefat, 2008; Malakooti et al., 2020; Marefat & Meraji, 2005; Moghadassian, 2008). Findings from a related study conducted by Malakooti et al. (2020), revealed that Persian-speaking monolinguals prefer NP1 attachment preference in an offline task. Similarly, in an online study, Arabmofrad and Marefat (2008) indicated a high attachment selection by L2 Persian learners. In contrast, the results from an online study carried out by Marefat & Farzizadeh (2018) showed that Persian L2ers adopt the same strategy like English native speakers when reading ambiguous relative clauses in both of their languages.

RC Processing and Attachment Ambiguity in L2

Some differences have been evidenced to account for parsing strategies of L2ers when processing RCs. Some of these are attributed to the disparency between the structural properties of relative clause and second language including their genitive constructions ("John's jacket"/"the father of John"), RC length (short/long), RC position (initial/final), the type of NPs (definite/indefinite), and their semantic dependencies (Baek, 2012; Fernandez, 2003; Hemforth et al., 2015; Marefat & Samadi, 2015). Among them, RC length and RC position are revealed to significantly influence RC processing, which is backed up by Hawkins' principle of domain minimization. Hawkins proposed that the parser chooses to reduce the dependencies of language units and their syntactic-semantic characteristics in which the dependencies are comprehended (Hawkins 2004). The movement of heavy constituents to the final position of the clause, as supported by this principle, might cause final-sentence RCs more especifically in Persian (Moulai Kohbanani et al., 2016) to decrease the processing difficulty, thus affecting L2 processing (L1 parsing strategy transfer). Moreover, the length of the RC is also found to impact relative clause ambiguity resolution by preferring high or low attachments specifically in learners' sentence parsing (Dussias & Sagarra, 2007). Previous research has reported that the linguistic factors such as length of RCs can influence how RC attachment ambiguities are obviated (Fodor, 2002; Swets et al., 2007; Zahn & Scheepers, 2015). In a study, Swets and colleagues (2007) tested Dutch Learners and native speakers of English and reported that participants showed high attachment choice when reading stimuli, indicating RC length effect in attachment resolution.

On other hand, L2 processing are assumed to be influenced by individual differences in memory span during retrieval (Jacob, 2009; Caplan, 2016; Karimia & Ferreira, 2016), age (Ha, 2005), and proficiency level (Miyao & Omaki, 2006) and L1 transfer (Fernandez, 1999) as general effects of L2 processing (Hopp, 2015). Therefore, these assumptions might lead to making different predictions for the patterns which may be elicited in L2 RC processing.

Consider ambiguous sentence (5) below, in that the relative clause *who played basketball at school* can be connected either high to the first NP *the boy* (high attachment) or to the second NP *doctor* (low attachment).

(5) Someone met the boy of the doctor who played basketball at school.

Findings from earlier psycholinguistic studies revealed that native English-speaking adults more preferentially refer RC to NP2, that is, to *the doctor*, in both offline

questionnaire and online experiments (MacDonald & Christiansen, 2002; Rah, 2009). In contrast, an NP1 attachment preference, that is, *the boy*; was observed in many other languages with similar structures, including Spanish (Dussias & Scaltz , 2008), Dutch (Loebell & Bock, 2003), German (Jacob, 2009), French (Frenck-Mestre, 2002), Greek (Papadopoulou & Clahsen, 2003; 2006), Persian (Arabmofrad & Marefat, 2008; Malakooti et al., 2020; Marefat & Meraji, 2005; Moghadassian, 2008). The above-mentioned Comparison of L2 processing strategies among languages shows that although Persian as a head-final language comes from a similar language family like English (Indo-European) and RCs in Persian appear following head nouns, as in English, Persian L2 learners may behave differently in L2 RC processing. Consequently, testing how Persian L2 learners and native English speakers resolve L2 RC ambiguity leads to a better characterization of sentence comprehension and processing in L1 and L2 readers and provides information for grasping the features of the humans' processing performance and the various strategies used to tackle the ambiguity.

Processing Models

The Competition Model (CM)

In the Competition Model (CM) accounted for both linguistic representations and language use for L1 and L2 acquisition (Bates & MacWhinney, 1989). The CM states that different languages' speakers focus on specific features of their languages to process linguistic material (Jacob, 2009). When reading an ambiguous sentence, a reader identifies a piece of information included in the sentence, which is more reliable for parsing. To cite an instance, English native speakers mainly rely on word order as a reliable indicator of a subject in English, while German native speakers count more on morphological cues, indicating that they are more inclined to concentrate often on highly valid cues in their L1. In view of free Persian word order in comparison with rigid English word order, Persian-speaking L2 learners are relatively more attentive to semantic clues, which is paramount in interpreting the RC attachment. In addition to finding a reliable cue with high validity, it is also important to decide upon the *cue cost* of each bit of information included in the sentence, meaning that whether the cue is easy to process like word order (low *cue cost*), or difficult to process such as morphological cues or semantic/syntactic dependencies (high *cue cost*) which involve more processing computations.

In this respect, the competition model holds that a reader examines the various bits of data contained in the sentence to find more valuable parsing cues, based on the validity and cost of cues. Thus, the more processing materials are valid and available, the more processing resources it gets (Jacob, 2009) while processing new linguistic input.

Shallow Structure Account (SSA)

L2ers' inadequate access to the knowledge of syntax in implicit processing is one of the reasons why learners' L2 processing is different from their L1, which is in harmony with Clahsen & Felsers' theory (2006). This theory holds that native speakers' unique syntactic representations are not processed in L2 processing, consequently, they are not activated

among L2ers (Clahsen & Felser, 2006; Jacob, 2009). Thus, when L2 learners' syntactic knowledge is shallow, it is predicted that semantic cues are preferable to syntactic ones among them to parse L2 RC attachments (Jacob, 2009). If L2ers do not rely on language-specific cues (Bates & MacWhinney, 1989, the competition model) and build only a shallow syntactic structure (Clahsen & Felser, 2006), they may make random attachment choices if there are no non-structural cues for disambiguation or may rely on semantic dependencies in making attachment choices.

In this study, we therefore seek to examine the processing behavior of Persian learners in L2, with a focus on the real-time processing of L2 RCs. Online processing of L2 RC provides information on how L2 readers behave when reading L2 ambiguous sentences. Focusing on predictions extracted from the theories and models, this research also attempts to investigate the impacts of the manipulated variables such as noun type, RC length, and RC position as experimental conditions in Persian learners and English natives when parsing L2 sentences with ambiguous RC, to provide a knowledge of the underlying structure of L2 parsing when no disambiguating cues appear in the sentences and potential NPs are available to host RCs.

To address the above-mentioned issues, the following empirical questions are addressed in the current study:

1. Are L2 learners' reading times slower than those of native speakers significantly?

2. Is L2 learners' online processing affected by their L1 as compared with native speakers?

3. Is Persian learners' L2 RC processing influenced by structural variables such as (in)definiteness, RC length, and RC position?

METHODOLOGY

Participants

41 participants participated in the study. Thirty-three of them completed the experiment and 8 discontinued their participation (5 Persian learners and 3 native English speakers). My friends and classmates helped to recruit the participants via posting general information about the test on platforms like Facebook and Instagram. They had to fill out the consent form before participating in the experiment.

The L1 group included 15 English native speakers (13 females, 2 males) who participated in the experiments (mean age = 30.67; SD = 4.67). Even though all of them were not residing in their countries when running the experiment. English was still their major language in daily communication. They were normal in terms of eyesight and no mental or physical inability were reported.

The L2 group comprised 18 Persian L2 learners (6 females, 12 males; mean age = 31.44; SD = 5.49) who were all college graduates or students who had been exposed to English in the classroom since their 12th year of high school where the main medium of instruction was Persian. Five of them reported having no knowledge of other languages, and in addition to English, 13 showed knowing another language. They were all residing

or studying in Iran when they took part in the research. L2 group participants had no eyesight problems and no mental or physical inefficiency.

Materials

The 32 experimental sentences were employed for this experiment. Some sentences were split into 4 segments such as *A policeman noticed/the bodyguard/of the actor/who was talking on the phone in the salon,* and some into five segments like *The manager/who fired/the girl/of the mayor /was angry*, to achieve the goal of research focused on L2 RC processing. Moreover, one question appeared after each experimental sentence for two purposes. One to initially decrease the probability of continuous motor behavior by participants (e.g. *Did a policeman notice the bodyguard of the actor*?), and one to detect preferred attachment by looking at reading time patterns resulting from understood sentences (e.g., who was tired?). Stimuli were organized with the intervention of the variables such as type of noun (definite vs. indefinite), length of RC (short vs. long), and type of RC (extraposed vs. non-extraposed), following a 2*2*2 factorial design. The variable indefinite noun was manipulated only to test whether NP1 bears the processing costs incurred in region 1, whereas NP2 and NP3 are always definite. Eight lists were created, each consisting of four items of each condition, with each list including exactly one of the four versions of each item. The added 32 filler items were composed of sentences with different grammatical structures. The experimental sentences and filler items were distributed across the experiment and presented in a pseudorandomized order during the experiment for each participant.

	target sentences	stimuli type
2	*The lecturer fell in love with/ the daughter/ of the psychologist/ who studied chemistry in California./Did the daughter fall in love?	definite-long-extraposedRC
3	*The director congratulated /the instructor/ of the schoolboy/ who was writing interesting reports./Was the instuctor recording the reports?	definite-long-extraposedRC
4	*The student had liked/ the secretary /of the professor / who was killed in the robbery event./Was he killed in the accident event?	definite-long-extraposedRC
5	*The father was talking to /the girl /of the young woman /who was standing in the garden./Was the young man talking to the girl?	definite-long-extraposedRC
6	*A policeman noticed /the bodyguard /of the actor/ who was talking on the phone in the salon. /Did a policeman notice the bodyguard of the actor?	indefinite-long-extraposedRC
7	*A journalist had dinner with/ the secretary/of the boss/ who liked working in the company./Did a man eat with the boss?	indefinite-long-extraposedRC
8	*A secretary met /the driver/ of the manager/ who was dreaming of holidays in the countryside. /Did a woman meet the driver of the manager?	indefinite-long-extraposedRC
9	*A researcher knew /the photographer /of the singer /who was reading a book in the library. /Was a book read in the library?	indefinite-long-extraposedRC
10	*The lecturer/who studied chemistry in California/ fell in love with/ the daughter/ of the psychologist./Did the lecturer study in Florida?	definite-long-non_extraposedRC
11	*The director /who was writing interesting reports/ congratulated /the instructor /of the schoolboy./Did the schoolboy congratulate the instructor?	definite-long-non_extraposedRC
12	*The student/ who was killed in the robbery event/ had liked /the secretary /of the professor./Was the professor killed in the robbery event?	definite-long-non_extraposedRC
13	*The father /who was standing in the garden /was talking to /the girl /of the young woman./Was the father standing in the garden?	definite-long-non_extraposedRC
14	*A policeman /who was talking on the phone in the salon/ noticed/ the bodyguard/ of the actor./Was the actor talking on the phone?	indefinite-long-non_extraposedRC
15	*A journalist/who liked working in the company/ had dinner with/the secretary/of the boss./Did a journalist liked working in the office?	indefinite-long-non_extraposedRC
16	*A secretary/ who was dreaming of holidays in the countryside/ met /the driver/ of the manager./Did the manager have the driver?	indefinite-long-non_extraposedRC
17	*A researcher /who was reading a book in the library/ knew /the photographer /of the singer./Did the reasearcher knew the photographer of the singer?	indefinite-long-non_extraposedRC
18	*The man wrote to /the manager /of the assistant /who was late./Did the man write to the manager?	definite-short-extraposedRC
19	*The doctor recognised/ the nurse/ of the pupil/ who was tired./Did the doctor recognise the nurse of the pupil?	definite-short-extraposedRC
20	*The girl talked to/ the coach /of the gymnast /who was sick./Was the girl sick?	definite-short-extraposedRC
21	*The dean liked /the secretary /of the boss/ who was late./Did the dean like the secretary?	definite-short-extraposedRC
22	*A nurse ignored/ the stepfather/ of the girl /who was upset./Did the girl ignore the stepfather?	indefinite-short-extraposedRC
23	*A woman ate with/ the cousin /of the dentist/ who was divorced./Did a woman eat with the cousin of the dentist?	indefinite-short-extraposedRC
24	*A passenger criticized/the waitress/of the pilot / who was angry./Did the pilot criticized the waitress?	indefinite-short-extraposedRC
25	*A reporter interviewed with/the doctor/ of the lady/ who was clever./Did a reporter interview with the doctor?	indefinite-short-extraposedRC
26	*The man /who wrote to /the manager /of the assistant /was late./Was the man late?	definite-short-non_extraposedRC
27	*The doctor /who recognised/ the nurse /of the pupil /was tired./Was the nurse tired?	definite-short-non_extraposedRC
28	*The girl /who talked to /the coach /of the gymnast/ was sick./Did the girl talk to coach?	definite-short-non_extraposedRC
29	*The dean /who liked/ the secretary/ of the boss/ was late./Did the dean like the secretary?	definite-short-non_extraposedRC
30	*A nurse /who was upset/ ignored/ the stepfather/ of the girl./Was the nurse upset?	indefinite-short-non_extraposedRC
31	*A woman/ who was divorced/ ate with/ the cousin /of the dentist./Was the man divorced?	indefinite-short-non_extraposedRC
32	*A passenger/ who was angry /criticized/the waitress/of the pilot./Was the passenger angry?	indefinite-short-non_extraposedRC
33	*A reporter/ who was clever/ interviewed with/the doctor/ of the lady./was the doctor clever?	indefinite-short-non_extraposedRC

34	*The guard concealed /the weapon /from the criminal yesterday.	filler
35	*The guard concealed /the weapon/ of his new colleague/ yesterday.	filler
36	*The author mailed /the story /to the editor /once again.	filler
37	*The author mailed/ the story /with the improvements/ once again.	filler
38	*The police informed /the guards /about the danger/ this morning.	filler
39	*The police informed /the guards /of the old castle/ this morning.	filler
40	*The journalist sent/ the report /to the magazine/ right away.	filler
41	*The journalist sent/ the report/ about the murder/ right away.	filler
42	*The robber hid /the jewels/ from the policemen/ yesterday.	filler
43	*The robber hid /the jewels/ of the millionaire/ yesterday.	filler
44	*The lady showed/ the necklace/ to her new neighbour/ once again.	filler
45	*The lady showed/the necklace/ with the diamond/ once again.	filler
46	*The salesman offered/ the apples/ to the little girl/ this morning.	filler
47	*The salesman offered/ the apples/ with the red patches/ this morning.	filler
48	*The soldier handed/ the weapon/ to his new comrade/ right away.	filler
49	*The soldier handed/ the weapon/ of his new comrade/ right away.	filler
50	*The guard fired/ the weapon/ on the training ground/ yesterday.	filler
51	*The guard fired /the weapon/ of his new colleague/ yesterday.	filler
52	*The author wrote/ the story/ within two weeks/ once again.	filler
53	*The author wrote/ the story/ with the happy end/ once again.	filler
54	*The police interviewed/ the guards/ during the morning/ once again.	filler
55	*The police interviewed/ the guards/ of the old castle/ this morning.	filler
56	*The journalist read/ the report /in the evening/ once again.	filler
57	*The journalist read/ the report/ about the murder/ right away.	filler
58	*The robber sold/ the jewels/ on the black market/ yesterday.	filler
59	*The robber sold/ the jewels/ of the millionaire/ yesterday.	filler
60	*The lady lost/ the necklace/ in the afternoon/ once again.	filler
61	*The lady lost/ the necklace/ with the diamond/ once again.	filler
62	*The salesman ate/ the apple/ with great appetite/ this morning.	filler
63	*The salesman ate/ the apple/ with the red patches/ right away.	filler
64	*The soldier destroyed/ the weapon/ in the fierce battle/ yesterday.	filler
65	*The soldier destroyed/ the weapon/ of his new comrade/ yesterday.	filler

Figure 1. Experimental sentences and filler for the self-paced reading experiment

Procedure

The SPR task, as the main experiment, was conducted online. A fixation point (+) was demonstrated in the center of the screen where sentences were displayed phrase by phrase. The experimental items were split into regions as illustrated in (3) and (4) where slashes denoting region boundaries, and numbers showing the region number. Participants pressed specific keys to control their reading speed and answered questions.

(3) The staff /who called /the assistant of /the manager /was late. (non-extraposed RC)

1 2 3 4 5

(4) Someone hit /the driver/ of the boss/ who was smiling. (extraposed RC)

1 2 3 4

Each time the participant pressed the button, the phrase disappeared and the next phrase of the sentence appeared in a non-cumulative mode (Marinis 2003, Jegerski, 2014). An asterisk (*) was placed before each new sentence to let participants be ready for a new sentence to begin. Immediately after the experimental sentences, a comprehension question was presented, followed by a prompt screen asking participants to respond to the comprehension question by pressing either a yes button (y) or a no button (n). The experiment began with a practice session to familiarize the participants with the sentence-by-sentence presentation. Participants were presented with a pause screen after the practice to prepare them to complete the experiment. The experiment took about 15 minutes to accomplish.

Figure 2. Illustration of the stimuli presentation in the self-paced reading experiment

Before participating in the test, each participant took part in two memory tests: a backward span test and a reading span task (Klaus & Schriefers, 2016). The results of these tests need to be expounded and analyzed in comparison with participants' RC processing in another research, but are included here for reasons of transparency. The participants also participated in an offline task (taken from Rah, 2009) to show their explicit decision of RC attachment by choosing NP1 or NP2 (Appendix B). Lastly, participants filled in the language history questionnaire (LHQ3) developed by Li et al. (2019).

RESULTS

The overall RTs obtained from target experimental sentences and comprehension questions were compared. The focus of the analysis was to analyze the elicited RTs from the position where RCs appeared (region 2) and (region 4) by condition to identify where the processing costs occurred for Persian-speaking L2 learners and native speakers. The RTs were analyzed using ANOVAs, measuring RTs' mean difference in terms of experimental conditions. The analysis examined RC processing performance for both groups focusing on analyzing RC type (extraposed vs. non-extraposed), RC length (short vs. long), and noun type. To explore where the significant effects come from, a post hoc test (Bonferroni) was run after performing ANOVAs. Moreover, the Pearson correlation test was used to explore any relationship between variables. Gender-based analyses were not integrated into the research design due to the unequal number of male and female participants in both groups as a limitation to research generalizability. Two software programs, R programming language and SPSS, were employed to do statistical analyses.

RC Processing

The SPR task provided RT's mean values for the regions of interest under experimental conditions. The analyses focused only on where the RCs appeared, regions 2 and 4. The measures were therefore subjected to a two-way ANOVA to find out if participants' online processing is influenced by the experimental conditions.

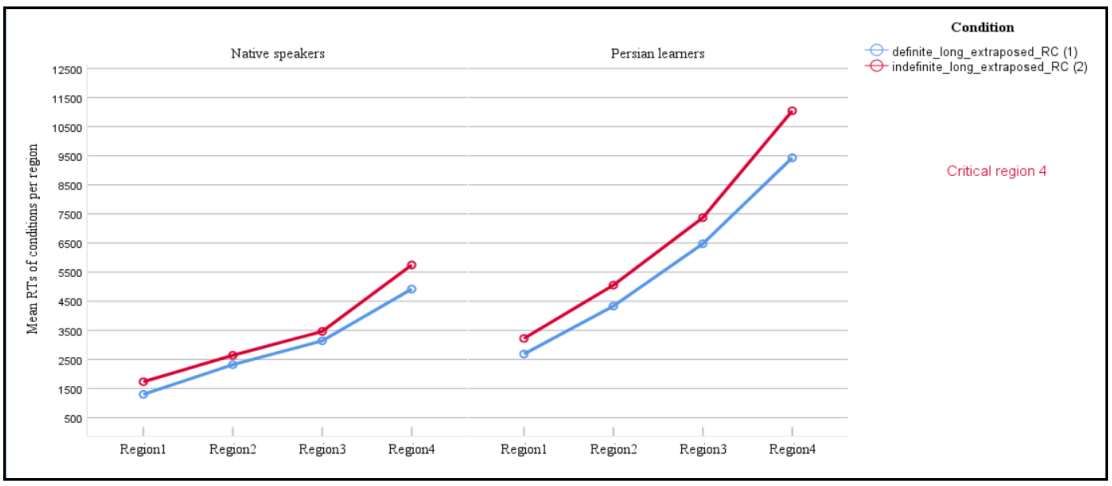

Figure 3. Mean reading times at critical region 4 and for conditions (1) (2) in both groups

As shown in Fig. 3, RTs for Persian-speaking L2 learners are overall longer than thoes for native speakers in both conditions. By looking at the figure in more detail, it is clear that mean RTs for condition (2) are overall higher than condition (1) for both groups, indicating that indefinite NP impacts RC online processing and may incur processing costs for both groups and all regions in particular in the critical region 4. Regarding the condition, there was no significant main effect (F (1, 31) = 2.517, p = 0.118), however, a significant difference for the group was yielded (F (1, 31) = 13.337, p = 0.001). This means the groups showed a difference in reading times, but no interaction effect (F (1, 31) = 1.719, p = 0.195).

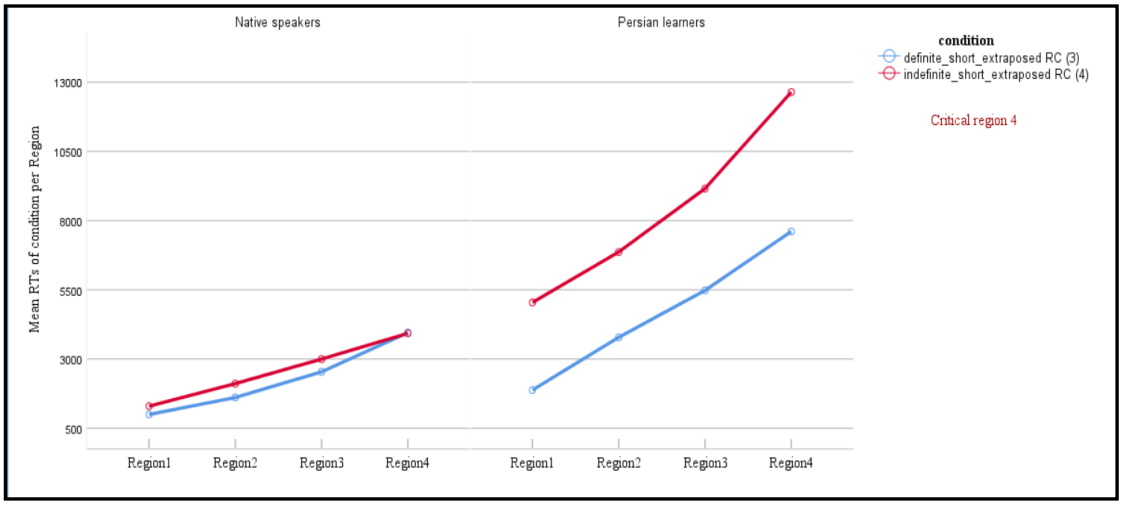

Figure 4. Mean reading times at critical region 4 and for conditions (3) (4) in both groups

Fig. 4 shows longer RTs in condition 4 than in condition 3 for Persian-speaking L2 learners. Analysis of a two-way ANOVA using the region 4 factor-condition and the group revealed no significant main effect for condition (F (1, 31) = 0.744, p = 0.392), but did reveal a significant main effect of the group (F (1, 31) = 31.953, p < 0.001), and insignificant interaction effect (F (1, 31) = 0.012, p = 0.913). Further to this, native speakers read faster overall, as shown by the general pattern of RTs.

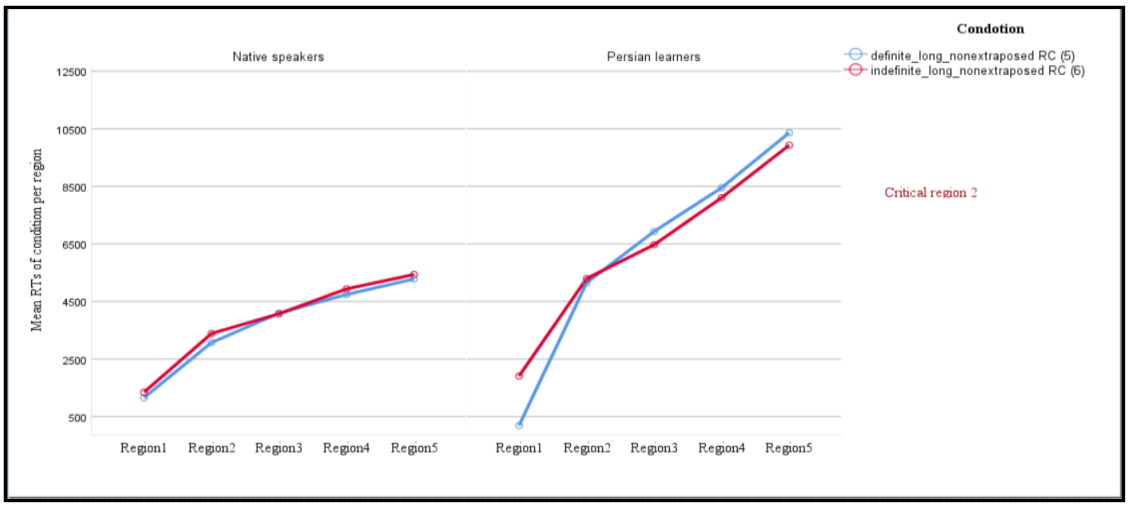

Figure 5. Mean reading times at critical region 2 and for conditions (5) (6) in both groups

In Fig. 5, no virtual difference in the mean RTs of conditions (5) and (6) is shown, and thus both groups behaved similarly when reading the sentences containing long RCs that were not extraposed RCs as illustrated parallel from region 1 to region 5. At critical region 2, ANOVA analysis with condition revealed no significant effect for condition (F (1, 31) = 0.043, p = 0.837), or for the group (F (1, 31) = 3.308, p = 0.074), and also no significant interaction (F (1, 31) = 0.025, p = 0.874). Analysis of conditions (5) and (6) in region 4 revealed identical results to conditions (1) and (2).

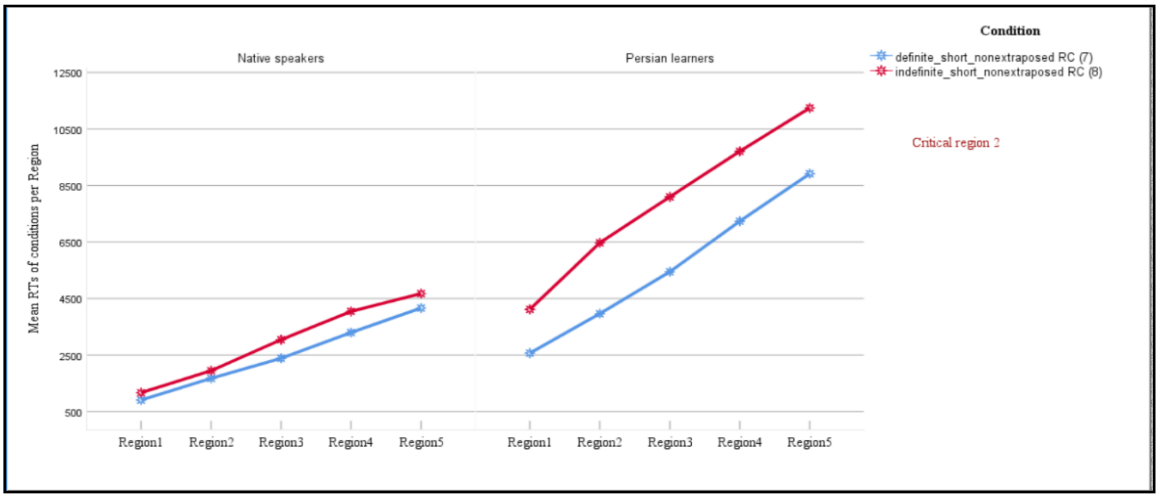

Figure 6. Mean reading times at critical region 2 and for conditions (7), (8) in both groups

As displayed in Fig. 6, both groups read condition 8 sentences more slowly than condition 7 sentences. Not surprisingly, analysis of RT comparisons in region 2 containing non-extraposed short RC revealed a significant effect of condition (F (1, 31) = 4.368, p = 0.041), but not for group (F (1, 31) = 3.102, p = 0.083). Likewise, no significant interaction was found (F (1, 31) = 0.183, p = 0.670).

Response Accuracy

The accuracy means of the correctly answered comprehension questions by conditions for both groups are shown in Fig. 5. It is clear from Fig. 7 that the accuracy means of the

comprehension questions answered are by far highest for sentences containing definite short extraposed RCs in both groups, but also for sentences with definite short non-extraposed RC, and indefinite short extraposed RC. This suggests that the participants frequently parsed and responded to more comprehension questions with short length and extraposed RC. Overall, although the native speakers reported numerically more accurate comprehension questions and processed them faster than the Persian learners, no significant difference was revealed between the groups.

Overall, the findings indicated that most readers were not considerably attentive to the conditions as their online RC parsing behavior was not predominantly affected by noun type, length of RC, and RC position, as reflected in both their comprehension questions and total reading times. In addition, two groups of participants similarly performed in most of the online tasks, with higher comprehension accuracy and shorter reaction times when reading sentences with conditions.

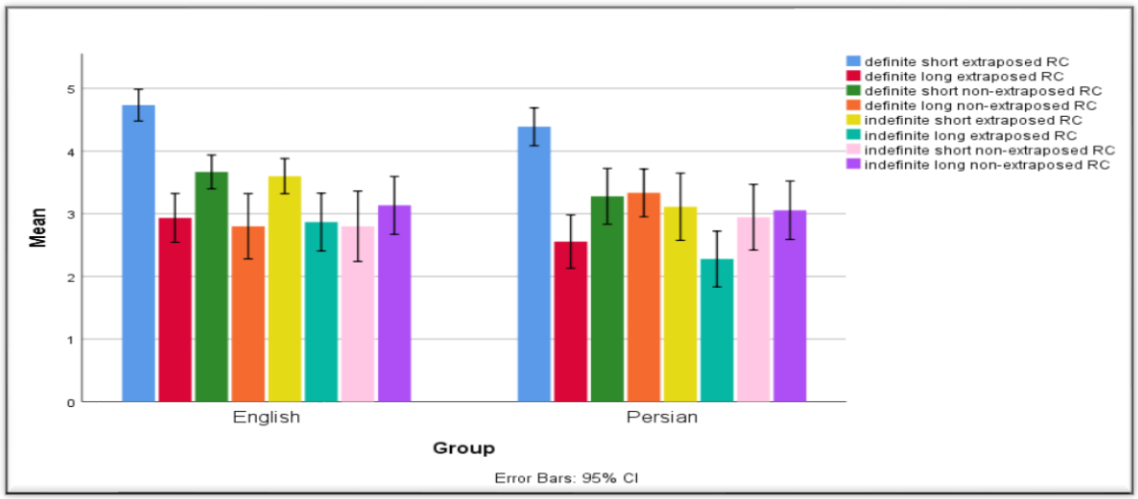

Figure 7. Mean accuracy for the comprehension questions across experimental conditions and groups

Attachment Preferences

Analysis of participants' attachment preferences showed overall N1 attachment by both groups in that in stimuli containing extraposed RCs in conditions (1) – (4), native speakers and Persian learners were more likely to behave antecedents of RCs reflected in RTs for Region 2 and processed faster than RCs referents in lower positions (Region 3), which does not apply to non-extraposed RCs. NP1 preference for Persian-speaking L2 learners is in line with the strong preference in the questionnaire study (Table 1), with a significant effect of condition and group, facilitating processing in particular for non-native Persian readers to comprehend the RCs easier with antecedents in high attachment positions. For English natives, the senario was unexpectedly different from what we expected. While the low attachment was a more preferable and clear attachment for them as evidenced by previous studies, the high attachment was found to parse easier and to comprehend faster, as revealed relatively in the offline task in this study with a 40

% tendency to high attachment yielding the significant effect of attachment in the ANOVA analysis ($F(1,14) = 113.449$, $p < 0.001$).

Table 1: Mean percentage of attachment choices for both groups

	response	Frequency	Percent	mean	SD
Native speakers	High	6	40	4.27	1.33
	Low	9	60	4.00	1.73
Persian learners	High	15	83.3	6.61	1.65
	Low	3	16.7	1.33	1.53

The *t*-test yielded significantly different RT means ($p = 0.003$) and ($p = 0.007$) for high attachment and low attachment choices respectively between two groups of Persian learners and native speakers. More clearly, the lower and upper positive bounds indicate that Persian readers have higher means, whereas the mean difference is greater for high attachment than for low attachment (see Table 2).

Table 2. Mean Difference of Reading Times for high/low attachment between Persian and native groups

		Levene's Test for Equality of Variances		t-test for Equality of Means					
								95% CI of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
High attachment	Equal variances assumed	4.716	.038	3.207	31	.003	.98	.30	.35	1.61
	Equal variances not assumed			3.281	30.894	.003	.98	.30	.37	1.59
Low attachment	Equal variances assumed	.222	.641	2.906	31	.007	.79	.27	.23	1.34
	Equal variances not assumed			2.819	24.775	.009	.79	.28	.21	1.37

DISCUSSION

Task Effects

The analysis of overall online processing RTs (Figures 1–4) showed that Persian-speaking L2 learners processed L2 sentences slower than native speakers across all conditions. Clear task effects in the current study are shown by the main effects of groups for conditions *(1), (2) (definite vs. indefinite long-extraposed RCs)* and *(3), (4) (definite vs.*

indefinite short-extraposed RCs) in region 4, meaning that Persian learners and English natives behaved very differently, as reflected in region 4 reaction times in all extraposed conditions. Moreover, ANOVA analyses revealed the main effects of conditions (7) and (8), with all participants having similarly longer reading times in region 2 in the indefinite condition than in the definite condition. L1 and L2 participants receiving comprehension questions showed statistically higher comprehension correctness and shorter reading time to comprehension questions, especially when processing sentences containing definite short extraposed or non-extraposed RCs than those with long non-extraposed RCs. Overall, however, Persian participants show slower processing than native speakers, indicating that they encounter further processing problems, from region 1 rising steadily to regions 2 or 4 where the RCs occurred. These results suggest that task conditions influence reading times for the length short and the RC type extraposed among the readers, such that comprehension questions for experimental stimuli that detect participants' understanding of the RC result in longer reading times in non-native speakers. Consequently, the analysis results of the experimental target items in SPR are consistent with participants' behavior in correctly answering comprehension questions.

Even though the findings are most consistent with the shallow structure hypothesis (Clahsen and Felser, 2006) and the Competition Model (CM) (Bates & MacWhinney, 1989), they are, in general, supported by the argument, which claims that task demands influence sentence processing. The discussion of the findings obtained from native and non-native readers' processing performance regarding task effects reveals that there may be a shallow knowledge of syntactic representation or more reliable language-specific cues in sentence processing between non-native speakers compared to native speakers.

Like the results obtained by Swets et al. (2008), non-native readers in the present research were similarly slower and less accurate in answering comprehension questions with indefinite long non-extraposed RCS. The lower accuracy mean rates for sentences with indefinite long non-extraposed may simply be owing to the difficulty of these questions to read. The L2 readers' language background and features may account for their weaker interpretation of experimental sentences and comprehension questions. Persian is a non-configurational language in which no relative pronoun mark grammatical gender, animacy, and noun number modified by the RC. Persian basic SOV word order may result in more processing costs for learners since they may be involved and confused in rearranging the verbs in experimental sentences, probably involving more processing resources for weaker readers. It is thus likely that the lower accuracy rates and slower processing of relative clauses show participants' troubles in analyzing the structure of the ambiguous sentences and identifying correct antecedents, which were inferred from participants' feedback and comments after the experiment.

Attachment Preferences

Like prior research on RC processing online (e.g., Felser et al., 2003; Papadopoulou and Clahsen, 2003), the L2 learners in the present investigation did not present prominent attachment choices by attaching a relative clause either high or low. However, these findings are consistent with those in other related research Swets et al. s (2008), that is,

differences in overall reading time in critical regions reflect differences in attachment preferences.

In this study, the L2 learners' L1 background may explain unclear attachment preferences online and offline. A considerable property of Persian relative clauses is that they play the role of modifier for nouns, where although there is a grammatical relationship between NP and the modifier clause, their comprehensions may rely on the lexical-semantic dependency of the nominal head or the language user's world knowledge of the relationship between the nominal head and the modifier, regardless of word order. Chan et al. (2011) argue that examining non-native learners' L2 relative clause parsing may demand a method that highlights the effect of semantics and pragmatics. This could mean semantics and knowledge of the world may play a vital role for Persian-speaking L2 learners in interpreting relative clauses in L2 as in L1. Syntactic parsing strategies are also available for them to use, however. This study shows that sentence plausibility, but not sentence structure, forecasts reading time and accuracy in interpreting subject relative sentences in L2.

The results from the analysis indicated that non-native Persian learners preferred high attachment to resolve RC ambiguity. This was reflected in faster reaction times for online tasks and preferences for offline tasks (83.3% high attachment, 16.7% low attachment), suggesting that they focused more on meaning congruity than on structural dependencies. In real-time processing, native English speakers behaved similarly to Persian learners with high attachment tendencies., however, with a strong low attachment preference (60%) with a notable propensity to high attachment in the offline task (40%). Factors such as lack of concentration, age, or memory span might be the reasons for this unexpected tendency to high attachment.

As discussed earlier, the reading time differences for both L2 learners and L1 native participants are totally in harmony with differences in participants' attachment preferences. The native speakers of English tended to choose low attachment and numerically showed faster RTs for experimental stimuli, whereas L2 learners showed high attachment preference and slower RTs for the stimuli with internal consistent patterns. Crucially, L2 learners' results developed previous findings obtained from English natives, claiming that sentences with ambiguity could provide a processing advantage over ones without ambiguity (Traxler et al., 1998). Alternatively, the difficulties in attachment selection for native Persian speakers are more likely the reason why L2 learners, not English natives, firstly ignored temporarily ambiguous sentences and delayed attachment decisions in the current study. However, learner participants attempted to detect antecedents online.

Focusing on the quantitative differences in L2 sentence processing, the results reveal that L2 learners and L1 native participants have differences in overall RTs and accuracy rates, with non-native participants showing longer RTs and lower correctness by the conditions. Hence, learner participants are slower in reading the sentences and are less accurate in answering comprehension questions, but there was an internal consistency between their overall reading time and response patterns.

CONCLUSION

This study examined L2 RC processing online using a self-paced reading test to find out how English native speakers and Persian learners of English behave when reading temporarily ambiguous sentences along with structural variables. The main result is non-native readers' slower processing than native readers but that their offline comprehension accuracy shows the same frequency like native speakers. The non-native readers in the current research parse ambiguous sentences online in the same way native speakers did, however, they did not show clear and complete effectiveness RC type and RC type have on RC parsing in the sentences. In general, the results suggest a significant difference between Persian and native readers' sentence comprehension only in terms of online processing speed (significant main effects of groups) and in short non-extraposed RCs (significant main effect of condition). In addition to task demand, it is more likely that shallowness in non-native sentence processing modulates online processing behavior.

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