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# The Role of Semantic Priming in Relative Clause Attachment Ambiguity Resolution in Persian

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**Abstract**
The present study investigated the role of semantic priming in the processing of ambiguous sentences containing Relative Clauses (RCs) preceded by a complex Noun Phrase (NP) by Persian native speakers. To this end, in a self-paced reading task using E-prime software, 63 Persian native speakers read sentences containing ambiguous RCs in their L1, i.e. Persian. The type of semantic relationship in this study was the one between the RC and one of the NPs within the complex NP to find out whether priming one of the NPs through this semantic manipulation would affect Persian native speakers' attachment preferences. The results of the off-line post interpretive (RC attachment preferences) and on-line data (reading times) revealed that semantic priming affects participants' attachment preferences, which suggests that their parsing preferences are not guided purely by syntactic information. The findings are in line with constraint-based models of sentence parsing, which assume that, during parsing, multiple sources of information interact and each of them constrains the interpretation in a particular way. The results also support the predictions of the Spreading Activation Model and Lexical Priming Theory.

**keywords**: RC attachment preference, ambiguity resolution, semantics, priming, native Persian speakers

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## Introduction

According to Kecskes (2008, 2014), native speakers' ambiguity resolution preferences in a particular language reflect conventional ways of organizing thoughts. One type of ambiguity in this regard is relative clause (RC) attachment ambiguity which has attracted a growing surge of interest in the field of psycholinguistics since it examines the nature of human sentence processing mechanism (Marefat & Farzizadeh, 2018; Marefat & Samadi, 2015; Papadopoulou & Clahsen, 2003). The RC attachment ambiguity resolution paves the way for explaining the properties of the humans' parsing mechanisms and also determines different sorts of linguistic information used to resolve ambiguity. An example of RC attachment ambiguity is presented below:

(1) *Alex saw [the driver]$_{NP1}$ of [the manager]$_{NP2}$ [who was eating breakfast]$_{RC}$*

In this sentence, the ambiguous RC "*who was eating breakfast*" is preceded by a complex Noun Phrase (NP) "*the servant of the actress*", and both NPs within the complex NP have the potential to act as a host for the subsequent RC. The RC can be interpreted as modifying either the first NP (i.e., the driver), resulting in a High Attachment (HA), or the second NP (i.e., the manager), leading to a Low Attachment (LA).

There are different accounts which explain the NP1 and NP2 attachment preferences. The two mostly cited structure-based parsing models are Predicate Proximity and Recency. According to Papadopoulou (2005, p. 108) Predicate Proximity, alternatively named Early Closure, "requires new material to be attached as close as possible to the IP node" which is the first NP in the complex NP resulting in a HA. On the other hand, Recency, alternatively named Late Closure, "is assumed to be universal and forces the new material to be attached to the most recently processed phrase" (Papadopoulou, 2005, p. 108) which is the second NP in the complex NP resulting in a LA. The other parsing model which explains the NP1 and NP2 attachment preferences is based on multiple-constraints accounts (Green & Mitchell, 2006; MacDonald, 1994; Thornton et al., 1998; Traxler et al., 2000) which assume multiple sources of information, including semantic plausibility, subcategorization preferences, and discourse context, interact while each constrains the interpretation in a particular way.

The relevant literature provides evidence that cross-linguistic differences exist in the resolution of this kind of ambiguity (Papadopoulou & Clashen, 2003). High attachment (NP1) preferences have been reported in various languages including Arabic (Bidaoui et al., 2016), Dutch (Desmet et al., 2006), French (Colonna et al., 2000; Dekydtspotter et al., 2008), Greek (Papadopoulou & Clahsen, 2003), German (Hemforth et al., 2015; Hemforth et al., 2000) Russian (Iudina & Fedorova, 2009), Persian (Arabmofrad & Marefat, 2008; Shabani, 2016), and Spanish (Fernández, 2003). Also, low attachment (NP2) preferences have been reported in English (Bergmann et al., 2008), Japanese (Jun & Koike, 2008), Portuguese (Finger & Zimmer, 2000), Romanian, Swedish, and Norwegian (Ehrlich et al., 1999).

Previous research suggests that various factors may affect RC attachment preferences including prosody (Dekydtspotter et al., 2008; Fodor, 2002, Zahn & Scheepers, 2015), the kind of relativizing element (Hemforth, et al., 2000), animacy (Desmet & Declercq, 2006), the amount of exposure (Dekeyser, 2005; Caffarra et al., 2015), relative pronoun type (Delle Luche et al., 2006), availability of alternative structures (Mitchell et al., 2000), position and length of the RC (Hemforth et al., 2015), individual differences in working memory (WM) capacity (Kim &

Christianson, 2013; Marefat & Samadi, 2015; Traxler, 2007), proficiency (Miyao & Omaki, 2006), as well as semantics (Marefat & Samadi, 2015). However, previous studies have not examined whether semantic relationship between the RC and one of the NPs in a complex NP may affect parsers' attachment preferences, so the present study intends to fill some of the void in this regard.

## Review of Literature

### *The Structure of Ambiguous RCs in Persian*

Megerdoomian (2000, p. 5) stated that Persian complex NP is "the equivalent of genitive or possessive construction in English" in which two nouns are linked together by *'s* or the preposition *of*. In Persian, the *ezafe* morpheme *-e* (-ye after vowels) is an unwritten short vowel that connects the head of an NP to its following constituents. Therefore, a Persian complex NP is a sequence of simple NPs without any overt links or boundaries as shown in (2) below.

(2). *dust bæraadær Ali*
*friend brother Ali*
*"A friend of Ali's brother"*

The actual pronunciation is provided in (3).

(3). *dust-e bæraadær-e Ali*

Like English, Persian RCs are post-nominal which provide some information about a nominal element or "head" in the main clause. However, unlike English, in Persian, there is no relative pronoun and the RCs are typically introduced by the complementizer *ke* which is the sole complementizer in Persian (Taleghani, 2008). Unlike its English equivalent, the Persian complementizer is obligatory; and it is always used at the beginning of all RCs regardless of animacy, function, gender or the number of the head nouns modified by the RC (Rahmany, Marefat, & Kid, 2011; Taghvaipour, 2004). Persian complementizer *ke* contains the semantic meaning of 'who', 'whom', 'which', 'whose' and 'that' in itself. Additionally, in Persian two NPs in the complex NP are linked together by *ezafe* morpheme *-e* and the ambiguous RC could be attached to either of these NPs in the complex NP. Moreover, the ambiguous RC always precedes the object marker *ra* in Persian. According to the Predicate Proximity account, Persian is a language that favors high attachment since Persian has a relatively free-word order which allows the verb to be distant from its complements (Faghiri et al., 2014). Therefore, the RC is attached to the first NP. An example of Persian ambiguous RC followed by a complex NP is presented in the following example:

(4).

رضا وکیل دکتر که داشت ناهار میخورد را دید.

*Reza vækil e doctor ke dasht nahar mikhord ra did.*
*Reza lawyer ezafe morpheme doctor who was lunch eat object marker saw.*
*'Reza saw the lawyer of the doctor who was eating lunch.'*

In this sentence, the ambiguous RC "*ke dasht nahar mikhord"* could be attached to either of NPs (i.e., *vækil or doctor) in the complex NP* (i.e., *vækile doctor)* which are linked together by *ezafe* morpheme *-e.* Therefore, this sentence could be interpreted as either *"vækil dasht nahar mikhord" (i.e., the lawyer was eating lunch)* resulting in a high attachment (NP1) or *"doctor dasht nahar mikhord" (i.e., the doctor was eating lunch)* leading to a low attachment (NP2).

***Theoretical Backgrounds for the Present Study***

The purpose of this study is to determine whether semantic priming can affect Persian native speakers' RC attachment preferences. The type of semantic manipulation in the present study is the one between the RC and one of the NPs in the complex NP. It is possible for an RC to be semantically biased toward NP1 or NP2. Consider the following sentence as an example:

5) *Alex saw the [the patient]$_{NP1}$ of [the nurse]$_{NP2}$ [who was very pale]$_{RC.}$*

In this sentence, there is a semantic relationship between NP1 and RC which may bias NP1 attachment preferences on the basis of the Spreading Activation Model (Colins & Loftous, 1975; Traxler et al., 2000). The Spreading Activation is a theory of how the human brain reiterates through a network of connected ideas to recover distinct information. This theory offers a range of ideas and concepts within our memory as cognitive units, each comprising a node and its related characteristics or elements, all connected by edges (Anderson, 1983). In a sort of web diagram, the spreading activation network could be explained schematically; shorter lines between two nodes imply that these ideas are more closely related to each other and they would naturally be associated more quickly to the original concept. From memory psychology aspects of Spreading Activation Model, on the basis of their personal experience, individuals construct their knowledge of the world that form their network of ideas which is considered as their knowledge of the world (Colins & Loftous, 1975; Traxler et al., 2000). Snowden (2015) stated that the spreading activation theory of semantic processing represents a less firmly structured revision of Quillian's (1966) network model. This model integrates the idea of semantic distance, based on which highly related concepts are located closer together compared to unrelated ones. Therefore, based on this model, when a word is activated, other words which are semantically related to it also become activated. Accordingly, when NP1, *"the patient",* in case of sentence (5) is activated, other words that are semantically related to it (i.e., *being pale)*, also become activated; and these related words boost the activation of each other and as a result, the first NP (i.e., *the patient*) remains more accessible compared to NP2 "*the nurse".* When the reader encounters the ambiguous RC (*who was very pale*"), s/he is expected to (if this theory is operative) attach the ambiguous RC to the more available NP, which is the first NP "the patient". Moreover, based on Lexical Priming Theory (Hoey, 2005) which states that large numbers of prefabricated elements are stored as units in the brain and primed by repeated encounters; it is more plausible for a patient to be pale than for a nurse, and this semantic relationship may bias NP1 attachment preference.

Similarly, the semantic relationship between NP2 and RC may bias NP2 attachment preferences.

6) *Alex saw the [the patient]$_{NP1}$ of [the nurse]$_{NP2}$ [who was filling the syringe]$_{RC.}$*

In sentence (6), there is a semantic relationship between NP2 and RC. Again, based on Lexical Priming Theory (Hoey, 2005), it is more reasonable for a nurse to fill a syringe than for a patient, and this semantic relationship may bias NP2 attachment preference. Moreover, based on the Spreading Activation Model, in this sentence, NP2 is more accessible compared to NP1, which makes it a more probable host for the following ambiguous RC.

Thus, there are hints in the literature indicating that when the RC is semantically biased towards one of the NPs in the complex NP, that NP becomes more salient, causing the RC to be attached to it. And if the semantics does not affect participants' parsing preferences it could be concluded that their attachment preference is guided solely by syntactic information.

Against the background presented, this study aims to investigate the role of semantic
priming in RC attachment preferences of Persian native speakers. More specifically, the study aims to answer the following question:

*Does priming one of the NPs within the complex NP through semantically associating it with the following RC influence RC attachment preferences of Persian native speakers?*

## Method

### *Participants*

Fifty-six Persian speaking monolinguals (mean age 22, range 16–42, 23 females, 33 males) took part in this experiment. Three participants were excluded because they had not completed the task or did not fulfill the criterion of 85% comprehension accuracy of filler sentences (see the Results section for details). Therefore, for data analysis, the data from 53 participants were used. Twenty-five participants provided data on Version 1 of the Paraphrase Decision Task (PDT) and twenty-eight participants provided data on Version 2 of the task.

### *Materials*

**Paraphrase Decision Task (PDT).** Two versions of PDT were used. Each version consisted of 70 sentences, including 28 test sentences and 42 fillers. In PDT, the stimuli were presented in a self-paced, chunk-by-chunk, noncumulative fashion. The PDT was implemented using E-Prime software.

**Test Sentences.** The experimental sentences used in this study were all structurally ambiguous sentences in Persian (the native language of the participants) containing a main clause and an ambiguous RC which could refer to either of the two preceding NPs that were linked together by the *ezafe* morpheme *-e in Persian.* In all test sentences, the ambiguous RC was introduced by the complementizer *ke*. Based on the semantic relationship between the RC and either of the two NPs in the complex NP, test sentences were categorized into three conditions:

*NP1-biased*: in which the RC was semantically related to NP1 (sentence 7 below);

*NP2-biased*: in which RC was semantically related to NP2 (sentence 8 below);

*Unbiased*: in which the RC could be linked to both NP1 and NP2 (sentence 9 below).

(7)

نگار معلم دانش آموز که ریاضی درس میداد را شناخت.

*Negar moœlem e danesh-amouz ke riazi dars midad ra šenakht.*

*Negar teacher ezafe morpheme student who mathematics was teaching object marker recognized.*

*'Negar recognized the teacher of the student who was teaching mathematics.'*

(8)

نگار معلم دانش آموز که در حیاط بازی میکرد را شناخت.

*Negar moœlem e danesh-amouz ke dœr hœyat bazi mikard ra šenakht.*

*Negar teacher ezafe morpheme student who in yard was playing object marker recognized.*
*'Negar recognized the teacher of the student who was playing in the yard.'*
(9)

نگار معلم دانش آموز که به خانه میرفت را شناخت.

*Negar moœlem e danesh-amouz ke be khaneh mirœft ra šenakht.*
*Negar teacher ezafe morpheme student who to home was going object marker recognized.*
*'Negar knew the teacher of the student who was going home.'*

The rationale for including Unbiased items in the study was to determine participants' general parsing preferences since in these sentences, there is no semantic relationship between the RC and either of NPs in the complex NP. Test sentences (7), (8), and (9) are considered as one set. In a norming study, twenty sets were developed into a questionnaire. It was distributed among 25 participants from a similar population as in the main study to evaluate the relationship set by the researchers between the RC and either of the NPs. None of these participants took part in the main study. Moreover, six experts in the field checked the content validity of the survey. As each set contains three sentences, there were 60 items altogether in the questionnaire. In each item, the RC was written in bold and the two NPs were underlined. Each item was followed by three choices: NP1, NP2, and both. The test takers were asked to decide which NP was related to the RC written in bold. An example is provided below:
(10)

*نگار معلم دانش آموز* ***که ریاضی درس میداد*** *را شناخت.*

معلم ☐ دانش‌آموز ☐ هردو ☐

*Negar recognized the teacher of the student who was teaching mathematics.*
the teacher ☐ the student ☐ both ☐

The test sentences would be included in the set of sentences for the main experiment if the corresponding choice had been selected by 90% of the respondents. More specifically, for the test item to be qualified as an NP1-biased RC, the first choice (i.e., NP1), should have been selected by 90% of the testees. Likewise, to be qualified as an NP2-biased RC, the second choice (i.e., NP2), needed to be selected by 90% of the testees. Finally, to be qualified as an Unbiased RC, the third choice (i.e., both), had to be selected by 90% of the testees.

Fourteen sets which met the criterion were used in the main experiment. In order to use all the fourteen sets, test sentences were presented in two versions, *Version 1* and *Version 2,* to reduce test fatigue and to avoid participants' test awareness. Each version included 14 NP-biased sentences (i.e., seven NP1 and seven NP2 RC-biased sentences). Moreover, for each NP-biased item, there was an Unbiased item. Accordingly, there were fourteen Unbiased RCs in each version. If the NP1-biased-RC item of a set was in *Version 1* of the main test, in *Version 2* it was replaced with the NP2-biased-RC item and vice versa. The Unbiased-RC item of each set was common in the two versions.

Test sentences were divided into four fragments, sentence (7) is repeated below in (11) as an example:
(11)

نگار/ معلم دانش آموز /که ریاضی درس میداد/ را شناخت.
4 3 2 1

*Negar/ moœlem e danesh-amouz/ ke riazi dærs midad/ ra šenakht.*
1 2 3 4
*'Negar knew the teacher of the student who was teaching mathematics.'*

This fragmentation is motivated by a need to prevent participants from assigning prosodic structure to the sentences presented and also to encourage natural reading of sentences. In these items, as shown in sentence 11, the third and the fourth fragments (i.e., the RC, the object marker *ra*, and the following verb) were the critical regions. The third fragment (i.e., the RC), is the part in which semantics is manipulated. The RC is followed by a verb in order to be able to observe possible spill-over effects, so the fourth segment (i.e., the verb) is considered as the post-critical region. As mentioned before the NP chosen by the participants in the Unbiased condition reveals their general parsing preference since there is no semantic association between the ambiguous RC and either of NPs in the complex NP. The prediction would be that if participants prefer a high (NP1) attachment, then their reading times for critical regions in sentences in which the RC is semantically associated with NP2 would take longer compared to sentences in which the RC is semantically associated with NP1. Conversely, if they favor attaching the RC to NP2 (i.e., low attachment) then, their reading time for sentences in which the RC is semantically associated with NP1 would take longer. Each test sentence was followed by a paraphrase which referred to either NP1 or NP2. Both paraphrases were accurate, half of the paraphrased sentences were disambiguated towards NP1 and the other half were disambiguated towards NP2. An example of a test sentence, together with its paraphrase, is presented below.

(12)

*فرنوش آرایشگر هنرپیشه که فیلم نامه تمرین میکرد را تحسین کرد.*

*آرایشگر فیلمنامه تمرین میکرد.*

*Farnooš arayešgar e honærpišeh ke filmnameh tæmrin mikærd ra tæhsin kærd.*
*Farnooš barber ezafe morpheme actress who script was practicing object marker adored.*
*'Farnooš adored the barber of the actress who was practicing the script.*
*Arayešgare filmnameh tæmrin mikærd.*
*The barber script was practicing*
*'The barber was practicing the script.'*

As observed, this sentence is disambiguated towards NP1 (i.e., high attachment). As another example, consider sentence (13) below in which the paraphrased sentence is disambiguated towards NP2 (i.e., low attachment).

(13)

فرنوش آرایشگر هنرپیشه که فیلم نامه تمرین میکرد را تحسین کرد.

هنرپیشه داشت فیلمنامه تمرین میکرد.

*Farnooš arayešgar e honærpišeh ke filmnameh tæmrin mikærd ra tæhsin kærd.*
*Farnooš barber ezafe morpheme actress who script was practicing object marker adored.*
*'Farnooš adored the barber of the actress who was practicing the script.*

*Honœrpišeh filmnameh tœmrin mikœrd.*
*The actress script was practicing*
*'The actress was practicing the script.'*

In (12), if the participants press *true* key, it means that semantic association does not affect their parsing preference and if they press *false* key, this shows that semantic association affects their parsing preference. On the other hand, in (13), if the participants press *true* key, this means that semantic association affects their parsing preference, and if they press *false* key, this shows that semantic association does not affect their parsing preference

**Filler Sentences.** Forty-two filler sentences were developed for this study. Fillers had various grammatical structures including unambiguous RCs and were matched with experimental sentences in length. The fillers were used for distracting the participants from becoming aware of the purpose of the study. Similar to experimental sentences, each filler was followed by a paraphrased sentence which was correct in half of the items and wrong in the other half. An example of a filler item with its paraphrase is provided below:

(14)

هفته گذشته منشی اداره با اتوبوس به اصفهان رفت.

منشی با قطار به اصفهان رفت.

*Hœfteh gozœshšteh monšie edœreh ba otobus be Esfœhan raft.*
*Last week the secretary the office by bus to Esfahan went.*
*'last week the secretary of the office went to Esfahan by bus.'*
*Monši ba ghœtar be Esfœhan rœft.*
*'The secretary went to Esfahan by train.'*

In all sentences, including test sentences and filler items, participants were required to determine whether the paraphrased sentence was correct or not. The paraphrased sentences served two purposes. First, to find out which NP was selected by participants as the host of the following RC; and second, to check whether the participants paid enough attention to the content of the test or not. Considering filler sentences, the paraphrased sentences only served the second purpose because their answers to paraphrases following the fillers could be checked only for accuracy. The participants with less than 85% accuracy in responses to fillers were excluded from the study. The participants' answers to paraphrases following the test sentences just indicated their attachment preferences, and thus could not be checked for accuracy.

Each version of the test included 70 items including 28 test sentences (including seven NP1-biased, seven NP2-biased, and fourteen Unbiased items) and 42 fillers. In order to prevent test fatigue, each version was divided into two halves and was presented to the participants in two sessions. Each participant took the first half including 35 items then after a short break s/he took the second half.

**Practice Test.** Before taking the main test, each participant took five warm-up sentences in order to get familiar with how to proceed with the experiment. These sentences were the same across the two versions. Like experimental sentences, the participants were asked to determine whether the paraphrases following each sentence were correct or not. The participants enjoyed the liberty to ask questions regarding the sentences, software, etc. Having mastered the procedure, the participants took the main test.

### *Procedure*

The participants were tested individually by an 18-inch laptop. First, the five-item practice test was administered to familiarize them with the task. Afterwards, the participants were given the main test containing 70 items. Using 22-point Times New Roman font, the stimuli were presented in a noncumulative, chunk-by-chunk, self-paced method. The participants received each sentence in four segments as indicated by the slashes in (11). The participants were also instructed that by pressing the space button on the keyboard, a segment would appear on the laptop screen. Each segment stayed in the middle of the laptop screen until participants' next key-press. After each key-press, the segment that the participants read disappeared and the then the following section showed up on the screen. This process continued until the last segment of the sentence appeared on the screen. When the participants finished reading each sentence, a true/false statement appeared on the screen. The participants were asked to determine whether that statement was correct or incorrect by pressing "Right arrow" or "Left arrow" buttons on the keyboard, respectively. If the 'Right arrow' was chosen in response to an HA paraphrase, it was interpreted as a sign of HA preference. If the 'Left arrow' was chosen, the preference was considered as LA. If the 'Right arrow' was the response to an LA paraphrase, that would mean a LA preference. Finally, if the 'Left arrow' was chosen in response a LA paraphrase, it would be an indication of a HA preference. No feedback was given regarding participants' responses. Moreover, participants' reading times (RTs) for each segment in each sentence and their answers to true/false paraphrased statements were recorded automatically by the software in milliseconds.

## Results

Prior to data analyses, participants' answers to the true/false statements following the fillers were checked to ensure that they had paid enough attention to the content of the test and read sentences carefully. Those participants whose accuracy scores were lower than 85% (three participants) were excluded from the analyses. On average, the participants answered 92.31 % of fillers correctly.

### *Results for Post-Interpretive Offline Data*

In order to find out whether semantics affects participants' attachment preferences, the percentages of their NP1 and NP2 choices across the three conditions were calculated. Participants' answers to sentences in the Unbiased condition reveals their parsing preferences in general. In the Unbiased condition, as Table 1 below shows, 87.06% of the responses referred to NP1 while only 12.94% of the responses referred to NP2 which clearly shows that they have a HA preference. Similarly, in the NP1-biased condition, 97.3% of responses referred to NP1, but just 2.69% of the responses referred to NP2. Contrary to these two conditions, in the NP2-biased condition, only 13.2% of the responses referred to NP1 and 87.87% of responses referred to NP2. These results clearly indicate that semantics affects participants' attachment preferences.

**Table 1**
*Percentage of NP1 and NP2 Selection Across the Three Biased Conditions*

| Condition | Antecedent | |
|---|---|---|
| | NP1 | NP2 |
| Unbiased | 87.06% | 12.94% |
| NP1-biased | 97.30% | 2.69% |
| NP2-biased | 13.20% | 87.87% |

***Results for On-line Data (Reaction Times)***

In the next step, participants' reaction times (RTs) for reading the critical region (i.e., region 3) and the post-critical region (i.e., region 4) in the three conditions were compared. Before analyzing the data, participants' RTs for each region were divided by the number of syllables in that region in order to normalize the RCs and the following regions for their differences in length (Carreiras & Clifton, 1999). Moreover, the distribution of the time was detected for outliers for each participant in each of the three conditions and was substituted by the mean RT for that participant in the condition where the outlier was located.

**Results for RCs.** Table 2 below presents the descriptive statistics for participants' mean RTs for reading ambiguous RCs across the three conditions (i.e., Unbiased, NP1-biased, NP2-biased).

**Table 2**
*Mean RTs for the RC Across the Three Conditions*

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Unbiased | 380.4776 | 46.27222 | 53 |
| NP1-biased | 337.2915 | 54.41719 | 53 |
| NP2-biased | 819.9768 | 176.30949 | 53 |

Mauchly's Test of Sphericity revealed that the assumption of sphericity had been violated, $\chi^2(2) = 72.89$, $p = 0.000$. Therefore, the degrees of freedom were corrected using Greenhouse-Geisser correction estimates ($\varepsilon = .56$). Repeated measures ANOVA determined that mean RTs for the ambiguous RCs (i.e., *region 3*) differed statistically significantly between three conditions (i.e., *Unbiased, NP1-biased*, and *NP2-biased*) [$F(1.136, 59.07) = 322.87$, $p = .000$, $\eta_p^2 = .861$]. Post hoc tests using the Bonferroni correction revealed that there were significant differences among RTs in the three conditions. The participants produced shorter RTs for sentences in which, through semantic manipulation, RC was semantically associated with NP1 ($M = 337.29$, $SD = 54.41$), but very longer RTs to sentences in which the RC was semantically associated with NP2 ($M = 819.97$, $SD = 176.3$). Moreover, there was also a slight but significant difference between the Unbiased condition ($M = 380.47$, $SD = 46.27$) and NP1-biased condition in which RC was biased towards NP1. There was also a significant difference between the Unbiased condition ($M = 380.47$, $SD = 46.27$) and NP2-biased condition ($M = 819.97$, $SD = 176.3$) in which RC was biased towards NP2. Although participants had a HA preference, the RTs for reading the NP1-biased sentences were significantly shorter than the Unbiased condition meaning that semantic manipulation helped them read and comprehend these sentences faster.

**Results for Spillover Region.** Table 3 below presents the descriptive statistics for participants' mean RTs for reading spillover region across the three conditions (i.e., Unbiased, NP1-biased, NP2-biased).

**Table 3**
*Mean RTs for the Spillover Region Across the Three Conditions*

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Unbiased | 1380.7822 | 130.97646 | 53 |
| NP1-biased | 1099.2471 | 219.31002 | 53 |
| NP2-biased | 2075.4410 | 634.22941 | 53 |

In the final step, the spillover effect was examined among the three conditions. Mauchly's test revealed that the assumption of sphericity had also been violated, in case of spillover region, $\chi2(2) = 73.167$, p = .000. Again, a repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean RTs for the post-critical region (i.e., *region 4*) differed statistically significantly among the three mentioned conditions $F(1.135, 59.03) = 75.88$, $p = .000$, $\eta_p^2 = .593$). Post hoc tests using the Bonferroni correction indicated that there were significant differences between the RTs in the three conditions. The participants produced shorter reaction times for sentences in which due to a semantic manipulation, RC was semantically associated with NP1 ($M = 1099.24$, $SD = 219.31$), but longer RTs to sentences in which the RC was semantically associated with NP2 ($M = 2075.44$, $SD = 634.22$). Additionally, there was also a significant difference between RTs in the Unbiased condition ($M = 1380.78$, $SD = 130.97$) and the NP1-biased condition ($M = 1099.24$, $SD = 219.31$). Moreover, there was a significant difference between RTs in the Unbiased condition ($M = 1380.78$, $SD = 130.97$) and the NP2-biased condition ($M = 2075.44$, $SD = 634.22$).

## Discussion

The present study examined whether RC ambiguity resolution by Persian native speakers is sensitive to semantic priming. The type of semantic manipulation investigated in this study was the one between the RC and one of the NPs in the complex NP. The results suggest that semantic priming between the RC and one of the NPs in the complex NP has clearly affected participants' attachment preference. The NP chosen by the Persian native speakers in the Unbiased condition (i.e., NP1) revealed that they had a HA preference in general. In the Unbiased condition, participants' attachment preference seems to be guided by the principles of Predicate Proximity which favors the attachment of RC to NP1. These findings are in line with previous studies (Arabmofrad & Marefat, 2008; Shabani, 2016) which have showed that in Persian language where adjuncts can occur between the verbs and their complements, principles of Predicate Proximity are more operative compared to Late Closure. The results also showed that when there was a semantic relationship between the RC and NP1, the participants chose NP1 as the host of the following RC and when there was a semantic relationship between the RC and NP2, the participants chose NP2 as the host of the following RC. The findings are consistent with constraint-based models (Green & Mitchell, 2006; MacDonald 1994; Thornton et al., 1998; Traxler et al., 2000) which assume that several sources of information including discourse context and semantic plausibility affect processing of ambiguous sentences, while each of them constrains the interpretation in a particular way during the processing. Therefore, in addition to the phrase structure information (Dussias, 2003; Papadopoulou & Clahsen, 2003) which has proven to affect relative clause attachment ambiguity resolution, lexical and discourse information including semantic information, may exert an influence on participants' sentence processing.

The findings of this study are also in line with the Spreading Activation Model's predictions (Colins & Loftous, 1975; Traxler et al., 2000) which posits that when a word is activated other words which are semantically related to it also become activated and these words (the NPs and the biased RCs) boost the activation of each other and make the NP to which the RC is biased towards more accessible one and make the parser attach the RC to it. Moreover, the findings are in line with Lexical Priming Theory (Hoey, 2005) which states that large numbers of prefabricated elements are stored as units in the brain and primed by repeated encounters.

Although the general picture is very clear, it would be interesting to see that participants' attachment preferences for RCs in three different conditions figured differently in the RTs measures we inspected. Processing cost for critical and post-critical regions in the NP2-biased condition was enhanced because participants' initial attachment (i.e., HA) had to be revised since the RC was semantically biased towards a non-preferred attachment (i.e., LA); therefore, they had to refixate their initial NP1 attachment as the host of the following RC which leads to longer RTs. In the Unbiased condition, the participants, based on Predicate Proximity principle, attached the ambiguous RC to the first NP. Since no reanalysis was necessary, they did not recheck NP1 attachment for RCs as it was the preferred one; accordingly, they produced shorter RTs. Moreover, in the NP1-biased condition, the participants produced shorter RTs even compared to the Unbiased condition. This means that although they had a HA preference in general, semantic manipulation helped them process and comprehend NP1-biased sentences faster.

The present study provides room for further research. The results of the study could be extended by replicating it in other languages in order to cross-validate these findings considering the role of semantics. This study could be replicated with L1-Persian learners of L2 English or even L1-English learners of L2 Persian with different levels of proficiency to assess whether their attachment preference is affected by their L2. Omaki and Ariji (2004) posit that among various issues addressed in L2 research, the question of how an L2 learner's grammar progresses from one stage to another in the course of time has received little attention. They proposed that investigating the ways L2 learners analyze and parse the target language input and comparing the results with those of native speakers of that language would provide researchers with some insights into how L2 learners restructure target language input in non-native-like ways. Moreover, there could be a more complete and more informative research by altering the dependent and independent variables considering different aspects of structural ambiguity and a broader range of participants. Future research could also focus on the type of tasks, for example, eye-tracking and event-related potential to triangulate the results. This study could be accompanied by special tests which measure Working Memory Capacity (WMC) of readers. As a result, researchers could investigate whether WMC has any influence on the type of RC attachment preferences studied in this study; such a consideration can hopefully supplement the available evidence on processing to build a more complete picture.

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