Relative Clause Attachment Ambiguity Resolution in Persian[1]

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Abstract
The present study seeks to find the way Persian native speakers resolve relative clause attachment ambiguities in sentences containing a complex NP of the type *NP of NP* followed by a relative clause (RC). Previous off-line studies have found a preference for high attachment; in the present study, an on-line technique was used to help identify the nature of this process. Persian speakers were presented with sentences that were semantically consistent with either high or low attachment resolution. Results of the analysis of reaction times from 32 participants by the use of RSVP technique revealed that high attachment is the strategy used by Persian native speakers for this type of ambiguity. The results are in harmony with the previous findings in the literature showing a high attachment preference by Persian native speakers. However, the findings are inconsistent with constrained based-models and suggest that native speaker use purely structure-based parsing strategies.

Key Words: Structural ambiguity, Persian ambiguous relative clauses, Attachment ambiguity, Parsing strategies

[1] This work was supported by funding from the University of Tehran Grant No. 4601011/1/3. The authors acknowledge helpful comments from the anonymous reviewers of IJAL on an earlier version of this paper. All errors are of course due to us.

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Introduction

One of the aims of studying sentences is to find the way people understand a language. In this regard, examining the processing of sentences with syntactic ambiguity has proved to be useful in providing insights into the underlying mechanisms of human sentence comprehension. Investigating the initial parsing, reanalyzing, and comprehending of such sentences, one can achieve this goal.

There is a special kind of ambiguous sentences in which there is an RC that can refer to either of the preceding NPs such as:

- The reporter photographed the patient$_{NP1}$ of the nurse$_{NP2}$ [who was looking happy]$_{RC}$.

Numerous studies have investigated this kind of ambiguous sentences and have shown that preferences vary across languages. For example, English speakers prefer to attach the RC to NP2 (or low attachment) (Carreiras & Clifton, 1999), and Ehrlich, Fernandez, Fodor, Stenshoel and Vinereanu (1999) found an NP2 attachment preference in Norwegian and Swedish languages as well. Cuetos and Mitchell (1988), on the other hand, found that languages like Spanish exhibit an NP1 (or high attachment) preference in RC attachment. The present investigation is an attempt to examine the Persian speakers' attachment preferences in such sentences when there is a semantic relationship between the RC and either of the NPs.

Theoretical Framework

Structural Ambiguity

Harley (2001) states that most of the evidence that supports modern theories of parsing comes from studies of syntactic ambiguity. In this type of ambiguity, the grammatical structure of a sentence allows two different interpretations, that is, the sentence can be parsed in more than one way. In other words, words in such sentences have the same meanings, but different structures can be assigned to certain string of words, each of which gives rise to a different meaning. *He wrote the letter on the table*, for example, can be interpreted as *he wrote the letter which was on the table* (as opposed to the one that is on the armchair), or

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it can be interpreted as *he was sitting on the table when he wrote the letter*. This kind of ambiguity is said to be structural because each of the ambiguous sentences can be represented in two structurally different ways (Corr, 2005). Structural ambiguity is actually indicative of the underlying syntactic structure of the sentence and often results in readers' being unclear or mistaken as to the meaning of the sentence (Bowen, Rohde & Wu, 2003). In other words, attention to only surface level structure of the sentence cannot explain the ambiguity of the sentence and studying the deep structure is required (Kess & Hoppe, 1981).

Parsing

Parsing or syntactic analysis is a process by which the mind structures incoming words into a hierarchical representation according to the grammar of the language (Boland & Blodgett, 2001). Questions of how parsing decisions are made and what strategies the mind uses in order to handle the ambiguity have dominated the study of parsing for many years. The results of many sentence processing studies show that the adult parser is capable of accessing and rapidly integrating various types of structural and nonstructural information during comprehension (see Gibson & Pearlmutter, 1998, for review).

It is clear that readers and listeners use their knowledge of language structure (phonology, morphology, syntax, and semantics) to constrain their interpretations of sentences. A parser, accessing the grammar of a language, for example, assigns different syntactic structures to a sentence.

Ambiguity Resolution Models

Generally, there are two dominant sentence processing models which differ in the type of information used in analyzing and disambiguating ambiguous sentences.

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Serial Models

According to this modular model, proposed by Frazier and colleagues (Frazier & Rayner, 1982; Frazier, 1978, 1987), the initial parsing decisions are made solely on the basis of knowledge about permissible grammatical structures (Filik, Paterson, & Liversedge, 2005) and nonstructural information like semantic plausibility or preceding context has no influence on the initial analysis. "After an initial choice has been made, a thematic processor uses a broad range of information, including semantic plausibility and pragmatics, to assess the quality of the resulting interpretation" (Traxler, Pickering, & Clifton, 1998, p. 560). In the literature, there are a number of studies that support serial accounts (e.g., Frazier & Rayner, 1982; Traxler et al., 1998; Van Gompel, Pickering, Pearson, & Liversedge, 2005).

Parallel Models

Constraint-based models which assume computing all the possible analyses at once at the choice point are referred to as parallel accounts (Green & Mitchell, 2006). According to the Constraint-based model, if the analysis for which there is much information turns to be incorrect and the analysis for which little evidence is available early in the parse turns out to be the correct analysis, garden path will occur. In other words, multiple sources of information, including subcategorization preferences, semantic plausibility, and discourse context (Traxler et al., 1998) interact, while each constrains the interpretation in a particular way. In fact, different knowledge sources available to the processor activate (or inhibit) a certain interpretation (that can also be inhibited by the other interpretations). Competition among the interpretations eventually results in the dominance of a single one (Treiman, Clifton, Meyer, & Wurm, 2003). So, the analysis that receives most support from the constraints mounts until reaching a threshold level and the processor moves to the next word.

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Construal model

Another account about the processing of ambiguous sentences is c*onstrual* hypothesis which maintains that there are some restricted cases where non-syntactic influences are ruled out. It is a revision of garden path theory weakened by the findings for parsing preferences in languages other than English (Dussias, 2003).

> *Construal Principle:* Associate a phrase XP (which can not be analyzed as instating a primary relation) into the current thematic processing domain; interpret XP within that domain, using structural (grammatical) and nonstructural (extra grammatical) interpretive principle. Current thematic processing domain means the extended maximal projection of the last theta assigner (Gilboy, Sopena, Clifton & Frazier, 1995, p. 134).

In this view, the parser distinguishes between two kinds of structural relationships: primary (relations between the verb and its core arguments) and nonprimary (relations that involve RCs and adjunct predicates). While primary phrases are parsed according to universal principles such as late closure and minimal attachment, nonprimary phrases are associated with current thematic (semantic) domain (Frazier & Clifton, 1996). According to construal hypothesis, there are some discourse principles, the most important of which is Refrentiality Principle, that lead the parser to high or low attachments. So, parsing decisions involve "the thematic processing domain, interpretive principles (e.g., the Refrentiality Principle and Gricean maxims), and language specific rules" (Dussias, 2003, p. 535). As an instance, Felser et al. (2003, p. 453) found that "whereas children primarily rely on structure-based parsing principles during processing, adult L2 learners are guided mainly by non-structural information." In other words, as Dussias (2003) states, semantic and interpretive considerations and availability of a grammatical option to block one of the two available interpretations will determine the parser's final attachment choice.

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Ambiguous Sentences Containing Embedded Relative Clauses

There are some ambiguous sentences containing an RC that can refer to either of the two preceding NPs. In the literature, this type of ambiguous sentences has been elaborately focused upon (Maia & Maia, 2005; Felser, Roberts, Gross & Marinis, 2003; Papadopoulou & Clahsen, 2003) because it shows a parametric function of parsing. The syntactic structure that has been mainly used is the form *NP1 of NP2 RC*, as exemplified in (1):

(1) Someone shot the servant $_{NP1}$ of the actress $_{NP2}$ [who was on the balcony] $_{RC}$.

If the parser attaches the RC to NP1, this is called NP1 attachment, early closure or high attachment, and if it attaches RC to NP2, it is called NP2 attachment, late closure or low attachment. RC attachment preferences in many languages especially English have been fully investigated and it has been found that RC attachment parsing is not applied universally. While speakers of languages like English (Cuetos & Mitchell, 1988; Frazier, & Clifton, 1996; Gilboy et al., 1995) and Arabic prefer an NP2 attachment, speakers of languages like Spanish (Cuetos & Mitchell, 1988; Carreiras & Clifton, 1993, 1999; Gilboy et al., 1995), Greek (Papadopoulou & Clahsen, 2003), German (Hemforth, Konieczny, Scheepers & Strube, 1998), and French (Frenck-Mestre & Pynte, 2000; Zagar, Pynte & Rativeau, 1997) prefer an NP1 attachment. Few studies done on Persian (Marefat & Meraji, 2005; Moghadassian, 2008) show that Persian native speakers opt for an NP1 attachment preference.

According to Karimi (2005, p. 31), Persian is a null-subject verb-final language with SOV word order in declarative sentences and subordinate clauses. Persian RCs, Like English ones, are post-nominal, typically introduced by the complementizer *ke*. There is no relative pronoun in Persian, and the RC is always introduced by the complementizer *ke.* Moreover, the complementizer *ke* in Persian is invariant. That is, it does not agree with the function of the noun phrase it follows and is used regardless of the animacy, gender, function, or number of the noun modified by the RC. One example is provided below.

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(2)

mæn	*hamsayeh šoma*	*ke*	*puldar æst*	*ra*	*mišenasæm*
I	Your neighbor	who/that	rich is	object marker	know, PRES, 3SG

'I know your neighbor who is rich.'

NP1/NP2 Attachment in Persian

In the above example (2), the RC can only refer to *one* NP, therefore the sentence is unambiguous. But there are some sentences in which two attachments are possible. In this regard, consider the following example:

(3)

an mærd	*dokhtær*	*-e*	*honærpiše*	*ke dašt ghædæm mizæd*	*ra*	*dozdid*
That man	daughter NP1	of	*actress* NP2	that was walking	object marker	kidnap, PAST, 3SG

'That man kidnapped actress's daughter who was walking.'

In this sentence (3), more than one parse is possible. The RC *ke dašt ghædæm mizæd* can be considered as the modifier of both the preceding NPs, i.e. as the modifier of the first NP (*dokhtær*) or the second NP (*honærpiše*) and this has made the sentence ambiguous. This is because both *dokhtær* and *honærpiše* are human beings and can be the one *who was walking*. Sentence (4) will no longer be ambiguous if the word *dokhtær* is substituted by the word *kif* (bag):

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(4)

an mærd	*kif*	*-e*	*honærpiše*	*ke dašt ghædæm mizæd*	*ra*	*dozdid*
That man	bag NP1	of	actress NP2	that was walking	object marker	kidnap, PAST, 3SG

'That man stole the actress's bag who was walking.'

In this sentence, the RC *ke dašt ghædæm mizæd* can refer only to NP2 *actress* because *kif* (bag) is inanimate and cannot be the proper antecedent for *who was walking*. The opposite attachment takes place in sentence (5) whose RC, semantically speaking, can refer only to NP1.

(5)

an mærd	*Šagerd*	*-e*	*mæghaze*	*ke dašt ghædæm mizad*	*ra*	*dozdid*
That man	shopboy NP1	of	shop NP2	that was walking	object marker	kidnap, PAST, 3SG

'That man stole the shop boy of the shop who was walking.'

The RC *ke dašt ghædæm mizad* can refer only to NP1, *šagerd* (shop boy) and not to NP2*, mæghaze* (shop).

What's the Persian native speakers' preference (NP1/NP2) in parsing such ambiguous sentences? Previous studies (Marefat & Meraji, 2005; Moghaddasian, 2008) show that in Persian the RC is preferably attached high (NP1). Those studies used off-line techniques but the present study undertakes to examine the issue with an on-line technique. The participants' preferences in this task will reflect the type of linguistic information (syntactic vs. semantic) available to them as the first attempt in parsing.

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The Present Study

This study is an attempt to find the Persian native speakers' attachment preferences. To this end, three types of sentences were used: those in which, semantically speaking, the RC exclusively refers to Np1, those in which the RC refers solely to NP2, and those in which the RC could semantically refer to both NP1 and NP2 (ambiguous sentences). Through a grammaticality judgment task, participants were required to say whether the sentences were grammatical or not. The rational behind this design is that if the tendency is to attach RC to NP1, then the reaction time for sentences in which RC is semantically related to NP1 will be faster than that for sentences in which the RC is semantically related to NP2. Moreover, if the tendency is to attach RC to NP2, the reaction time for sentences in which RC refers to NP2 should be faster.

Methodology

Participants

A total of 45 guidance and high school monolingual male students aged between 12 and 14, with Persian as their mother tongue participated in this study. They were randomly selected from a pool of 180 students of a school in Gorgan, a northern city in Iran. They came from the same pool as those in the pilot study. The purpose for choosing the students of this age range was to make sure that they have already mastered their first language and, consequently, would not have problems with vocabulary or sentence structure of test sentences and have not yet mastered a second language which could affect their judgments. Furthermore, all the participants were interested in taking the test and curious about the results.

Instrumentation

Four versions of a computer-based test in Persian were used in this study. The tests included warm up sentences, filler sentences, and test items. The first two types of sentences were the same across the four versions of the test but the test sentences varied.

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The warm-up sentences

Five grammatical and five ungrammatical sentences were presented to students as warm-up sentences to familiarize them with what they were expected to do. Like the test sentences, participants were required to read the warm-up sentences on the computer screen and then judge the grammaticality of those sentences by pressing certain buttons. The aim was to familiarize the participants with the way to work with the software and to ensure that they know the notions of grammaticality and ungrammaticality. During the warm-up, it was emphasized that the participants were free to ask any question they had with regard to the sentences, software, etc. Furthermore, five of the warm-up sentences were included as the first items in the real test so this would prepare students to continue the test.

The test sentences

Fifteen sets of items were developed (i.e., a total of 45 sentences) as the test sentences. In each set, the sentences varied according to the NP to which the RC of the sentence referred. In other words, each set involved three conditions: in the first condition the RC could be attached only to NP1, in the second condition to NP2 only and in the third one which was ambiguous it could be attached to both NP1 and NP2.

These test sentences were divided into three versions. These versions were balanced so that each condition in each set appeared only once in each version and all conditions were present in each version. In this way, each participant received 5 sentences in which the RC referred to NP1, 5 referring to NP2 and 5 ambiguous ones (referring to both NP1 and NP2). Examples of each condition in each set are provided below:

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a. RC referring to NP1:
(6)

an mærd	*Šagerd*	*-e*	*mæghaze*	*ke dašt ghædæm mizæd*	*ra*	*dozdid*
That man	shopboy$_{NP1}$	of	shop $_{NP2}$	who was walking	object marker	kidnap, PAST, 3SG

'That man stole the shop boy of the shop who was walking.'

b. RC referring to NP2:
(7)

an mærd	*Kif*	*-e*	*honærpiše*	*ke dašt ghædæm mizæd*	*ra*	*dozdid*
That man	bag$_{NP1}$	of	actress $_{NP2}$	that was walking	object marker	kidnap, PAST, 3SG

'That man stole actress's bag who was walking.'

c. RC referring to both NP1 and NP2:
(8)

an mærd	*dokhtær*	*-e*	*honærpiše*	*Ke dašt ghædæm mizæd*	*ra*	*dozdid*
That man	daughter$_{NP1}$	of	actress $_{NP2}$	that was walking	object marker	kidnap, PAST, 3SG

'That man kidnapped actress's daughter who was walking.'

The filler items

To obscure the regularities in the test items, 14 filler items (seven grammatical and seven ungrammatical sentences) were used. These sentences were selected from newspaper articles to maintain authenticity. Examples are provided below:

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(9)

cinæmay	*-e*	*Iran*	*mitævanæd*	*jaygahe*	*vizhei*	*beine*	*mærdom*	*peida konæd*
Cinema	of	Iran	can	a place	special	among	people	find, PAST, 3SG

'Iran's cinema can find a special place among people.'

(10)

**bæradær*	*-e*	*æli*	*dær*	*Tehran*	*ke*	*æst diruz*	*amæd*
*Brother	of	Ali	in	Tehran	that	is yesterday	come, PAST, 3SG

'*Ali's brother in Tehran that is yesterday came.'

Sentence (10) is grammatically wrong, because in the RC *dær Tehran ke æst*, the RC indicator which refers to *bæradær-e Ali* should be at the beginning of the clause (*ke dær Tehran æst*) not within it.

Another function the filler items had was to ensure that the participants did attend to the content of the sentences they read on the monitor. In this way, each version of the test included 39 items: 10 warm-up sentences, 15 test sentences, and 14 fillers. The warm-up and filler items were the same across the four versions of the test but the test sentences varied. Table 1 provides an overview of the different sentences in each version.

Table 1
The distribution of the different sentences in each test version

	Grammatical sentences	**Ungrammatical sentences**
RC referring to NP1	5	--
RC referring to NP2	5	--
RC referring to NP1/NP2	5	--
Warm up sentences	5	5
Filler items	7	7

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Pilot Study

A two-stage pilot study was conducted to examine the naturalness of the sentences used in the tests and to identify potential pitfalls in the proposed research methodology and the developed software. In the first stage, 10 adult Persian native speakers were asked to rate the naturalness of the sentences on the basis of a Likert scale from 1 to 5. All the sentences were judged natural. In the second stage, the study was conducted in a small scale and the three versions of tests were submitted to the 12 third grade guidance school students (each version to 4 students). In the light of the experience gained through the pilot study, some sentences were revised and/or replaced by some new ones.

Moreover, based on the results of these pilots, the decisions as to how long each word should be presented on the monitor were made. That is, it was found that presenting the words for 250 milliseconds is optimum because this time interval allows the participants to judge the grammaticality of the sentences only with the help of their sub-conscious knowledge.

Procedure

The participants were tested individually by computer (a laptop). The test sentences were presented in a non-cumulative way, using Rapid Serial Visual Processing (RSVP). The participants were taught that by pressing the space button on the keyboard a sentence would appear in the following manner: at first a fixation cross appeared for 1500 ms, blinking three times and then disappeared. Thereafter, at the same location, the first word appeared for 250 ms and then disappeared. This process continued until the last word of the sentence. Up to this point, the words appeared automatically and the participants had no control over it. The timing for the presentation of the words was based on the findings of the pilot study. Then two boxes would appear, one for (*dorost*) which means correct/grammatical and the other one for (*ghalæt)* meaning false/ungrammatical. The participants were instructed to select one of them and make their grammaticality judgments by

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pushing a certain response key if it was grammatical and another one if the sentence was ungrammatical. The two keys chosen for this step were the right and down arrow keys. Because the two keys are adjacent, participants could push these keys by the same finger and use of the other hand or fingers would not play any role in the results. Decisions and decision times were automatically recorded. Decision time, or reaction time, was estimated as the interval between the disappearance of the last word and the participant's pressing the button to judge the grammatical status of the sentence. Based on the participants' questions in the pilot study, it was emphasized in the instructions that sentences appeared on the monitor only once and they were only required to judge the sentences on the basis of their grammaticality and not, for example, of their being real or unreal.

Results

As it was mentioned above, in this study, each sentence was followed by a grammaticality judgment question to make sure that the participants paid attention to the content of the sentences. Results showed that the participants were in general better at accepting grammatical sentences as correct than they were at rejecting the ungrammatical ones. That is why performance on grammatical sentences was taken as a criterion for participant selection.

To analyze the obtained data, it was pruned firstly according to the above-mentioned criteria. Those participants whose performance on grammatical sentences was low were excluded (those whose overall response accuracy rate was below 75%). In this way only 40 participants remained. Then, the outliers in the data from reaction times to grammatical sentences were identified and excluded. On the whole, of the 48 participants who participated in the study, data from 32 participants were entered into subsequent analyses.

Results for Accuracy of Judgments

As far as responses to the grammaticality status of the sentences are concerned, first the descriptive statistics were calculated. As Table 1

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shows, performance is almost the same in the three conditions. The participants' performance is well above chance level as they accurately judged 60 to 70 percent of the test sentences.

Table 2
Grammaticality judgment responses for the three conditions

	Mean	SD	N
NP1	3.56	1.32	32
NP2	3.09	1.17	32
NP1 & NP2	3.19	1.06	32

Note: the maximum possible correct score for each condition is 5.

The repeated measures ANOVA results also showed that there is no difference between the three conditions, $F (2, 62) = 1.6$, $p = .209$. This means that after reading the sentences, in the very long run, participants accurately made grammaticality judgments about the sentences. Perhaps the only difference between the three conditions is that for certain conditions they took longer time to make decisions. To check this, we analyzed the data for reaction times, the results of which are presented below.

Results for Reaction Time

Table 3 presents an overview of the participants' mean reaction times to each of the three conditions. All reaction times are given in milliseconds.

Table 3
Reaction times for grammatical judgment of the sentences in the three conditions

	Mean	SD	N
NP1	15.967	8.429	32
NP2	20.120	11.168	32
NP1 & NP2	15.173	9.458	32

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As the table indicates, the participants produced shorter reaction times to sentences in which due to a semantic cue, RC has to be attached to NP1, but longer reaction times to sentences in which, again, due to a semantic cue, RC has to be attached to NP2. Moreover, as the table shows there seems to be no difference between ambiguous sentences (those in which the RC can be attributed to either NP) and those in which RC refers to NP1. This means that the default strategy to resolve the ambiguity is to attach RC to NP1. A repeated measures ANOVA was conducted to check the significance of the above-mentioned differences. The results showed a significant effect for the type of antecedent (NP1 only, NP2 only, either NP1 or NP2), $F(2, 62) = 5.058$, $p = .009$. Pairwise comparisons showed no significant difference between reaction times to sentences with NP1 antecedents and reaction times to ambiguous sentences. But reaction times to NP2 antecedents were significantly different from reaction times to both NP1 antecedents and ambiguous sentences. This means that when the RC refers to NP2, processing cost to make judgments about the sentences is enhanced because the initial attachment has to be revised since the RC semantically disambiguates towards a structurally non-preferred attachment.

Discussion

The main objective of the present research was to investigate whether evidence from an on-line technique converged with previous findings demonstrating Persian native speakers' preference to attach a RC to NP1 in structures such as *NP1 of NP2 RC* when processing ambiguous constructions. The results presented additional evidence compatible with previous findings of a high attachment preference in Persian by showing that violating the preferred structural attachment through semantic cues elicited significant latencies. Therefore, these findings seem to suggest that Persian native speakers are guided by structure-based parsing strategies. Because if semantics were playing a role, we would expect the reaction time to be the same for both sentences in which RCs semantically refer to NP1 or NP2. Within the constraint-based accounts, semantic constraints are expected to contribute to comprehension. But,

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in this study, the constraints provided by semantic relatedness of the RC to NP2 could not make the readers immediately recognize that the sentence is grammatical because it was against their expectation that RC must be attached to NP1, a syntactically guided preference.

Received 2 January, 2008
Accepted 23 March, 2009

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