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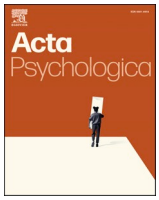

# The effects of restrictiveness on relative clause processing in Farsi

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ABSTRACT

With an eye-tracking experiment, we investigated the processing of Farsi object and subject relative clauses. Since restrictive relative clauses in Farsi are marked and distinguished clearly by the enclitic particle ی /–i/ attached to the head noun, we also compared the processing of restrictive and non-restrictive relative clauses. Seifi (2021) conducted a corpus analysis that showed that object relative clauses are in general less frequent than subject relative clauses. However, while non-restrictive relative clauses are predominantly subject relative clauses, restrictive relative clauses are more balanced in the corpus. In an eye-tracking experiment, Farsi speakers processed restrictive and non-restrictive relative clauses differently. In non-restrictive relative clauses, the effect is similar to that found in most other languages: a clear processing delay in object relative clauses, compared to subject relative clauses. This effect was visible both at the relative clause verb and at the end of the matrix sentence. In restrictive relative clauses, on the other hand, the picture is different: Just as for the non-restrictive relative clauses object relative clauses had long reading times in the relative clause, but at the end of the sentence a reverse effect was found. Thus, the processing data reflected the pattern found in the corpus. We discuss these findings in terms of the distinct functions of restrictive and non-restrictive relative clauses.

## 1. Introduction

A relative clause or an adjective clause is a type of subordinate clause that adds extra detail to a noun phrase. Every relative clause contains an element whose interpretation is provided with the head noun or antecedent, meaning that there is an anaphoric relation between the relativised element and the antecedent. There are different types of relative clauses, depending on their function in the sentence. For example, in a sentence with a relative clause as in '*The neighbour [that called you] left home*', the information in the relative clause is integrated into the matrix sentence. In such restrictive or integrated relative clauses, presupposed information is used to identify the referent of a noun phrase. In this example, this is done by linking the antecedent '*the neighbour*' to the presupposed referent of the pronoun '*you*'. In a non-restrictive or supplementary relative clause, on the other hand, new information is presented based on the assumption that the referent of the antecedent can already be identified as in '*My neighbour [, who is a real bore,] will visit me for dinner tomorrow*'.

Languages differ in the way they express restrictiveness. In English, for instance, non-restrictive relative clauses are usually marked by an intonation break in the speaker's voice, and they are usually set off by commas in writing. Other languages, such as Arabic mark the distinction grammatically (Alqurashi, 2018). In Arabic, a non-restrictive relative clause is initiated by the particle و /wa/ immediately preceding the relative complementizer الذى/ʔallaði/. Restrictive relative clauses, on the other hand, are unmarked in Arabic. Other languages, such as Farsi[1] and Mandarin also mark restrictiveness explicitly. Lin and Tsai (2015) state that in Mandarin relative clauses, restrictiveness is marked by the

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[1] The term "Farsi" is used throughout this article to refer specifically to the variant of the Persian language spoken in Iran. This choice is based on the linguistic argument presented by Karimi (n.d.), who notes that the use of "Persian" as an unmarked term may inadvertently suggest a hierarchy among the language's variants. Karimi argues that Tajiki and Dari, for example, are syntactically closer to earlier stages of Persian than the variant spoken in Iran, known as Farsi. By using "Farsi," we aim to acknowledge the equal linguistic standing of all Persian language variants and to avoid any implication that the Iranian variant is the primary or default form. This terminological precision is particularly pertinent to our research focus, which is exclusively on the Iranian variant of Persian.

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particle '*de*' which can be placed in two positions within the noun phrase, before or after the demonstrative-numeral-classifier sequence. The different positions of '*de*' indicate the two different potential interpretations, restrictive and non-restrictive, respectively. The grammatical marking of the difference between restrictive and non-restrictive relative clauses in some languages may influence their processing.

To explore this, we investigate the processing of relative clauses in Farsi. The language distinctly marks restrictiveness; in Farsi, restrictive relative clauses are differentiated from non-restrictive ones by the presence of the enclitic particle ی /–i/, which is affixed to the antecedent within restrictive constructions. For Farsi relative clauses, there is some indication that there may be differences in distribution between the two types of relative clauses. In a corpus study, Seifi (2021) demonstrated that restrictive object relative clauses occur with a higher frequency of 39.34 % ($n$ = 110) compared to non-restrictive object relative clauses, which appear at a rate of 18.33 % ($n$ = 13). This contrast is more pronounced than the frequency distribution difference observed between restrictive and non-restrictive subject relative clauses. The findings suggest that the variation in frequency may be associated with differences in the processing of these types of relative clauses.

Before discussing possible effects on processing, we will first explain the structure of the Farsi relative clause in more detail. While in OV languages like Farsi, verbs follow their objects (i.e., head-final languages), they come before them in VO languages as English (i.e., head-initial language). As a general rule, Farsi has an SOV (Subject-Object-Verb) sentence word order (see example sentence 1), and verbs follow their objects (i.e., head-final language). However, concerning the placement of relative clauses, English and Farsi are head-initial (i.e., post-nominal). In Farsi, unlike in English, the syntactic order of the embedded noun phrase (NP) and the embedded verb phrase (VP) within both subject relative clauses (2) and object relative clauses (3) remains unchanged, preserving the NP + VP structure. In relative clauses with a transitive verb and a definite noun subject and object, relative clauses are differentiated by the object marker را /rā/ after the object (embedded noun phrase) in the subject relatives.

1)

سایان در را باز کرد.

Sāyān dar rā bāz kard.

Sayan door OM open do-PST.3SG.

'Sayan opened the door.'

2)

زنی که بچه ها را دوست داشت.

zan-i ke baçehā rā dust dāşt.

woman-RES COMP child.PL OM friend have-PST.3SG.

'The woman who(that) liked the children'

3)

زنی که بچه ها دوست داشتند.

zan-i ke baçehā dust dāştand.

woman-RES COMP child.PL friend have-PST.3PL.

'The woman whom(that) the children liked.'

The major distinctive feature between a restrictive and non-restrictive relative clause is the enclitic particle ی /–i/ which attaches to the antecedent in a restrictive relative clause. Thus, the reader knows from the outset whether the clause is restrictive or not. Example sentences (4) and (5) illustrate a restrictive and non-restrictive relative clause, respectively.

4)

مؤلفی که این کتاب را نوشته است نویسنده خوبی است.

**moallef-i** ke in ketāb rā neveşte ast

author-RES COMP this book OM write-PRS-PTCP be-PRS.3SG

nevisandeye xubi ast.

writer-EZ good-INDF be-PRS.3SG.

'The author who/that has written this book is a good writer.'

5)

مؤلف که این کتاب را نوشته است نویسنده خوبی است.

**moallef** ke in ketāb rā neveşte ast

author COMP this book OM write-PRS-PTCP be-PRS.3SG

nevisandeye xubi ast.

writer-EZ good-INDF be-PRS.3SG.

'The author, who has written this book, is a good writer.'

There is no relative pronoun in Farsi relative clauses. Instead, the complementizer که /ke/ introduces the relative clause regardless of the function, number, animacy, and gender of the antecedent in the relative clause (Taghvaipour, 2005). The occurrence of که /ke/ in the equivalent Farsi structure in both restrictive and non-restrictive relative clauses is obligatory (Aghaei, 2006). The complementizer is followed immediately by an NP which is marked as either the subject or the object. The object marker را /rā/ is another marked feature of the Farsi language. Relative clauses are disambiguated by the presence or absence of the object marker را /rā/. In subject relative clauses with a transitive verb, the object marker, را /rā/, follows a definite embedded noun phrase, as in (6).

In Farsi, a transitive verb with a direct object takes an object marker postposition with را /rā/ being used in a formal register and the variants of 'ro' or 'o' in more colloquial use. However, there is controversy over the definiteness of the object marker. The studies of Lambton (1979), Lazard (1992), Mahootian and Gebhardt (1997), Sadeghi (1970), Windfuhr (2011), and Yousef and Torabi (2013) qualify the postposition را /rā/ as a definite object marker and imply that all definite objects in Farsi must be marked with /rā/.

6)

زنی که ظرف ها را می شوید خواهر من است.

zan-i ke zarfhā rā mişuyad xāhare man ast.

woman-RES COMO dish.PL OM wash-PRS.3SG sister- EZ I be-PRS.3SG.

'[The woman who is doing the dishes] is my sister.'

Since Farsi is a pro-drop language, the subject of an object relative clause (7 a) can be dropped as in the example (7 b)

7)

a.

پسری که من میشناسم به کلاس آمد.

pesar-i ke man mişenāsam be kelās āmad.

boy-RES COMP I know-PRS.1SG to class come-PST.3SG.

'The boy whom I know came to the class.'

b.

پسری که میشناسم به کلاس آمد.

pesar-i ke mişenāsam be kelās āmad.

boy-RES COMP know-PRS.1SG to class come-PST.3SG.

'The boy whom I know came to the class.

In contrast to English, Farsi allows for the repetition of a relativized element within a relative clause through the use of a resumptive pronoun or a pronominal enclitic. Seifi's (2021) corpus analysis of 738 relative clauses found that a majority, 643 cases (87.1 %), employed a gap strategy where the relativized element was not repeated. Additionally, the study identified 82 instances (11.1 %) where a resumptive pronoun was used and 13 instances (1.8 %) that featured a pronominal enclitic. Notably, subject relative clauses did not utilize resumptive pronouns, whereas all genitive relative clauses and the majority of oblique relative clauses (87.7 %) did include resumptive pronouns, as exemplified in sentence 8. Object relative clauses were also found to occasionally use resumptive pronouns or pronominal enclitics (8.13 %, $n = 10$), but predominantly exhibited a gap (91.87 %, $n = 113$).

8)

سه کشور در مورد مسائلی که با آن روبرو هستند گفتگو و رایزنی میکنند.

se keşvar darmored-e masāel-i ke bā ān

three country about-EZ issue.PL-RES COMP with that

ruberu hastand goftogu ve rāyzani mikonanad.

face be-PRS.3PL discussion and consultation do-PRS.3PL.

'The three countries are discussing and consulting on the issues that they face.' (Lit. 'The three countries are discussing and consulting on the issues$_i$ that they face with it$_i$).'

In sum, in Farsi, the order of the embedded noun phrase and verb phrase in subject and object relative clauses is the same; they are distinguished by the presence or absence of the object marker right after the noun phrase that follows the complementizer. The object marker را /rā/ and the restrictive marker, the enclitic particle ی /–i/, may influence relative clause processing by providing early cues for recognizing different types of relative clauses. Regarding that frequency distributions are different in restrictive and non-restrictive constructions (Seifi, 2021), marking a relative clause as restrictive may lead to different processing preferences. The restrictive marker may alter the preference readers have for either type of relative clause.

Contrasting subject and object relative clauses enables us to understand the cognitive mechanisms involved in processing and comprehension of syntactically complex sentences. Many (psycho)linguistic studies have shown that the processing of subject relative clauses of the form '*The professor that saw the students was going to the class.*' is easier than object relative clauses of the form '*The professor that the students saw was going to the class.* This effect has been found in various languages, irrespective of word order and placement of the head (final or initial) in post-nominal and prenominal relative clauses, including English (e.g., Gibson, 1998; Grodner & Gibson, 2005; King & Just, 1991; King & Kutas, 1995; Staub, 2010; Staub et al., 2017; Traxler et al., 2002), Dutch (e.g., Frazier, 1987; Mak et al., 2002, 2006), German (e.g., Mecklinger et al., 1995), Spanish (e.g., Betancort et al., 2009), French (e.g., Holmes & O'Regan, 1981), Chinese (e.g., Chen et al., 2008; Gibson & Wu, 2013; Hsiao & Gibson, 2003;), Japanese (e.g., Ishizuka et al., 2003; Ueno & Garnsey, 2008), Turkish (e.g., Aydin, 2007; Kükürt, 2004), and Korean (e.g., Kwon et al., 2013). However, there are a few exceptions in the literature: for example, object relative clause preference has been reported for Basque (e.g., Carreiras et al., 2010) and some have reported it for Chinese (e.g., Cui, 2013; Wu et al., 2010).

Kwon et al. (2013) argue that languages which allow post-nominal relative clauses make it easier to comprehend subject relative clauses. However, this same subject relative preference has been repeatedly observed for pre-nominal relative clauses in Korean (self-paced reading time: Kwon et al., 2006; Kwon, 2008; eye-tracking: Kwon et al., 2010) and Japanese (Miyamoto & Nakamura, 2013; Ishizuka et al., 2003; ERP: Ueno & Garnsey, 2008). To determine whether the subject relative clause advantage also shows in brain responses and to disentangle the typological elements that might be involved, Kwon et al. (2013) examined event-related brain potentials (ERPs) in response to Korean relative clauses. Their findings imply that while brain activity to relative clauses in SVO and SOV languages is strikingly similar, the positioning of the relative clause in relation to its head noun dictates that the neural response is localized to different regions within the sentence structure. This observation is particularly intriguing when considering the Farsi language, which, despite its SOV general sentence word order—similar to Korean—features post-nominal relative clauses like English. This structural characteristic of Farsi may provide additional insights into how the brain processes relative clauses across different language typologies, as revealed by ERP studies.

To date, there has been a dearth of research on the processing of subject and object relative clauses in Farsi. While previous studies have primarily focused on the processing of restrictive relative clauses, it is important to investigate the potential processing differences between restrictive and non-restrictive relative clauses in Farsi. This is particularly relevant given the clear distinction between these two types of relative clauses in Farsi, as well as the findings of a recent corpus study (Seifi, 2021) which revealed distinct frequency distributions for restrictive and non-restrictive relative clauses. Therefore, our study aims to address this gap in the literature and shed light on the potential processing differences between these two types of relative clauses in Farsi. By doing so, we hope to contribute to a more comprehensive understanding of relative clause processing in Farsi and provide insights that can inform future research in this area.

The use of eye-tracking in relative clause sentence processing studies provides several strengths, including high temporal resolution, non-invasiveness, high sensitivity, fine-grained analysis, and objective measures. Eye-tracking allows researchers to measure participants' eye movements in real-time, providing detailed information about the timing and duration of fixations on specific words or regions of interest. This can help to identify the specific factors that influence relative clause processing, such as the position of the relative clause within the sentence or the type of relative clause. Eye-tracking is a safe and comfortable method for participants to use and provides objective measures that can increase the reliability and validity of the results (Rayner et al., 2006). To the best of our knowledge, there is a significant gap in the literature regarding the on-line processing of Farsi restrictive and non-restrictive subject and object relative clauses. To overcome this gap and to provide a comprehensive understanding of the processing mechanisms involved in Farsi relative clause comprehension, we have employed the eye-tracking method to investigate the real-time processing of restrictive and non-restrictive subject and object relative clauses by native Farsi speakers. Our study will contribute to the existing literature on relative clause processing and provide valuable insights into the processing of these complex linguistic structures in Farsi.

Different theoretical accounts of relative clause processing characterize the difficulty or ease of processing subject and object relative clauses. Some of these accounts may help us predict the relative clause preference in Farsi too. The first class of accounts attribute the relative clause processing differences to the structural asymmetry of subject and object relative clauses. For instance, the Structural Distance Hypothesis (O'Grady et al., 2003) posits that the structural distance between a relativized antecedent and a gap correlates with the difficulty or easiness of processing a relative clause. The structural distance corresponds to the number of syntactic nodes or projections which intervene between the antecedent and the gap. Accordingly, the structural distance between the antecedent and gap in the subject relative clause as in (9) is always shorter than that in the object relative clause (10) because the gap is embedded deeper in the object relative clause. In the subject relative clause, the position of the gap is located in the inflection phrase whilst the gap is embedded in the verb phrase in the object relative clause. Therefore, Structural Distance Hypothesis predicts a subject relative clause advantage.

9)
The woman that *e* liked the children.
The woman [CP that [ IP *e* [VP liked the children]].
number of nodes between the gap and the antecedent = 2 (CP, IP).
10)
The woman that the children liked *e*.
The woman [CP that [IP the children [VP liked *e*]]].

Similarly, example (11), which is a subject relative in Farsi, has the shortest distance between the head noun and gap; there are two projections between the head noun and gap. The verb inflection and the filler denote the same number and person in this example. In example (12), there are three projections between the head noun and gap. The verb inflection and the filler do not denote the same number and person in this example.

11)

زنی که بچه ها را دوست داشت.

zan-i ke baçehā rā dust dāşt.
woman-RES COMP child.PL OM friend have-PST.3SG.
'The woman who(that) liked the child'
the woman [CP ke [IP *e* [VP the children rā liked]].
number of nodes between the head noun and gap = 2 (CP, IP)

12)

زنی که بچه ها دوست داشتند.

zan-i ke baçehā dust dāştand.

woman-RES COMP child.PL friend have-PST.3PL.

The woman [CP ke [IP the children [VP *e* liked]].

number of nodes between the head noun and gap = 3 (CP, IP, VP)

Another structure-based model is Perspective-shift (MacWhinney & Pleh, 1988) which focuses on sentence-internal relationships. A subject's role is to show the clause perspective since inherently subjects are more salient than objects. Communication is interrupted when interruptions, lack of shared knowledge, complexity and discontinuity take place. Processing an SS (Subject-modifying, Subject-extracted) relative clause as in 'The actor that watched the director forgot a line.' does not require any perspective shift because the subject of the matrix clause and the relative clause is the same. However, in SO (Subject-modifying, Object-extracted) relative clauses as in 'The actor that the director watched forgot a line.', two perspective shifts are required: one from the perspective of the subject of the matrix clause to the relative clause subject. After processing the relative clause, the second perspective shift occurs, the perspective of the relative clause goes back to the matrix subject.

Relative clause processing differences can also be explained by word-order heuristics (Townsend et al., 2001). According to this structure-based model, the input is initially parsed, and thematic roles are provisionally assigned by placing the information onto canonical word-order patterns. In English, subject relative clauses follow the conventional (SVO) agent-action-patient word order, which makes them easier to process (Price & Witzel, 2017). Similarly, the canonical word order theory (MacDonald & Christiansen, 2002) suggests that the word order in English subject relative clauses is similar to the word order in canonical declarative sentences, which are used more frequently and with greater ease than object relatives.

In English, subject and object relative clauses have the word order (SVO) agent-action-patient, as in [The man that saw the woman], and (OSV) patient-agent-action, as in [The man that the woman saw], respectively. However, Farsi is an SOV order language and subject relative clauses conform to the canonical (SOV) agent-patient-action word order, and the order of constituents after the complementizer /ke/ is NP + VP. In object relative clauses, the NP is unmarked, as in [man-i ke woman saw], while in subject relative clauses, the NP is marked as the object, as in [man-i ke woman-obj saw]. Therefore, while the disambiguation of subject and object relative clauses in English is based on the order of noun and verb phrases in the relative clause, the disambiguation of Farsi relative clauses depends on morphological cues at the beginning of the relative clause. Keenan and Comrie (1977) made a cross-linguistic generalisation concerning the construction of relative clauses known as the Accessibility Hierarchy (AH). Keenan and Comrie (1977) attribute grammatical relations to the subject/object processing asymmetry. Based on typological studies on the restrictive relative clauses in 50 languages, Keenan and Comrie (1977) proposed the Noun Phrase Accessibility hypothesis. According to their hypothesis, all languages conform to the following hierarchy in relativisability of noun phrases with different grammatical roles in a sentence, as illustrated in (13).

13)

Subject > Direct Object > Indirect Object > Oblique > Genitive > Object of Comparison

Another category of theoretical approaches that may predict the processing differences of relative clauses is the relative frequency with which they occur. Under expectation models, frequency disparity is attributed to object relative clause processing difficulty (Price & Witzel, 2017). Corpus studies (Abdollahnejad & Marefat, 2017; Seifi, 2021) show a higher frequency distribution of subject relative clauses in comparison with their object counterparts. Reali and Christiansen (2007) in their frequency-based approach argue that the more frequent certain structures are in a given language, the easier their processing will be. This would lead to the prediction that there is a subject relative clause preference in processing Farsi relative clauses. However, there may be a difference between restrictive and non-restrictive relative clauses in this respect as restrictive object relative clauses are relatively more frequent than non-restrictive object relative clauses (compared to subject relative clauses; Seifi, 2021). Therefore, a frequency-based account would predict that the processing difference between subject and object relative clauses will be larger in non-restrictive relative clauses than in restrictive relative clauses.

According to Price and Witzel (2017), memory-based models attribute the costs of relative clause processing in terms of encoding, storage and structural integration of the noun phrases involved in a relative clause. The effect at the object relative clause verb might be because of retrieval and integration of antecedent and embedded noun phrases. Gordon et al. (2006) proposed a similarity-based account suggesting that the processing demands for memory retrieval and storage are heightened in object-extracted relative clauses when the noun phrases involved share similar features, such as both being animate or inanimate, or both being full noun phrases. This model posits that the similarity between noun phrase representations can impede the speed and accuracy of memory retrieval, as evidenced by numerous memory-based studies. The necessity to retrieve a noun phrase from memory arises to fulfil the syntactic or semantic requirements imposed by the verb within a relative clause. This retrieval challenge, particularly when dealing with similar noun phrase types, helps to explain the observed differences in processing subject and object relative clauses. Gordon et al. (2001) highlight that the similarity in noun phrase representations contributes to these processing disparities. Furthermore, Gordon and Lowder (2012) contend that the human parser operates with limited cognitive capacity, which can be strained by certain syntactic structures. Object relative clauses, for instance, may tax this capacity to the point of slowing down processing or leading to misunderstandings.

In this study, our objective was to explore potential processing asymmetries between object and subject relative clauses in Farsi, as well as to determine if the pronounced distinction between restrictive and non-restrictive forms of these clauses is evident in the processing patterns of native Farsi speakers. The theories we have reviewed generally suggest a preference for subject over object relative clauses. The degree to which our data will reveal differences between restrictive and non-restrictive relative clauses is contingent upon the theoretical frameworks' capacity to account for sensitivity to discourse-related cues, exemplified by the Perspective-shift model (MacWhinney & Pleh, 1988), or to the frequency of occurrence in actual language usage, as highlighted by Seifi (2021).

**Table 1**
An Example of an Item in Farsi Including Subject and Object Relative Clauses in Restrictive and Non-restrictive Conditions.

| |
|---|
| 1) (SR Res) |
| همسایه ای که پیرمرد را لوداد خانه اش را به سرعت ترک کرد. |
| hamsāye-i ke pir mard rā lodād |
| neighbour-RES COMP old man OM betray-PST.3SG |
| xāneaş rā besorat tark kard. |
| home-enclitic.3SG OM quickly leaving do-PST.3SG. |
| 'The neighbour that betrayed the old man left his home quickly.' |
| 2) (OR Res) |
| همسایه ای که پیرمرد لوداد خانه اش را به سرعت ترک کرد. |
| hamsāye-i ke pir mard lodād |
| neighbour-RES COMP old man betray-PST.3SG |
| xāneaş rā besorat tark kard. |
| home-enclitic.3SG OM quickly leaving do-PST.3SG. |
| 'The neighbour that the old man betrayed left his home quickly.' |
| 3) (SR Non-res) |
| همسایه که پیرمرد را لوداد خانه اش را به سرعت ترک کرد. |
| hamsāye ke pir mard rā lodād |
| neighbour COMP old man OM betray-PST.3SG |
| xāneaş rā besorat tark kard. |
| home-enclitic.3SG OM quickly leaving do-PST.3SG. |
| 'The neighbour, who betrayed the old man, left his home quickly.' |
| 4) (OR Non-res) |
| همسایه که پیرمرد لوداد خانه اش را به سرعت ترک کرد. |
| hamsāye ke pirmard lodād |
| neighbour COMP old man betray-PST.3SG |
| xāneaş rā besorat tark kard. |
| home-enclitic OM quickly leaving do-PST.3SG. |
| 'The neighbour, whom the old man betrayed, left his home quickly.' |

*Note.* SR res = restrictive subject relative clause, OR Res = restrictive object relative clause, SR Non-res = non-restrictive subject relative clause, OR Non-res = non-restrictive object relative clause.

## 2. Method

### 2.1. Participants

A total of forty-two Iranian graduate students (PhD and Master's candidates) at the University of Groningen volunteered to participate in the experiment. The cohort included 35 native Farsi speakers, four native Azerbaijani Turks, two Kurds, and one Arab. Given that Farsi is the sole language of instruction in Iranian educational institutions, speakers of other native languages typically have limited literacy in their mother tongues and are proficient in reading and writing Farsi. Consequently, those non-Farsi-speaking Iranian participants were also included in the experiment. The demographic breakdown of the participants was 16 males and 26 females, with an average age of 30.76

**Fig. 1.** Reading Direction and Patterns in a Farsi Sentence.

years (ranging from 22 to 40 years old). Before they arrived in the Netherlands, all participants had completed their undergraduate or Master's degrees in Iran. English language education in Iran begins in the 7th grade, at approximately 11 years of age, and continues as a mandatory subject throughout secondary education. Additionally, some participants pursued English language learning through extracurricular courses. The majority of the participants are currently pursuing their PhDs, with their time in the Netherlands varying from 6 months to 4 years. The participants had learned English as a second language. They all reported having either normal corrected-to-normal vision, and none reported any reading disabilities or other language-related impairments.

### 2.2. Materials and design

This study focused on two types of relative clauses in two versions: subject and direct object relative clauses either in a restrictive or a non-restrictive version. An example of an item in each of the four versions is given in Table 1. All the antecedents and the embedded noun phrases were animate full NPs, and all the relative clause verbs were transitive. All four versions of relative clauses were subject-modifying (the antecedents were the subject of the matrix sentence). They were either subject or object-extracted relative clauses (the referents of the antecedents were subject or object of the relative clauses). The test sentences either contained a subject relative clause (1 and 3), or an object relative clause (2 and 4). There is no change in the order of the embedded noun phrase and the verb phrase. The only difference between (1–2) and (3–4) is the restrictive enclitic /–*i*/ attached to the antecedent in (1–2). The materials for this experiment consisted of 36 items, each consisting of four sentence versions. Initially, the items were adapted from Staub (2010) and Staub et al. (2017). Then, for the present experiment, the items were translated into Farsi carefully. Table 1 presents examples of both restrictive and non-restrictive subject and object relative clauses in Farsi. We did not conduct a formal plausibility check of the materials with a large group of native speakers; however, we presented the sentences to a native Farsi speaker and solicited her feedback.

The object marker in the subject relative clauses and the enclitic /–i/ in restrictive relative clauses provide the reader with morphological cues as to which relative clause they are reading in the experiment. The subject-verb agreement did not provide information on the items since the antecedent and embedded noun phrase do not differ in number. The four versions of every item were distributed across four different lists so that precisely one version of each set appeared in a list and an equal number of items of the same version appeared across the lists.

Each participant read nine *restrictive* subject relative clauses, nine *restrictive* object relative clauses, nine *non-restrictive* subject relative clauses, and nine *non-restrictive* object relative clauses (see Table 1). The test items in every version were presented together with 60 filler items of various syntactic types. These items were based on the Cambridge Preparation for the TOEFL (Gear & Gear, 2002).

To ensure that the participants read the sentences attentively, 25 %

**Table 2**
Areas of Interest for Data Analysis.

| | |
|---|---|
| 7) (SR Res) | \| همسایه ای \| که \| پیرمرد را \| لوداد \| خانه اش را به سرعت \| ترک کرد. \| |
| | Matrix VP Pre-matrixVP VP OM NP COMP HD |
| 8) (OR Res) | \| همسایه ای \| که \| پیرمرد \| لوداد \| خانه اش را به سرعت \| ترک کرد.\| |
| | Matrix VP Pre-matrixVP VP NP COMP HD |
| 9) (SR Non-res) | \| همسایه \| که \| پیرمرد را \| لوداد \| خانه اش را به سرعت \| ترک کرد. \| |
| | Matrix VP Pre-MatrixVP VP OM NP COMP HD |
| 10) (OR Non-res) | \| همسایه\| که \| پیرمرد\| لوداد\| خانه اش را به سرعت\| ترک کرد.\| |
| | Matrix VP Pre-MatrixVP V NP COMP HD |

*Note*. SR res = restrictive subject relative clause, OR Res = restrictive object relative clause, SR Non-res = non-restrictive subject relative clause, OR Non-res = non-restrictive object relative clause. HD = head noun (antecedent), COMP = complementizer, NP = noun phrase, OM = object marker, VP = verb phrase, Pre-MatrixVP = pre-matrix verb, Matrix VP = Matrix verb. '|' marks the division between the areas of interest.

of the test sentences or stimuli, were paired with a simple verification statement (True/False) about the content of the relative clause and the matrix sentence ($n = 8$) or filler sentences ($n = 16$). Half of the statements were true to the content of the target sentence, and the other half were false.

### 2.3. Procedure

Participants were tested individually in the eye lab at the University of Groningen. Eye movements were recorded using a Tobii 1750 Eye tracker (Tobii Technology Inc.), interfaced with a laptop. The sampling rate was 50 HZ. Stimuli were displayed on a 17-inch monitor. Participants were seated approximately 68 cm from the computer screen. The movements of both eyes were recorded. Sentences were presented in 40 pt. Arabic Typesetting font. We opted for Olive Green, lighter 80 % for the background of stimuli to avoid a strain on the participants' eyes. All parts of the matrix sentences including the clause and matrix verb appeared on one line. The stimuli and fillers were presented as in the example sentence in Fig. 1.

Each list was divided into three sections: First, the participants read ten practice sentences, after which there was a short break. Then, they read the first 48 sentences of the experiment, which were again followed by a pause. After this break, the final set of 48 sentences was read. A nine-point calibration was carried out three times: before the practice part, before the first experimental part, and before the second experimental part. Before each sentence, an asterisk appeared on the right side of the screen at the position where the first word would be presented. Half of the participants were exposed to the two experimental parts in one order, the other half in the reverse order. The experiment was built and run with Tobii's Clearview software.

Before starting the experiment, the participants were instructed to read silently at their own pace for comprehension and were informed that they would be checked for comprehension of some of the sentences randomly. A space bar press either led to the next item or a comprehension verification statement. The participants answered True by clicking on the key '*C*' and False on '*M.*' These keys were marked with a green and a red sticker, respectively.

**Table 3**
Means (in ms) for Reading Time Measures (Standard Deviations) by Condition for the Antecedent, Complementizer Ke Embedded Noun Phrase, Embedded Verb Phrase, Pre-matrix Verb, Matrix Verb Regions.

| | Restrictive | | Non-restrictive | |
|---|---|---|---|---|
| | SR | OR | SR | OR |
| Antecedent | | | | |
| First-pass | 395(225) | 463(315) | 387(343) | 346(220) |
| Total reading time | 712(542) | 766(718) | 578(529) | 631(529) |
| Complementizer Ke | | | | |
| First-pass | 227(100) | 228(87) | 206(86) | 248(105) |
| First-pass total | 227(109) | 228(94) | 211(85) | 248(166) |
| Regression path duration | 307(245) | 341(269) | 264(205) | 295(189) |
| Total reading time | 337(258) | 324(203) | 352(254) | 563(658) |
| Embedded noun phrase | | | | |
| First-pass | 384(236) | 358(221) | 437(268) | 412(244) |
| First-pass total | 472(248) | 426(251) | 614(338) | 518(266) |
| Regression path duration | 537(326) | 502(365) | 722(435) | 602(386) |
| Total reading time | 998(791) | 823(565) | 1127(802) | 1050(685) |
| Embedded verb phrase | | | | |
| First-pass | 530(279) | 569(380) | 572(298) | 584(328) |
| First-pass total | 638(277) | 698(407) | 664(291) | 740(399) |
| Regression path duration | 700(371) | 781(510) | 712(358) | 855(604) |
| Total reading time | 1106(773) | 1179(861) | 1037(577) | 1358(836) |
| Pre-matrix verb | | | | |
| First-pass | 785(412) | 798(432) | 854(433) | 808(485) |
| First-pass total | 925(415) | 987(422) | 957(391) | 1049(495) |
| Regression path duration | 940(424) | 1059(530) | 1040(505) | 1240(857) |
| Total reading time | 1287(819) | 1376(696) | 1277(786) | 1453(807) |
| Matrix verb | | | | |
| First-pass | 578(359) | 525(347) | 523(354) | 560(320) |
| Regression path duration | 2036 (2167) | 1687 (1658) | 1506 (1793) | 1774 (1666) |
| Total reading time | 763(451) | 681(490) | 657(492) | 744(528) |

### 2.4. Data analysis

We divided the sentences into six regions: the antecedent, complementizer که */ke/*, embedded noun phrase in the relative clause, embedded verb phrase in the relative clause, pre-matrix verb, and matrix verb (see Table 2).

For each region, four reading time measures were compared. The first-pass reading time (FP) or gaze duration is defined as the sum of all the fixations made in a region until the eyes of the reader leave the region either to the left or to the right. First-pass total reading time (also known as right bounded time or total gaze duration) (FPtot) sums up all fixations within a region before moving on progressively (which means to the left in Farsi). This measure consists of first-pass reading times, including additional fixations that follow regressive eye movements. Regression path duration (RPD) is defined as the total time from initially encountering a word to moving to the following word. Total reading time (TRT) sums up all fixations made within a region of text including those fixations during re-reading the region. Fig. 1 illustrates the reading direction from right to left in a Farsi filler sentence in the present experiment. The blue balls show the fixations (with the accompanying number revealing the order of fixations), and the blue lines are saccades between the fixations.

We corrected the vertical drifts manually by pulling the fixations up or down the areas of interest with the Fixation program (Cozijn, 1994). Within 17.1 % of FP, 16.5 % of FPtot, 7 % of TRT, and 16.5 % of RP on the areas of interest, no reading time measurement was recorded; they were skipped by the readers. Of the remaining cases 17.3 % of FP, 19.7 % of FPtot, 29.5 % of TRT, and 23 % of RP have been discarded because of the poor quality of the measurements, due to blinks or failure to track the eyes. We deleted observations above and below 2 SD from both the participant and item means. Accordingly, 26 outliers in FP, 33 outliers in FPtot, 30 outliers in TRT, and 46 outliers in RP were deleted. Since reading time data are inherently skewed, we transformed the data by

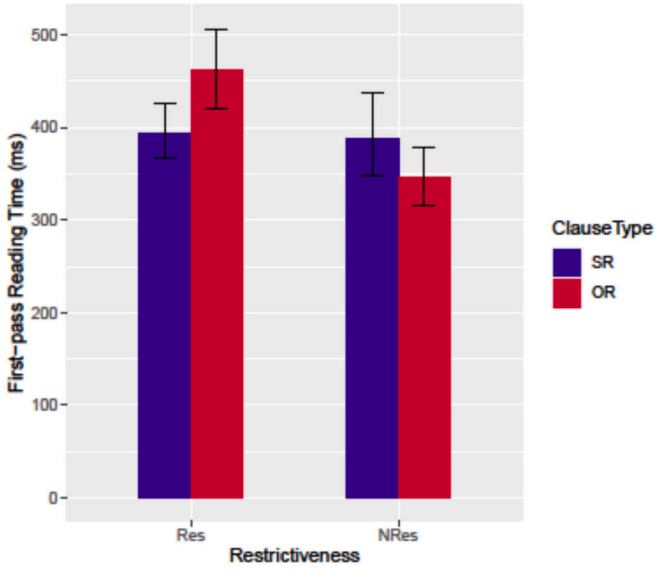


**Fig. 2.** Experiment 1 Mean and Standard Error for First-pass Reading Time for the Antecedent Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

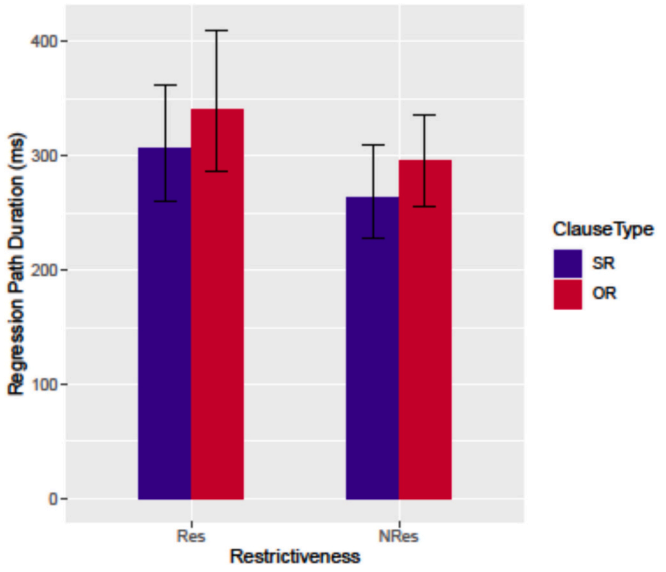


**Fig. 3.** Experiment 1 Mean and Standard Error for Regression Path Duration for Complementizer ke Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

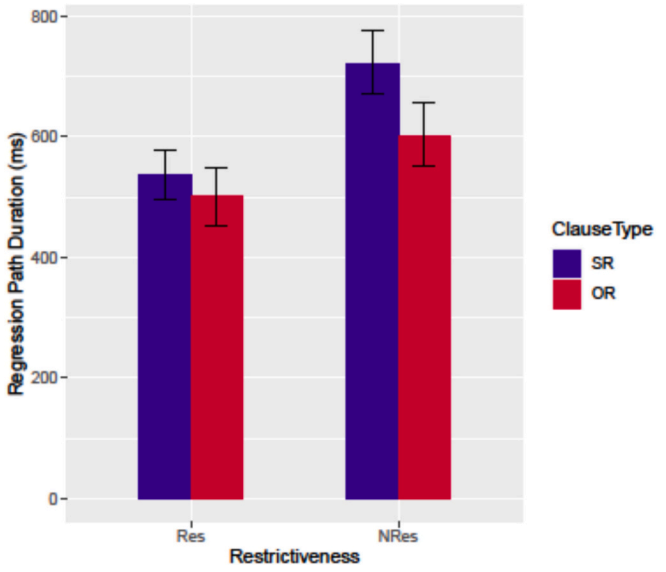


**Fig. 4.** Experiment 1 Mean and Standard Error for Regression Path Duration for the Embedded Noun Phrase Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

taking logarithmic to approximate the normal distribution of the reading times.

Statistical analysis was conducted using linear mixed-effects models of the reading times. We used R (R Core Team, 2019) and the *lme4* package (Bates et al., 2015) to predict the times of the eye movement measurements (first-pass, first-pass total, total reading time, regression path duration) based on Clause Type (subject versus object) and Restrictiveness (Restrictive versus Non-restrictive). We produced the figures by using the package *ggplot2* (Wickham, 2016).

We started out with models including full random part (intercepts and slopes for both participants and items). However, these models did not converge, even when dropping the slopes for the interaction. Thus, the models we present in the results included only the random intercepts for subjects and items. First, we created the model with the main effects and then compared it with the model with the interaction to determine whether the model fit increased when the interaction was added. As random effects, we included intercepts for subjects and items and by-subject and by-item random slopes for the effect of Clause Type and Restrictiveness and their interaction. First, we created the model with the main effects and then compared it with the model with the interaction. The comparison between models with and without interactions was conducted by using the anova function in R. We used treatment coding: The subject relative was the baseline for Clause Type and the restrictive condition was the baseline for Restrictiveness. In the models without the interactions, the simple effects can be interpreted as main effects. In the case of an interaction, an extra analysis was run to test the effect of Clause Type in the Non-restrictive condition by changing the baseline for Restrictiveness into the Non-restrictive condition.

## 3. Results

Means for reading time measures and standard deviations are presented in Table 3 and the figures revealing the eye-tracking measurements are presented in the Appendix.

### 3.1. Antecedent

The antecedent in restrictive relative clauses is marked by the particle /−i/ which is shown in the example (14). Example (15) is a non-restrictive relative clause without a restrictive marker.

14)

**The babysitter-i**| ke| the child rā|liked| a qualified nurse|was. (Restrictive)

15)

**The babysitter**|ke | the child rā |liked| a qualified nurse|was. (Non-restrictive)

For the *First-pass Reading Time* (which is in this region the same as the *First-pass total Reading Time* and the *Regression Path Duration*), adding the interaction of Clause type and Restrictiveness did not improve the model ($\chi 2(1) = 1.12$, $p = .29$). In the model without the interaction of Clause type and Restrictiveness (marginal $R^2$ squared = 0.019), the main effect of Restrictiveness was significant ($B = 0.176$ $SE = 0.046$, $t = -3.82$, $p < .001$): Reading times were slower in restrictive conditions than in non-restrictive conditions.

For the *Total Reading Time,* adding the interaction of Clause type and Restrictiveness did not improve the model ($\chi 2(1) = 1.54$, $p = .21$; marginal $R^2 = 0.028$). In the model without the interaction of Clause type and Restrictiveness, there was a main effect of Clause Type ($B = 0.115$, $SE = 0.042$, $t = 2.71$, $p = .007$): object relative clauses were read

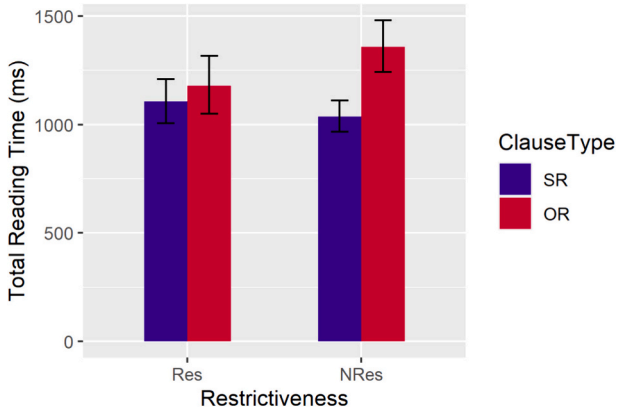


**Fig. 5.** Experiment 1 Mean and Standard Error for Total Reading Time for Embedded Verb Phrase Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

slower than subject relatives. There was also a main effect of Restrictiveness ($B = -0.224$, $SE = 0.050$, $t = -4.70$, $p < .001$): reading times on the antecedent of non-restrictive relative clauses were shorter than the reading times of restrictive relative clauses.

In sum, the main finding at the antecedent is a significant effect of Restrictiveness for all the measurements, indicating that the reading times on the head of restrictive relative clauses (which contains the particle */−i/*) were longer than on the head of non-restrictive relative clauses (see Fig. 2; here and in the following, we will present the measure that is most representative in a graph). Only in the Total Reading Time, which included re-reading from later parts of the sentence, an effect of Clause Type was found: in object relative clauses there was more re-reading of the head than in subject relative clauses.

### 3.2. Complementizer Ke

The complementizer is the same in all conditions. There were no significant effects in the *First-pass Reading Time* and in the *First-pass Total Reading Time*. At the complementizer */ke/*, adding the interaction of Clause type and Restrictiveness did not improve the model for the other measures (RPD: $\chi2(1) = 0.003$, $p = .95$; TRT: $\chi2(1) = 3.24$, $p = .071$). The marginal $R^2$ for the optimal models was 0.019 for RPD and 0.020 for TRT.

For the *Regression Path Duration*, there was a significant effect of Restrictiveness ($B = -0.155$, $SE = 0.066$, $t = -2.34$, $p = .02$), with longer reading time on restrictive relatives than on the non-restrictive relative clauses. For the *Total Reading Time,* the effect of Restrictiveness was significant ($B = 0.181$, $SE = 0.059$, $t = 3.09$, $p = .002$): in re-reading, the complementizer ke in restrictive relative clauses was read *faster* than in non-restrictive relative clauses.

In sum, the regression path duration shows longer reading times for complementizer Ke on the restrictive relative clause than on the non-restrictive relative clauses (see Fig. 3). In contrast, the total reading times show that re-reading times for complementizer Ke in the non-restrictive relative clauses were longer than in the restrictive relative clauses.

### 3.3. Embedded noun phrase

In Farsi, the position of the embedded noun phrase is fixed in both subject and object relative clauses, see examples (16 and 17). However, the embedded noun phrase in subject relative clauses (where it is the object) is marked by the object marker */rā/*.

16)

The babysitter| ke| **the child** rā |liked| a qualified nurse| was. (SR)

17)

The babysitter| ke | **the child** |liked| a qualified nurse| was. (OR)

There were no significant effects in the *First-pass Reading Time*. Adding the interaction of Clause type and Restrictiveness did not improve the model for the other measures (FPtot: $\chi2(1) = 0.87$, $p = .35$; RPD: $\chi2(1) = 0.56$, $p = .45$; TRT: $\chi2(1) = 1.25$, $p = .26$). The marginal $R^2$ for the optimal models was 0.035 for FPtot, 0.040 for RPD, 0.017 for TRT. For the *First-pass Total Reading Time*, the *Regression Path Duration,* and the *Total Reading Time* the pattern of results was the same. In the model without the interactions of Clause type and Restrictiveness, the effect of Clause Type was significant (FPtot: $B = -0.150$, $SE = 0.030$, $t = -5.04$, $p < .001$; RPD: $B = -0.166$, $SE = 0.036$, $t = -4.56$, $p < .001$; TRT: $B = -0.094$, $SE = 0.043$, $t = -2.20$, $p = .03$): Object relative clauses were read faster than subject relative clauses. The effect of Restrictiveness was also significant (FPtot: $B = 0.135$, $SE = 0.035$, $t = 3.88$, $p < .001$; RPD: $B = 0.179$, $SE = 0.041$, $t = 4.28$, $p < .001$; TRT: $B = 0.153$, $SE = 0.048$, $t = 3.19$, $p = .002$): non-restrictive relative clauses were read slower than restrictive relative clauses.

In sum, at the embedded noun phrases, reading times on the subject relative clauses were longer than the object relative clauses (see Fig. 4). This effect can be explained by the extra length of the region in subject relative clauses, because of the object marker following the NP.

### 3.4. Embedded verb phrase

The position of the embedded verb phrase in subject and object relatives is the same. It follows the embedded noun phrase and is positioned at the end of the relative clause. The verb phrases are in bold type in (18) and (19).

18)

The babysitter|ke|the child rā|**liked**|a qualified nurse|was. (SR)

19)

The babysitter|ke|the child|**liked**|a qualified nurse| was. (OR)

There were no effects in the First-pass Reading Time, the First-pass Total Reading Time, and in the regression path duration. For the Total Reading Time, adding the interaction of Clause type and Restrictiveness did not improve the model ($\chi2(1) = 1.19$, p = .28; marginal $R^2$ squared = 0.017). In the model without the interactions, there was a significant effect of Clause Type (B = 0.177, SE = 0.041, t = 4.29, p < .001): Object relative clauses were read slower than subject relative clauses.

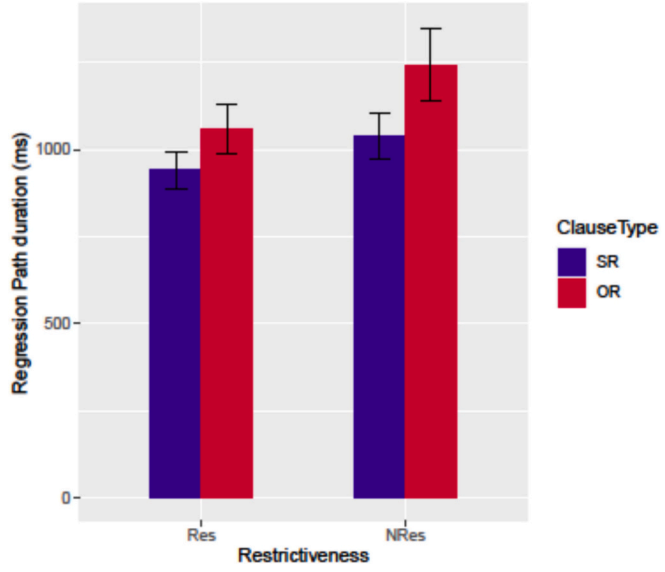


**Fig. 6.** Experiment 1 Mean and Standard Error for Regression Path Duration for Pre-matrix Verb Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

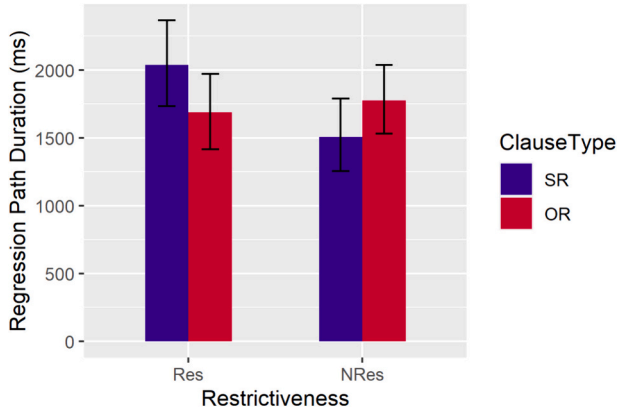


**Fig. 7.** Experiment 1 Mean and Standard Error for Regression Path Duration for Matrix Verb Region Split by Clause Type and Restrictiveness.
Note. Res = restrictive, NRes = non-restrictive, SR = subject relative clause, OR = object relative clause.

In sum, in the embedded verb phrases, reading times on the object relative clauses were longer than the subject relatives, but only when the participants re-read the verb after first reading the rest of the sentence (see Fig. 5).

### 3.5. Pre-matrix verb region

Since Farsi has an SOV word order, object, object marker, adjective and adverbs precede the main verb. Therefore, in our materials, the matrix verb does not follow the embedded verb phrase of the relative clause directly (20).

20)

The babysitter| ke | the child |liked| **a qualified nurse**| was.

There were no significant effects in the *first-pass Reading Time.* For the other measures, adding the interaction of Clause type and Restrictiveness did not improve the model for the measurements (FPtot: $\chi2(1) = 0.60, p = .44$; RPD: $\chi2(1) = 1.03, p = .31$; TRT: $\chi2(1) = 0.47, p = .49$). The marginal $R^2$ for the optimal models was 0.023 for RPD, 0.012 for TRT, and 0.012 for FPtot).

For the *First-pass Total Reading Time,* the Regression *Path Duration,* and the *Total Reading Time* there was a significant effect of Clause Type (TRT: $B = 0.088$, $SE = 0.024$, $t = 3.69$, $p < .001$; RPD: $B = 0.118$, $SE = 0.030$, $t = 3.99$, $p < .001$; TRT: $B = 0.127$, $SE = 0.05$, $t = 1.98$, $p = .05$), with longer reading time in the object relative conditions than in the subject relative conditions. For the *Regression Path duration*, there was also a significant effect of Restrictiveness ($B = 0.01$, $SE = 0.034$, $t = 2.888$, $p = .004$): Reading times in non-restrictive relative clauses were longer than in restrictive relative clauses.

In sum, the main finding was a significant effect of Clause Type, illustrating that the reading times in the object relative conditions were more prolonged than in the subject relative conditions. Only in the Regression Path Duration, there was also an effect of Restrictiveness: Reading times in non-restrictive relatives were longer than in restrictive relatives (see Fig. 6).

### 3.6. Matrix verb

The matrix verb is positioned at the end of the sentence. It could be a transitive, intransitive, or copula verb. The Matrix verb is illustrated in bold in (21). Note that for this region First-Pass total reading time and Total Reading Time are the same.

21)

The babysitter| ke | the child |liked| a qualified nurse| **was**.

For all four measures, adding the interaction of Clause type and Restrictiveness improved the model (FP: $\chi2(1) = 8.15, p = .004$; FPtot & TRT: $\chi2(1) = 7.48, p = .006$; RPD: $\chi2(1) = 10.02, p = .002$). The marginal $R^2$ for the optimal models was 0.0097 for FP, 0.019 for RPD, and 0.012 for FPtot & TRT). There was a significant effect of Clause Type in the restrictive conditions (FP: $B = -0.118$, $SE = 0.060$, $t = -1.96$, $p = .05$; FPtot & TRT: $B = -0.130$, $SE = 0.062$, $t = -2.10$, $p < .04$; RPD: $B = -0.230$, $SE = 0.102$, $t = -2.252$, $p = .02$): object relative clauses were read faster than subject relative clauses.

In subject relative clauses, there was an effect of Restrictiveness (FP: $B = -0.144$, $SE = 0.065$, $t = -2.22$, $p = .03$; FPtot & TRT: $B = -0.209$, $SE = 0.067$, $t = -3.10$, $p = .002$; RPD: $B = -0.392$, $SE = 0.105$, $t = -3.73$, $p < .001$): Non-restrictive relative clauses were read faster than restrictive relative clauses. There was a significant interaction of Clause Type and Restrictiveness (FP: $B = 0.257$, $SE = 0.090$, $t = 2.86$, $p = .004$; FPtot & TRT: $B = 0.257$, $SE = 0.094$, $t = 2.74$, $p = .006$; RPD: $B = 0.479$, $SE = 0.151$, $t = 3.17$, $p = .001$). In non-restrictive conditions, the reading times for the object relative clauses were longer than the reading times for the subject relative clauses (FP: $B = 0.140$, $SE = 0.060$, $t = 2.32$, $p = .02$; FPtot & TRT: $B = 0.128$, $SE = 0.063$, $t = 2.04$, $p = .04$; RPD: $B = 0.25$, $SE = 0.102$, $t = 2.43$, $p = .02$).

In sum, the interactions of Clause Type and Restrictiveness conditions for three reading time measurements were significant. They indicate that reading times of the matrix verb in non-restrictive relative clauses were longer in object relative clauses than in subject relatives. In contrast, in restrictive relative clauses, there were longer reading times in subject relative clauses than in object relative clauses (see Fig. 7).

## 4. Discussion

The present experiment aimed to investigate if there is any processing asymmetry between Farsi object and subject relative clauses and whether restrictiveness affects processing relative clauses by L1 Farsi speakers. To this end, with an eye-tracking method, we tested the effect of Clause Type and Restrictiveness in Farsi relative clauses. The expectation was that there would be a delay in reading Farsi object relative clauses of the type studied in the experiment, and especially in non-restrictive object relative clauses.

The results show that there is indeed a processing delay in object relative clauses compared to subject relative clauses, which is consistent with findings in many other languages and with Structural Distance Hypothesis (O'Grady et al., 2003), Perspective-shift(MacWhinney & Pleh, 1988), Word-order heuristics (Townsend et al., 2001), Canonical word order (MacDonald & Christiansen, 2002), Accessibility Hierarchy (Keenan & Comrie, 1977),and Similarity-based account (Gordon et al., 2006).

Research on the processing of English relative clauses (Staub, 2010; Staub et al., 2017) suggests that difficulties tend to emerge earlier, particularly within the embedded noun phrase, rather than at the verb within the relative clause. This study differs from previous research in that it found processing problems in later stages. The effect of processing difficulty in object relatives is revealed at the continuation of the main clause (pre-matrix verb) in first-pass total reading time, regression path duration, and total reading time. The effect is also found in re-reading times at the embedded verb phrase and the antecedent. Thus, the effect of Clause Type is comparable to the effect seen in many languages such as English, but it seems to appear later in this experiment.

The fact that the effect appears quite late on the object relative clauses may have to do with the fact that the relative clauses are unambiguously marked as subject or object relative clauses at the noun phrase region. The embedded noun phrase in the subject relative clauses elicited long first-pass total reading time, regression path duration, and total reading times, due to the presence of the object marker */rā/*. We might say that the presence or absence of an object marker is a cue that unambiguously guides the reader to the correct interpretation so that no difficulty or doubt is left to be solved in the next regions, which may facilitate processing of the syntactic structure of the relative clauses.

A notable syntactic difference between Farsi and English relative clauses is their respective word order. In English, the sequence of words is essential for differentiating subject relative clauses from object relative clauses. In contrast, Farsi relative clauses exhibit a uniform word order for both subject and object types, following the structure NP NP VP. Consequently, word order is not a distinguishing factor between subject and object relative clauses in Farsi. The differentiation is instead marked morphologically by the use of the object marker /rā/.

The restrictiveness marker and the complementizer /ke/ are the first cues that signpost the start of a relative clause in a sentence. Since readers do not encounter a relative pronoun in the Farsi relative clauses, they face a noun phrase after the complementizer /ke/ which unambiguously shows them the type of the relative clause. When readers encounter an embedded noun phrase accompanied by the object marker in a subject relative clause, they are prompted to infer a subject and a verb to complete the clause's meaning. Conversely, in an object relative clause, where the embedded noun phrase lacks the object marker, readers must establish both an object and a verb. Although both subject and object relative clauses require the construction of two syntactic projections, the presence of the object marker in the subject relative clause can facilitate a more rapid projection of the subject and verb. Consequently, projecting an object in object relative clauses may be

more time-consuming than projecting a subject in subject relative clauses.

The ease of projecting a subject in subject relative clauses is further enhanced by Farsi's pro-drop nature. In pro-drop languages like Farsi, subjects are often not explicitly stated because they are implied by verb conjugation. This means that the verb's inflection provides cues about the person, and number, allowing readers to easily infer the subject without needing it to be explicitly mentioned. This linguistic economy is particularly advantageous in subject relative clauses, where the subject's identity is often recoverable from the verb's inflectional ending.

For instance, in a Farsi sentence, the verb ending can indicate whether the subject is first, second, or third-person singular or plural. As a result, Farsi readers are accustomed to sentences that lack an overt subject pronoun, and their cognitive processing is tuned to extract the subject information from the verb's morphology. This proficiency in interpreting verb inflections for subject information means that when a subject relative clause is encountered, Farsi readers can quickly and efficiently identify the subject, even in its absence, leading to faster processing times compared to object relative clauses where such morphological cues are not as readily available for the object. This would be in line with a cue-based retrieval account.

The first region after the relative clause, the pre-matrix verb region, includes an object of the matrix sentence, an object marker and an adverb, adjective, preposition, or object of a preposition, which are located before the matrix verb. There were significantly longer reading times in object relative clauses in the pre-matrix verb region. In sentences with object relative clauses, the subject of the matrix sentence is different from the subject of the relative clause. There has been a shift from the subject of the matrix sentence to another subject in the relative clause. This shift back to the subject of the matrix sentence may explain the delay in reading times at the continuation of the matrix clause and in re-reading the previous regions (cf. MacWhinney and Pleh's (1988) perspective shift theory). Consequently, in Farsi, there is a preference for subject relative clauses, but the time course differs from what has been reported for English.

The second main question in this study was whether restrictiveness plays a role in the processing of Farsi relative clauses. We hypothesized that Farsi speakers may process restrictive relative clauses differently from non-restrictive relatives because there is a clear distinction between the two, which is signalled through an enclitic morpheme /−i/ attached to the antecedent. In the experiment, non-restrictive relative clauses were read slower than restrictive relative clauses at the embedded verb phrase, the pre-matrix region, and the matrix verb. This difference in reading times is consistent with their frequency distribution in a Farsi corpus (Seifi, 2021): non-restrictive relative clauses are much less frequent than restrictive relative clauses. Thus, the restrictive relative clause preference might be in line with the general notion of MacDonald and Christiansen's (2002) frequency-based approach which indicates that frequent structures are processed more easily.

Apart from the general effect of restrictiveness, this experiment reveals that in Farsi object relative clauses are particularly difficult in non-restrictive relative clauses. For non-restrictive relative clauses, the pattern aligns with findings in many other languages: object relative clauses exhibit a pronounced processing delay when compared to subject relative clauses. However, the distinction in processing times between subject and object relative clauses within restrictive relative clauses is less pronounced. Notably, at the conclusion of the relative clause sentences - specifically at the matrix verbs - an interaction between Clause Type and Restrictiveness emerges, presenting an intriguing pattern: a preference for subject relative clauses in the non-restrictive condition and a preference for object relative clauses in the restrictive condition.

The question is whether the interaction of Clause type and Restrictiveness at the end of restrictive and non-restrictive relative clauses is an effect that originates from the previous region, a spillover effect, or it is from the wrap-up process at the end of the matrix sentence. There is no interaction in the restrictive object relative clauses at the pre-matrix verb region but there is a significant effect of Clause Type and Restrictiveness for the regression-path duration, which indicates a processing difficulty in non-restrictive object relatives. Therefore, we may conclude that the interaction of Clause type and Restrictiveness is a spillover effect from the processing difficulty at the pre-matrix verb region. The interaction of Clause Type and Restrictiveness at the end of the restrictive subject relative clauses on the matrix verb may be reflected in a wrap-up effect at the end of the sentence, which might illustrate the fact that the readers make regressions to recall or confirm their processing decisions made in an earlier stage.

The interaction at the matrix verb may be related to the fact that restrictive object relative clauses can be used to connect an antecedent that is new to the discourse, to a given referent, the noun in the relative clause (e.g., Fox & Thompson, 1990). A restrictive relative clause thus would link this new information to presupposed information, which may be more likely to be presented as the subject of the relative clause, resulting in an object relative clause. This is in line with the results of the corpus study by Seifi (2021), in which object relatives are more common in restrictive relative clauses (39.34 %) than in non-restrictive relative clauses (18.33 %).

If the antecedent does not have the clitic /−i/, as in example (22), the antecedent 'the neighbour' may be interpreted as given and 'the old man' as new information. Therefore, it is less likely that 'the old man' is the subject in the relative clause, as is the case in the object relative clause in (22). That would explain the stronger preference for subject relative clauses in non-restrictive relative clauses.

22)

(Non-restrictive object relative clause)

همسایه که پیرمرد لوداد خانه اش را به سرعت ترک کرد.

hamsāye ke pirmard lodād

neighbour COMP old man betray-PST.3SG

xāneaş rā besorat tark kard.

home-enclitic.3SG OM quickly leaving do-PST.3SG.

'The neighbour, whom the old man betrayed, left his home quickly.'

In restrictive relative clauses, the antecedent (‘*the neighbour*’ in example 23) is presented as new information, by virtue of the clitic /−i/. This makes it more likely that ‘*the old man*’ is given, and hence gets the subject role in the relative clause. Therefore, given that the antecedent is new, an object relative clause fits well because the new referent expressed by the antecedent is made accessible by the relative clause.

23)

(Restrictive object relative clause)

همسایه ای که پیرمرد لوداد خانه اش را به سرعت ترک کرد.

hamsāye-i ke pir mard lodād

neighbour-RES COMP old man betray-PST.3SG

xāneaş rā besorat tark kard.

home-enclitic.3SG OM quickly leaving do-PST.3SG.

‘The neighbour that the old man betrayed left his home quickly.’

Earlier in the discussion, we hypothesized that projecting a subject (in subject relative clauses) is easier than projecting an object (in object relative clauses). One mechanism related to this is the use of resumptive pronouns. In Farsi relative clauses, the referent of the antecedent of the relative clause can be repeated in the relative clause with a pronoun. In line with the literature that claims that resumptive pronouns are optional in Farsi (Taghvaipour, 2005), we did not use resumptive pronouns in the stimulus sentences. However, some of the participants remarked that the lack of a pronoun in the object relative clauses made them look unnatural. Seifi (2021) showed that the usage of resumptive pronouns increases as the frequency of a relative clause type decreases in the Farsi corpus: Only 4.54 % of restrictive object relative clauses (5 out of 110) contained a resumptive pronoun, versus 38.46 % of non-restrictive relative clauses (5 out of 13). It might be helpful to scrutinize whether adding a resumptive pronoun in object relative clauses as the ones used in the present experiment, indeed increases the processing ease of the object relative clauses used in the stimuli of the present experiment or not.

## 5. Conclusion

We found the conventional penalty associated with object relative clauses in the online relative clause processing experiment by native Farsi speakers. However, two important considerations must be taken into account. Firstly, the increased difficulty in processing object relative clauses manifested significantly later, specifically in the region preceding the matrix verb. Second, because of the presence of an object marker beside the noun phrase in the subject relative clauses, we could not combine the embedded noun phrase and verb phrase regions. Adding a resumptive pronoun and object marker to an object relative clause increases the length of the relative clause; therefore, it is necessary to test the online processing of these relative clause types with a non-reading task. To investigate how processing Farsi relative clauses with or without a resumptive pronoun unfolds in real-time, the Event-Related Potentials (ERP) method might be interesting. ERP will make the comparison of noun phrases with or without an object marker possible.

Finally, it may be concluded that the asymmetry in the processing of the Farsi object and subject relative clauses especially on non-restrictive types mirrored the patterns of distributions which the Farsi corpus analysis revealed. In Farsi, the readers rely on morphological cues to disambiguate the sentence reliably. Restrictiveness has a significant role in this processing asymmetry.

## CRediT authorship contribution statement

**Pouran Seifi:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Hanneke Loerts:** Writing – review & editing, Supervision. **Pim Mak:** Writing – review & editing, Supervision, Resources, Formal analysis.

## Declaration of competing interest

This is to state that neither author has a conflict of interest.

## Data availability

I have submitted the data and script to Mendeley Data repository.

Eye movements data for The effects of restrictiveness on relative clause processing in Farsi by L1 speakers (Original data) (Mendeley Data)

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