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# Comprehension of Turkish Relative Clauses: Evidence from Eye-tracking and Corpus Analysis

**Talat Bulut[1], Emine Yarar[2], H. Wu[3]**

**Abstract**

**Purpose:** Previous studies in English revealed that it is easier to comprehend subject relative clauses (SRCs) compared to object relative clauses (ORCs). However, subsequent research into processing of relative clauses in typologically different languages produced conflicting results. The present study aimed to investigate relative clause processing in Turkish and to test the predictions of the accounts of relative clause processing. **Method:** Thirty-six Turkish adult monolinguals took part in an eye-tracking experiment. Eye movements of the participants were recorded while they read Turkish sentences with subject and object relative clauses. **Results:** Analyses of both comprehension scores and eye-movement measures indicated a disadvantage in processing Turkish ORCs as revealed by more comprehension errors and elevated total reading times as well as more regressions. Furthermore, a corpus analysis conducted using a balanced corpus of Turkish revealed that SRCs are more frequent than ORCs in Turkish. **Conclusion:** The results are discussed with respect to the predictions of the relative clause processing accounts. It is suggested that a combination of factors including syntactic structure, structural frequency and morphological information shapes and constrains processing patterns of relative clauses.

**Keywords:** Turkish, relative clause processing, eye-tracking, corpus analysis, syntax, frequency, morphology

**Türkçe İlgi Tümceciklerinin Anlaşılması: Göz İzleme ve Derlem Çalışması**

**Türkçe Özet**

**Amaç:** Önceki çalışmalarda İngilizce özne ilgi tümceciklerinin (xÖİT) nesne ilgi tümceciklerine (NİT) kıyasla daha kolay bir şekilde anlaşıldığı gösterilmiştir. ÖİT ve NİT arasındaki bu bakışımsızlığı açıklamak amacıyla çeşitli varsayımlar ortaya atılmıştır. Çizgisel Uzaklık Varsayımı, boşluk-dolgu gibi bağımlılıklar arasındaki çizgisel uzaklığın (araya giren sözcük sayısının) bu yapıların işlemlenme hızını etkilediğini iddia etmektedir.

[1] Corresponding Author, İstanbul Medipol University, Faculty of Health Science Department of Speech and Language Therapy, Turkey, tbulut@medipol.edu.tr
[2] Department of English Linguistics, Hacettepe University, Turkey, yarar@hacettepe.edu.tr
[3] Institute of Cognitive Neuroscience, National Central University, Taiwan, denisewu@cc.ncu.edu.tw

Yapısal Uzaklık Varsayımına göre ise bu tür bağımlılıkların işlemlenmesindeki belirleyici faktör, boşluğun sözdizim ağacının ne kadar derinlerinde yer aldığı, yani boşluk ile dolgu arasında ne kadar budak olduğudur. Tümce işlemleme desenlerini etkilediği öne sürülen bir diğer etken ise ilgili yapıların sıklığıdır. Sıklığı temel alan yaklaşımlara göre bir dilde sıkça kullanılan yapılar, daha az kullanılan yapılara göre daha kolay bir şekilde işlemlenmektedir. Bu üç farklı varsayım İngilizce gibi baş-ilk dillerde aynı öngörüde bulunarak ÖİT'nin NİT'ye göre daha kolay bir şekilde işlemleneceğini öne sürmektedir. Türkçe gibi baş-son dillerde ise çizgisel ve yapısal uzaklığın öngörüleri farklılaşmakta, Çizgisel Uzaklık Varsayımına göre NİT'nin, Yapısal Uzaklık Varsayımına göre ise ÖİT'nin daha kolay işlemleneceği beklenmektedir. Türkçede daha önce dengeli bir derlem kullanılarak ÖİT ve NİT'ye ilişkin sıklık bilgileri incelenmemiş olup, mevcut çalışma kapsamında dengeli bir derlem kullanılarak bu yapıların sıklığı belirlenecek, böylelikle yapısal sıklığı temel alan yaklaşımların bakışımsızlığın yönüne ilişkin öngörüsü tespit edilecektir. Çalışmanın amacı yukarıda bahsedilen tümce işlemleme kuramlarının Türkçe ilgi tümceciklerinin işlemleme sürecine ilişkin olarak ortaya koyduğu hipotezlerin test edilmesidir. **Yöntem:** Çalışma kapsamında bir göz izleme deneyi gerçekleştirilmiş, anadili Türkçe olan otuz altı tek dilli yetişkin deneye katılmıştır. Katılımcılar ÖİT ve NİT içeren tümceler okurken göz izleme cihazı ile göz hareketleri kaydı alınmıştır. Deney tümceleri içerisinde ilgi alanları şu şekilde belirlenmiştir: ilgi tümceciği içerisindeki ad ve eylem, baş sözcük, taşma alanı ve ana tümcenin eylemi. Her bir ilgi alanı üzerinde katılımcıların sergilediği ilk sabitleme süreleri, toplam okuma süreleri ve geriye dönüşler (regresyonlar) analiz edilmiştir. Göz izleme çalışmasına ek olarak sırasıyla ÖİT ve NİT belirten *-(y)An* ve *-DIK+iyelik* biçimbirimlerinin sıklıkları, Türkçe Ulusal Derlemi kullanılarak tespit edilmiştir. **Bulgular:** ÖİT içeren tümcelere kıyasla NİT içeren tümcelerde daha fazla anlama hataları yapılmış, katılımcılar NİT içeren tümcelerde daha fazla toplam okuma süreleri ve geriye dönüşler sergilemiştir. Dolayısıyla hem anlaşılma oranları hem de göz hareketleri bakımından NİT yapılarının ÖİT yapılarına göre daha fazla işlemleme güçlüğünü beraberinde getirdiği saptanmıştır. Bu farklılık baş sözcüğün hemen ardından gelen taşma alanında görülmüştür. Derlem incelemesi neticesinde ise Türkçede *-(y)An* biçimbirimi ile kurulan ÖİT yapılarının *-DIK+iyelik* biçimbirimleriyle kurulan NİT yapılarına göre daha sık kullanıldığı saptanmıştır. **Sonuç:** Çalışmadan elde edilen bulgular, İngilizce gibi baş-ilk dillerde elde edilen sonuçlara benzer olarak baş-son Türkçede ÖİT'nin, NİT'ye göre daha kolay işlemlendiğini göstermiştir. Bu sonuç, sözdizimsel yapıyı temel alan Yapısal Uzaklık Varsayımının öngörüleriyle örtüşmekte, Çizgisel Uzaklık Varsayımının tahminleriyle uyuşmamaktadır. Bununla birlikte elde edilen bulgular yapısal sıklığı temel alan yaklaşımların öngörüleri ile de tutarlı görünmektedir. Genel olarak bakıldığında çalışmadan elde edilen bulgular birçok dilde gözlenen ÖİT ve NİT bakışımsızlığını

desteklemektedir. Çalışma neticesinde sözdizimsel yapı, yapısal sıklık ve morfolojik bilgiler dahil olmak üzere bir dizi faktörün, ilgi tümceciklerinin işlemlenme desenini şekillendirdiği ve sınırlandırdığı sonucuna varılmıştır.

**Anahtar sözcükler:** Türkçe, ilgi tümceciklerinin işlemlenmesi, göz izleme, derlem incelemesi, sözdizim, sıklık, morfoloji

## Introduction

Information about the properties of language comprehension can be gathered by having people read challenging sentences. These challenging sentences disrupt the normal reading process, allowing researchers to examine specific aspects involved. Two types of challenging sentences have been frequently used in psycholinguistic experiments: sentences with structural ambiguities and syntactic complexities (Gordon, Hendrick & Johnson, 2004). Ambiguities such as the famous reduced relative clauses of Bever (1970), exemplified in (1), have provided insights into the qualities of the human parser.

1. The horse raced past the barn fell.

In (1), the embedded verb *raced* is initially analyzed as the main verb, which must be reanalyzed as a reduced relative when the real main verb *fell* is reached, hence causing temporal ambiguity. In such sentences, one is led to a garden-path which turns out to be mistaken.

The notion of complexity has been invoked in studies on long-distance dependencies. These structures pose processing difficulties because they involve keeping elements of a sentence in memory for extended time and/or because they presumably involve syntactic movement. An example of a long-distance dependency is found in relative clause constructions such as (2) below:

2. The scientist$_i$ who $e_i$ praised the author smiled.

The sentence above contains a subject relative clause, with the gap (*e*) occupying the subject position in the relative clause. In (2), the head noun of the relative clause (*the scientist*$_i$) needs to be integrated with the gap position in order to determine the arguments of the verb and correctly map the thematic roles. The sentence below (3) exemplifies an object relative clause, where the gap is in the object position within the relative clause.

3. The scientist$_i$ who the author praised $e_i$ smiled.

Psycholinguistic interest in relative clauses stems from several reasons. Firstly, relative clauses were used to test the psychological reality of traces and gaps (Bever & McElree, 1988; Pickering & Traxler, 2001), such as $e_i$ in (2) and (3) above. Secondly, the extracted element (*scientist* in (2) and (3)) must be carried unattached while processing the intervening material (Traxler, Morris & Seely, 2002), which provides insights into the role of verbal working memory in language processing (Just & Carpenter, 1992; King & Just, 1991). This line of research generally found that subject relative clauses (SRCs) are processed more easily than object relative clauses (ORCs) (Martin, 2003). This finding was reported for processing of English relative clauses by L1 (King & Just, 1991; King & Kutas, 1995; Pickering, 1994; Traxler et al., 2002) and L2 speakers of English (Bulut, Uysal & Wu, 2016; Izumi, 2003). This SRC processing advantage was revealed in other Indo-European languages, as well, including Dutch (Frazier, 1987; Mak, Vonk & Schriefers, 2002, 2006), French (Cohen & Mehler, 1996; Frauenfelder, Segui & Mehler, 1980; Holmes & O'Regan, 1981), German (Mecklinger, Schriefers, Steinhauer & Friederici, 1995; Schriefers, Friederici & Kühn, 1995) and Spanish (Betancort, Carreiras & Sturt, 2009).

To test the universality of the SRC advantage cross-linguistically, some studies were carried out in typologically different languages such as Chinese (Hsiao & Gibson, 2003; Lin & Bever, 2006; Lin & Garnsey, 2011), Japanese (Ishizuka, 2005; Ueno & Garnsey, 2008), Korean (Kwon, Gordon, Lee, Kluender & Polinsky, 2010; Kwon, Polinsky & Kluender, 2006), and Basque (Carreiras, Duñabeitia, Vergara, Cruz-Pavı´a & Laka, 2010). However, the results of these studies were inconsistent. Some of the studies confirmed the SRC advantage (Kwon et al., 2006; Kwon et al., 2010; Lin & Bever, 2006), while some others reported an ORC advantage (Carreiras et al., 2010; Chen, Ning, Bi, & Dunlap, 2008, Hsiao & Gibson, 2003). Therefore, it is not clear to what extent the universality of the SRC processing advantage holds across languages of the world. To shed light on this question, recent studies

investigated relative clause (RC) processing in Chinese by utilizing different methods including event-related potentials (ERPs) (Bulut, Cheng, Xu, Hung & Wu, 2018; Sun et al., 2016; Wang, Yue, Li & Li, 2017), self-paced reading/listening (Cheng, Wu & Huang, 2018; Xu, Duann, Hung & Wu 2019) and eye-tracking (Mansbridge, Tamaoka, Xiong & Verdonschot, 2017; Sung, Cha, Tu, Wu & Lin, 2016; Sung, Tu, Cha & Wu, 2016). The weight of the evidence from these recent studies suggests either ORC processing advantage for Chinese or variable processing patterns depending on the sentence segment, contrary to the overwhelming evidence for SRC preference in English. These findings from Chinese cast doubt on the universal claims of certain relative clause processing accounts, which are reviewed below. The present study aims to further test the predictions of the relative clause processing accounts in Turkish, which is also a head-final language with pre-nominal relative clauses, and hence offers a further test of processing asymmetry in RCs in a language typologically different from English.

**Accounts of Relative Clause Processing**

The following section provides a summary of the major theories which attempt to explain the processing asymmetry commonly observed between SRCs and ORCs.

***Memory-Based Accounts***

These accounts claim that sentence processing is limited by working memory capacity. For this reason, elements in a sentence that occupy working memory space lead to processing difficulties. A typical example of the memory-based accounts is Gibson's Dependency Locality Theory (DLT; Gibson, 1998, 2000). DLT proposes two metrics which can account for sentence processing dynamics: storage resources and integration resources. Another major account which highlights the role of working memory in sentence processing is similarity-based interference. The two metrics of DLT and the similarity-based interference account are outlined below.

*Storage Resources*

According to this metric, incomplete head-dependencies need to be tracked for successful processing of a sentence (Hsiao & Gibson, 2003). It is argued that the higher number of temporarily incomplete dependencies in ORCs compared to SRCs underlies the ORC difficulty in English. To illustrate, when the SRC in (2) and ORC in (3) above are compared, it is seen that at the location where the two RCs start to differ (*praised* and *the*), the number of incomplete dependencies varies between the RCs. Specifically, after the part of the SRC "The scientist who praised" is read, only two heads are required: a noun as the object of the relative clause and a verb for the matrix sentence. On the other hand, after the part of the ORC "The scientist who the" is read, four syntactic heads are needed: a noun for the determiner "the", a verb for the relative clause, a verb for the matrix sentence, and an empty category associated with the filler "who" (the last one of which is a controversial linguistic postulate, but even if it is discarded, the number of incomplete dependencies is greater for English ORCs than SRCs). Hence, the difficulty of processing ORCs can be explained with reference to the storage of greater number of incomplete head-dependencies required for parsing of sentences.

*Integration Resources*

Whereas the storage resources metric is based on the number of incomplete dependencies kept in working memory, integration resources are associated with the process of connecting an incoming word to its dependent in the current syntactic structure (Gibson, 1998, 2000). Integration cost is estimated by calculating the distance of the dependency (Hsiao & Gibson, 2003). For example, in the SRC in (2), the wh-filler *who* and the verb *praised* are connected locally in the absence of any intervening material. On the other hand, in the ORC in (3), the noun phrase (NP) *the author* intervenes between the wh-filler and the relative clause verb, which leads to a more distant dependency. The integration resources

metric has also been conceptualized as the Linear Distance Hypothesis (LDH) (Carreiras et al., 2010) owing to its focus on the linear, rather than structural, distance between dependencies, drawing a contrast with the Structural Distance Hypothesis summarized below.

*Similarity-Based Interference*

According to this account, the effect of working memory on processing dependencies is quantified in terms of the similarity of the items held in memory (Gordon, Hendrick, & Johnson, 2001; Lewis & Vasishth, 2005; Van Dyke & McElree, 2006). For example, Gordon et al. (2001) found that when a pronoun (e.g., *you*) or a name (e.g., *Joe*) replaced the relative clause NP (such as *the author* in 2 and 3), the difference between SRCs and ORCs was reduced or eliminated altogether. It is claimed that interference is reduced when the two referents in relative clauses come from different categories so that the cues associated with them do not interfere with each other. This interference effect might emerge whilst encoding, storing or retrieving NPs. In a self-paced reading paradigm accompanied by a memory task involving recall of words, Van Dyke & McElree (2006) found processing difficulty on the matrix verb when the recalled words could plausibly act as objects, thus causing retrieval interference. For instance, the sentence "It was the boat that the guy who lived by the sea sailed/fixed in two sunny days." revealed longer RTs on the underlined matrix verb *fixed* compared to *sailed* when the participants had to remember three words (table-sink-truck) that could serve as semantic objects for the verb *fixed* but not for *sailed*. This finding was taken to support retrieval interference since the matrix verb (*fixed/sailed*) is the region where the correct referent (*the boat*) is to be retrieved from memory and thus the dependency is to be established.

***Frequency-Based Accounts***

It was shown through corpus studies and psycholinguistic research that frequency of linguistic structures affects processing dynamics (Reali & Christiansen, 2007). To put it

simply, frequency-based accounts claim that the more frequent a particular structure is in a given language, the easier it will be processed. In some theories adopting this approach, frequency has been conceptualized as experience and surprisal (Hale, 2001; Levy, 2008) and entropy (Hale, 2003). In parallel with these conceptualizations, constraint-based approaches propose that alternative structural interpretations of a sentence being processed are partially activated depending on frequency, plausibility and other constraints (Gennari & MacDonald, 2008; MacDonald, 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Reali & Christiansen, 2007). Thus, such approaches emphasize statistical regularities as a factor affecting real-time processing dynamics and argue that syntactic and semantic structures are continuously activated in parallel. As a result, comprehension difficulty emerges from the competition between partially activated alternative structures. The activation level of each construction is determined by the linguistic experience of the listeners/readers, with more frequently occurring structures receiving higher activation than less frequent ones. Thus, it is claimed that RC processing, just as any component of language processing, is affected by the frequency of relevant structures as well as their semantic plausibility.

***Structural Accounts***

Certain researchers propose a uniform underlying syntactic structure across languages and, accordingly, they assert universal processing dynamics in certain aspects of sentence processing. The Structural Distance Hypothesis (SDH, O'Grady, Lee, & Choo, 2003) is a prominent example for the structural accounts. According to this approach, structural distance corresponds to the number of syntactic nodes/projections in the syntactic structure intervening between the head noun and the gap. In SRCs, as in (4a) below, the gap position *e* from which the head noun is extracted is within the inflection phrase (IP). In ORCs, as in (4b) below, on the other hand, the gap is embedded in the verb phrase (VP), which is deeper than the IP in the syntactic structure. This hierarchy of subject and object positions is assumed by almost all

theories of syntax (O'Grady et al., 2003). In particular, more syntactic nodes intervene between the gap and the head in ORCs than in SRCs (Collins, 1994). For this reason, SDH claims that ORCs are associated with more processing difficulty than SRCs.

4a. The $boy_i$ [CP $that_i$ [IP $e_i$ saw the girl]]

4b. The $boy_i$ [CP $that_i$ [IP the girl [VP saw $e_i$]]]

[CP: Complementizer phrase; IP: Inflectional phrase; VP: Verb phrase]

Structural distance is always greater in ORCs than in SRCs, as syntactically objects are embedded deeper than subjects, and this holds true for both head-initial and head-final languages (Carreiras et al., 2010). Therefore, SDH predicts an SRC advantage in any language.

**Relative Clauses in Turkish**

In Turkish, a head-final language, relative clauses typically precede their heads and, thus, are pre-nominal, as shown in (5) below. Turkish relative clauses do not include any overt relative pronouns. Instead, relative clause (RC) participles, namely, *-(y)An* and *-DIK*, which are suffixed to the verb, mark subject and object relatives, respectively (Hankamer & Knecht, 1976; Kornfilt, 1997; Underhill, 1972). In most typical Turkish RCs, the verb is nonfinite, with the verb not inflected for tense and aspect (Göksel & Kerslake, 2005).

5a. Turkish subject relative clause:

[CP $e_i$ [VP Kız-ı gör-en]] çocuk$_i$ git-ti.

$e_i$ girl-ACC see-SRC boy-NOM$_i$ go-PAST.3sg

"The boy who saw the girl went."

5b. Turkish object relative clause:

[CP Kız-ın [VP $e_i$ gör-düğ-ü]] çocuk$_i$ git-ti.

girl-GEN $e_i$ see-ORC-3sg.POSS boy-NOM$_i$ go-PAST.3sg

"The boy who the girl saw went."

The RC participles *-(y)An* and *-DIK* follow the rules of Turkish vowel harmony. That is, the vowels written in uppercase change depending on the context of sounds in which they appear. The consonants in *-DIK* also change based on voicing alternations in Turkish (Göksel & Kerslake, 2005). ORCs with *-DIK* have the structure of a genitive-possessive construction, hence the subject takes the genitive marking and the participle takes the possessive case (Göksel & Kerslake, 2005; Özsoy, 1994). In a sentence context, on the other hand, subjects are marked with the nominative case. In Turkish, accusative case on NPs marks direct objects.

**Predictions of Theories for Turkish Relative Clause Processing**

For languages like English, the predictions of all theories of RC processing mentioned above are the same: ORCs should be processed with more difficulty than SRCs. This is because in terms of storage (indicated by incomplete syntactic dependencies), integration (indexed by greater filler-gap distance) and frequency (revealed by corpus analysis), SRCs are advantaged compared to ORCs in head initial languages such as English with post-nominal relatives. As for structural accounts, they all predict an SRC advantage across all languages, as mentioned above. However, in languages with pre-nominal relative clauses such as Turkish, Korean and Chinese, although ORCs are associated with deeper syntactic structure than SRCs, they do not necessarily exhibit more distant filler-gap dependencies than SRCs, which renders these languages useful to tease apart the predictions of RC processing theories.

The predictions of the theories that aim to account for relative clause processing dynamics differ somewhat for Turkish. As explained above, the storage resources account quantifies processing difficulty in terms of the number of incomplete head-dependencies. When the reader encounters the first word *girl-ACC*, which is marked for an object function, in SRC in (5a) above, two syntactic heads are predicted: a matrix verb and a subject. Although the canonical word order in Turkish is SOV, it is common to drop subject pronouns

or to scramble the subject to another location in the sentence for pragmatic reasons (Göksel & Kerslake, 2005). When the next word *see-SRC* in (5a) is encountered, however, the reader realizes that a relative clause is being read due to the subject relativizing particle *-(y)An* suffixed to the verb. Therefore, two syntactic heads are required: a noun as the subject for the RC verb and a verb for the matrix sentence. Finally, at the third word in (5a), which is the head noun of the RC, only one syntactic head is required: a matrix verb. The number of syntactic heads predicted for the ORC in (5b) is the same as that predicted for the SRC. At the first word *girl-GEN*, two syntactic heads are predicted: a noun complement that completes the genitive-possessive construction (such as *girl-GEN book-POSS*: the girl's book) and a matrix verb. When the second word *see-ORC-3sg.POSS*, which signals RC reading, in (5b) is encountered, again two heads are predicted: a noun serving as the object of the RC and a matrix verb. Finally, only a matrix verb is predicted on the third word. Therefore, the storage resources account predicts equal cost of processing while reading SRCs and ORCs in Turkish, unlike its prediction of an SRC advantage for English.

As for the integration resources account, or LDH, in which processing difficulty is parallel to the distance between dependencies, an ORC advantage is predicted for Turkish. This is because in (5) above, the filler *boy-NOM*$_i$ has to be connected to its gap $e_i$ in the relative clause, where it is assigned its grammatical position (see Carreiras et al. (2010) for a discussion of filler-gap configurations in head-final and head-initial languages). According to LDH or the integration account, the number of intervening words between the filler and the gap in the relative clause is the determining factor of processing difficulty. Therefore, in ORC (5b) above, there is no intervening discourse referent and only a single word (*see-ORC-3sg.POSS*) between the filler (*boy-NOM*$_i$) and its gap ($e_i$) in the relative clause, whereas in SRC (5a), there is one discourse referent (*girl-ACC*), or two words (*girl-ACC* and *see-SRC*), which intervene and thus cause the processing difficulty.

Similarity-based interference account, as discussed, capitalizes on interference caused by cue similarity of referents that need to be held in working memory while establishing dependencies. Since the present study did not attempt to specifically test predictions of this account, the experimental items only include two descriptive noun phrases (e.g., *engineer* and *plumber* in Table 1) in SRCs and ORCs. Therefore, similarity-based interference would be predicted to occur in both SRCs and ORCs due to the same type of referents used. Future research with different referent configurations is needed to test this account in more detail. Certain implications of the present findings for the similarity-based interference account are addressed in the Discussion section in terms of retrieval cues.

Structural accounts, on the other hand, always predict an ORC disadvantage due to the greater hierarchical depth of object positions in sentence structure compared to SRCs (note that in (5) above, the extraction site – i.e., position of the gap $e_i$ – is immediately within CP in the SRC, but it is deeper inside VP in the ORC); hence more processing cost is predicted for ORC in Turkish, as well.

In terms of frequency, structural frequency of SRCs and ORCs has been rarely investigated in Turkish. An exception is Slobin (1982), who collected recordings of parent-child interaction and thus generated a small-scale corpus of Turkish language spoken by children and adults. He found SRCs to be more frequently produced by Turkish children and adults. Due to the lack of systematic corpus studies in Turkish making use of balanced corpora, the present study reports a corpus study investigating relative structural frequency of SRCs and ORCs in Turkish. If, as Slobin (1982) reports, SRCs are found to be more frequent than ORCs, this will mean that frequency-based accounts predict SRC processing advantage.

**Previous Studies in Turkish**

Psycholinguistic studies on Turkish RCs have focused mainly on first language acquisition. The general finding in this line of research is that SRCs in Turkish are acquired

by children at an earlier age than ORCs (Hermon, Öztürk, & Kornfilt, 2007; Kükürt, 2004; Özcan, 1997; Özge, Marinis, & Zeyrek, 2009; Slobin, 1982; cf. Ekmekçi, 1990). Language processing by Turkish-speaking children and adults has also been investigated in recent studies (Aydın & Zagvozdkina, 2019; Boran, 2018; Kahraman, 2015; Kahraman, Sato, Ono & Sakai, 2010; Özge, Marinis & Zeyrek, 2015; Turan, 2018). The self-paced reading studies conducted by Kahraman and colleagues found longer reading times for ORCs than SRCs in the relative clause region (on the RC verb (Kahraman et al., 2010) or the spillover region of the RC verb (Kahraman, 2015)) with and without a disambiguating prior context. Similarly, two eye-tracking studies attributed a higher processing cost to ORCs than SRCs in Turkish (Aydın & Zagvozdkina, 2019; Turan, 2018). Another eye-tracking study, on the other hand, revealed significantly lower comprehension scores for Turkish ORCs than SRCs in the absence of any significant differences between the RC types in terms of eye-movement measures (Boran, 2018). These findings are generally compatible with the predictions of SDH, as outlined above. On the other hand, the self-paced listening study carried out by Özge et al. (2015) revealed processing difficulty with both SRCs and ORCs depending on the sentence segment in both children (aged 5-8) and adults. These findings were interpreted by the authors as evidence for incremental processing of morphosyntactic cues in a given structure, according to which the parser builds expectations regarding the rest of the sentence. Hence, these findings support an expectation-based approach to sentence processing, which can be conceptualized within the scope of the frequency-based accounts reviewed above.

Despite the previous psycholinguistic research into Turkish RCs, the on-line processing patterns have not been adequately explored. Moreover, with the exception of a few studies, psycholinguistic studies on Turkish RCs up to now have generally used off-line methods such as acting out, imitation, and sentence-picture matching. Furthermore, a great majority of the previous studies on processing RCs were conducted in English and other

typologically similar languages. Therefore, in this field of research there is a lack of cross-linguistic studies conducted in typologically different languages. Recent studies in Chinese, a head-final language, (Bulut et al., 2018; Xu et al., 2019) revealed an ORC processing advantage, conflicting with the majority of findings in English and demonstrating the significance of cross-linguistic research. As highlighted above, Turkish exhibits different linguistic properties from English, too, in terms of position of dependencies and morphology. These differences might reveal cross-linguistically distinct preferences or strategies of processing. Against this background, the present study employed the eye-tracking methodology to obtain on-line measurements of the processing of Turkish SRCs and ORCs by native readers. The eye-tracking experiment was preceded by a corpus analysis in order to obtain a frequency profile of Turkish SRCs and ORCs. The findings are discussed with reference to the theories of sentence processing.

## Method

### Corpus Analysis

In order to investigate the relative frequency of SRCs and ORCs in modern Turkish, we performed a corpus analysis using the Turkish National Corpus (TNC) (Aksan et al., 2012). TNC is a balanced corpus which has a size of 50.7 million words across various domains of language use with 2% of spoken data. For the analysis, the SRC and ORC particles were searched in the entire corpus consisting of both written and spoken data. As pointed out above, the SRC particle attached to the verb is *-(y)An* and the ORC particle is *-DIK*, which is followed by a possessive morpheme. The possessive morpheme agrees with the subject of the relative clause. Although the materials of the present study included only third person singular subjects of relative clauses and, hence, the possessive morpheme on the ORC verbs agreeing with the third person singular subject, all possible forms of possessive constructions (first person singular and plural, second person singular and plural, third person

singular and plural) were searched to compare SRC and ORC generally. It was found that there were 644,307 instances of SRC particles (56.9%) and 487,306 instances of ORC particles (43.1%), and that this difference was statistically significant ($\chi^2 > 100$; $p < .0001$). It should be noted that the functions of *-(y)An* and *-DIK* are not only to relativize subjects and direct objects, respectively, but also to relativize oblique objects, adverbials, possessors and possessed constituents (Göksel & Kerslake, 2005). Besides, there is another morpheme (*-(y)AcAK*) which can also be used to construct ORCs when the sentence refers to a future situation. Therefore, a more comprehensive corpus study is needed to compare frequency distributions of relative clauses in Turkish in a more systematic way.

## Eye-Tracking Experiment

### *Eye-Movement Measures*

In eye-tracking research, a number of eye movement measures are employed to examine the dynamics of word and sentence reading (Inhoff & Radach, 1998; Rayner, 1998; Rayner & Pollatsek, 2006). In the present study, three common measures that represent the total reading time, the first fixation duration, and the total visit count are reported. *Total reading time* measures the sum of the duration for all fixations in both first-pass reading and other re-readings within a region; therefore, it reflects the total time that is necessary to process the target word in the specific sentential context. *First fixation duration* measures the duration of the first fixation on a region and it is associated with spillover effects from the previous region (Rayner & Pollatsek, 2006). *Visit count* measures the total number of visits (including the first fixation and all subsequent regressions) within a region; therefore, it reflects the difficulty of integrating a previous part of text with the rest of the sentence, which leads to regressions to that part of the sentence. This interpretation is substantiated by the observation that long regressions across word boundaries (more than 10 letter spaces back) occur because of comprehension difficulties and that good readers are very accurate in

regressing to the part of text that cause the comprehension difficulty (Frazier & Rayner, 1982).

**Participants**

Thirty-six undergraduate students from Hacettepe University took part in the experiment. All of them were monolingual native speakers of Turkish and had normal or corrected-to-normal vision and hearing.

**Materials**

Twelve sets of experimental sentences with reversible subject and object relative clauses and 12 filler sentences were created (see Table 1 for examples). All the reversible relative clauses in the experiment had two animate NPs, one as the head of the RC and the other as the object or the subject of the RC. Because the two animate NPs were equally likely to be the head of the RC and the subject/object of the RC, syntactic and/or morphological processing of the RC suffix was necessary to map thematic roles to the arguments.

Table 1. *Example experimental and filler sentences, and areas of interest for eye-movement recordings.*

| | | **RC** | **Head Noun** | **Spillover** | **Matrix Verb** |
|---|---|---|---|---|---|
| **Experimental Sentences** (# 24) | **SRC** | Mühendis-i kızdır-an<br>engineer-ACC anger-SRC | tesisatçı<br>plumber | hemen araba-yla<br>quickly car-by | uzaklaş-tı.<br>get away-PAST.3sg |
| | | The plumber who angered the engineer quickly got away by car. | | | |
| | **ORC** | Mühendis-in kızdır-dığ-ı<br>engineer-GEN anger-ORC-3sg.POSS | tesisatçı<br>plumber | hemen araba-yla<br>quickly car-by | uzaklaş-tı.<br>get away-PAST.3sg |
| | | The plumber who the engineer angered quickly got away by car. | | | |
| **Filler Sentences** (# 12) | Aslında ödevi bitirmiştim ama bir gözden geçireyim dedim.<br>Actually I finished the homework but I wanted to go over it. | | | | |

For the experimental sentences, four areas of interest were identified and investigated in eye-movement analysis as shown in Table 1. The first area of interest contains the relative clause excluding the head noun, comprising the first NP and the relative clause verb. The second area of interest contains the head noun of the relative clause. The third area of interest

contains the two words that come immediately after the head noun of the RC, which is predicted to exhibit possible spillover effects from the preceding RC region. Some of the experimental sentences contained one or two words following the spillover area to make the sentence more natural. In such cases, these additional words were not included in the analyses. Finally, the fourth area of interest contains the matrix verb region, which is always the last word of the experimental sentences.

As shown in Table 1, because Turkish ORCs are typically longer than SRCs by one syllable (consisting of one letter in half of the experimental materials and two letters in the other half) in the relative clause verb (*kızdıran – kızdırdığı*) and one letter in the suffix of the first NP (*mühendisi – mühendisin*), the sentences were not exactly matched in terms of orthography/morphology.

Each sentence was paired with a comprehension question, which resulted in 36 comprehension questions in total for both the experimental sentences and the fillers. For the comprehension questions about the experimental sentences (n = 24), one-third (n = 8) of them required the readers to understand the syntactic/semantic relations between the main/embedded NP and the matrix verb, while two-thirds (n = 16) of them involved the relations between the main/embedded NP and the verb in the embedded clause. Comprehension questions about the fillers (n = 12) probed general understanding of the sentences. The answers to half of the questions were true and to the other half of the questions were false, which were randomly distributed across conditions.

Both the sentences and comprehension questions were checked by two native speakers of Turkish to ascertain the validity of the materials. The experimental items were randomly split into two lists. The items were counterbalanced across the two lists such that an equal number of each condition appeared in each list and no participant saw more than one version of each item. Therefore, in each one of the two lists, there were 12 experimental sentences, six

of which were SRCs while the other 6 were ORCs. Twelve filler sentences of various syntactic structures were also added to each list. Half of the participants received the first list, while the other half of participants received the second list. Each list started with an instruction page followed by three filler items for practice.

**Procedure**

A Tobii Technology 1750 integrated eye-tracker with binocular registration (Tobii Technology, Stockholm, Sweden) with a sampling rate of 50 Hz was used in order to collect eye-movement data. The accuracy of the eye tracker was 0.5 degrees, and its spatial resolution was approximately 0.25 degrees. The experiment took place in Human Computer Interaction Research and Application Laboratory at Middle East Technical University. Participants were seated at a distance of approximately 60 cm from a 17'' TFT monitor with a resolution of 1280x1024 pixels. Each letter constituting the visual stimuli subtended a visual angle of about 1.5 degrees. Participants were told to read the sentences silently at their natural pace for comprehension. After calibration, participants started reading the instructions first, and proceeded to read the sentences by pressing a key. Each sentence was presented one at a time on the computer screen in black against white background. The sentences were centered on the screen and each experimental sentence was presented in two lines. After a participant read a sentence, s/he pressed a key to move to the next presentation. After each sentence, a true/false comprehension question about the previous sentence appeared. Participants answered the questions by pressing one of the two keys indicated on the keyboard. Tobii Studio software was used to control stimulus presentation and to process the eye-movement data.

## Results

### Comprehension Results

Following previous eye-tracking studies (Warren & Gibson, 2002), the data from two participants were removed from further analysis because their comprehension accuracy was 70% or lower for both experimental and filler sentences.

Accuracy in answering comprehension questions was highest for the fillers (91%), followed by SRCs (90%) and the lowest for ORCs (76%). A direct comparison of the comprehension accuracy between SRCs and ORCs with a two-tailed paired-samples t-test showed that comprehension of sentences with SRCs ($M$ = 0.90, $SD$ = 0.184) was better than that of sentences with ORCs ($M$ = 0.76, $SD$ = 0.193), $t(33) = 2.750$, $p$ = .01, suggesting that in Turkish ORCs were associated with more comprehension difficulty than SRCs.

### Eye-Movement Results

In addition to the two participants with low comprehension accuracy, six more participants were excluded from the analysis of eye-tracking data because of excessive head movements during the experiment which resulted in the loss of more than 30% of the eye-tracking data. The eye-movement data from 28 remaining participants are presented in Table 2.

Table 2. *Eye-movement measures for the areas of interest.*

| **Areas of Interest** | **Relative Clause Type** | **Dependent Measures** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Total reading time (in secs)** | | **First fixation duration (in secs)** | | **Visit count** | |
| | | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| RC | Subject Relative | 1.023 | 0.621 | 0.165 | 0.046 | 2.28 | 1.02 |
| | Object Relative | 1.008 | 0.660 | 0.159 | 0.047 | 2.23 | 1.26 |
| Head Noun | Subject Relative | 0.394 | 0.263 | 0.162 | 0.071 | 1.53 | 0.94 |
| | Object Relative | 0.385 | 0.310 | 0.175 | 0.101 | 1.49 | 1.06 |
| Spillover | Subject Relative | 0.591* | 0.266 | 0.193 | 0.067 | 1.53 * | 0.59 |
| | Object Relative | 0.713* | 0.350 | 0.188 | 0.052 | 1.90 * | 0.91 |
| Matrix Verb | Subject Relative | 0.676 | 0.313 | 0.190 | 0.039 | 1.99 | 0.61 |
| | Object Relative | 0.758 | 0.394 | 0.199 | 0.052 | 2.07 | 0.92 |

The data was subjected to a series of one-way ANOVAs both by subjects (*F1*) and by items (*F2*) with the factor of RC type (subject relative clause & object relative clause). The results are presented below for each area of interest.

***RC Region***

In the RC region, all three measures of reading time failed to produce a significant difference between SRCs and ORCs [total reading time: *F1* (1,27) = .070, *p* = .794; *F2* (1,11) = .022, *p* = .884; first fixation duration: *F1* (1,27) = .351, *p* = .559; *F2* (1,11) = 1.267, *p* = .284; visit count: *F1* (1,27) = .132, *p* = .719; *F2* (1,11) = .290, *p* = .601].

***Head Noun Region***

Similarly, there was no significant difference between SRCs and ORCs in the head noun region for all the three measures [total reading time: *F1* (1,27) = .047, *p* = .830; *F2* (1,11) = .210, *p* = .656; first fixation duration: *F1* (1,27) = .414, *p* = .525; *F2* (1,11) = 1.674, *p* = .222; visit count: *F1* (1,27) = 2.114, *p* = .158; *F2* (1,11) = .220, *p* = .648].

***Spillover Region***

By-subjects analysis of the spillover region revealed a significant difference between SRCs and ORCs for total reading time and visit count measures [total reading time: *F1* (1,27) = 5.596, *p* = .025; visit count: *F1* (1,27) = 6.195, *p* = .019]. However, by-items analysis of this region for the same measures did not produce any significant effects [total reading time: *F2* (1,11) = 2.411, *p* = .149; visit count: *F2* (1,11) = .025, *p* = .878]. Analyses of the first fixation duration measure did not exhibit any significant differences in this region [*F1* (1,27) = .303, *p* = .587; *F2* (1,11) = .001, *p* = .981].

***Matrix Verb Region***

There was no significant difference between SRCs and ORCs in the matrix verb region for all the three measures [total reading time: *F1* (1,27) = 2.603, *p* = .118; *F2* (1,11) =

.022, $p$ = .884; first fixation duration: *F1* (1,27) = .819, $p$ = .373; *F2* (1,11) = .033, $p$ = .859; visit count: *F1* (1,27) = .433, $p$ = .516; *F2* (1,11) = .051, $p$ = .826].

Although the foregoing analyses were performed with raw eye-movement data, some psycholinguistic studies reporting reaction time and eye-movement data prefer to analyze log-transformed data in order to control for non-normal distributions in the sample and meet the normality assumption of statistical tests (Vasishth, Chen, Li, & Guo, 2013; Wu, Luo, & Zhou, 2013). We repeated the by-subjects analyses reported above with the log-transformed measures of eye movements. The results of these analyses paralleled those of the raw data, as only the analyses of the total reading time and visit count measures showed significant differences between SRC and ORC in the spillover region ($F$s > 4.899, $p$s < .036), and there were no other significant differences for any one of the eye-movement measures in any one of the regions of interest ($F$s < 3.732, $p$s > .064).

These results demonstrate that the processing of the relative clause region with the head noun proper or the matrix verb did not yield significant differences between the RC types. On the other hand, the by-subjects analyses revealed significantly more total reading time in and more regressions to the spillover region immediately following the relative clause and its head noun, which did not reach significance in the by-items analyses. It is quite common in psycholinguistic research to observe significant by-subjects but insignificant by-items results, particularly in self-paced reading and eye-tracking studies (Chen et al., 2008; Traxler et al., 2002). Failure to observe a significant difference for these measures in the by-items analyses might be due to variability in the length of the spillover region across the experimental items. Although this region was two-word long across all items, due to morphological suffixation, its length ranged from 6 letters to 21 letters. This might have been aggravated by the limited number of items.

## Discussion

The present findings seem to show a processing disadvantage associated with ORCs relative to SRCs, which was indicated by decreased comprehension accuracy and increased total reading time in and regressions to the spillover area immediately following the head of the relative clause. No significant difference was found between the two conditions in the eye-tracking data of the RC, head noun or the matrix verb regions, which implies that the processing difficulty in ORCs is not reflected immediately upon encountering the relative clause and the NP. As discussed below, this might be due to the nonfinite structure of the verb in Turkish RCs. Taken together, the present results are consistent with the processing asymmetry between SRCs and ORCs as observed in a number of languages, while multiple factors including syntactic structure, morphology and structural frequency may play a role in shaping this processing pattern.

In the present study, the locus of processing difficulty with significant reading time difference between SRCs and ORCs was the spillover region, which immediately followed the RC head. A similar finding was reported by Betancort et al. (2009) in an eye-tracking paradigm for Spanish. In their study, Spanish ORCs were associated with more total reading time than SRCs in the critical RC region as well as the region following it. This suggests that the region immediately following the critical RC area might be affected by the syntactic complexity of the material in the previous region. On the other hand, the present study found no effect of the RC type on eye-movement measures in the first and the second areas of interest (the entire RC region), which is different from many studies on English and other languages (Gordon et al., 2001; Traxler et al., 2002). The reason for the lack of an effect in the processing of relative clauses per se may be related to the way that Turkish relatives are formed. As mentioned above, typically in Turkish RCs the verb is nonfinite, with the verb not inflected for tense and aspect (Göksel & Kerslake, 2005). This is different from English,

which has finite verbs in RCs. Nonfinite verbs may require less processing resources than finite ones and, hence, may not reflect an effect of the RC type immediately. Alternatively, in Turkish an RC reading may not be disambiguated until the head noun is reached, because there is no relative pronoun as in English (e.g., *who, which, that*) which signals the existence of an RC early in the sentence. However, a previous self-paced reading study did report shorter RTs for SRCs than ORCs on the RC verb in Turkish (Kahraman et al., 2010). Also, the self-paced listening study conducted by Özge et al. (2015) reported longer listening times for Turkish ORCs than SRCs on the first segment of the RC (the noun phrase) as well as longer listening times for SRCs than ORCs on the RC verb. The findings of these studies do not appear to be readily reconcilable with those of the present study. However, the current study differs from these reading and listening time studies in terms of presentation of stimuli as the entire sentence was presented on the screen in the current study, unlike a self-paced design as implemented in the previous studies. This might have led participants to adopt different strategies when performing the task.

A recent eye-tracking study also revealed higher processing costs for ORCs than SRCs in Turkish (Aydın & Zagvozdkina, 2019). However, this effect was observed only on the RC verb, unlike the current study in which we found ORC disadvantage in the spillover region only. The materials of Aydın and Zagvozdkina (2019) differed from those of the current study in that they included additional lexical items in the relative clause in order to manipulate the linear distance between the gap and the RC verb. Importantly, the ORC disadvantage on the RC verb was found only when these lexical items separated the gap and the RC verb. On the other hand, when these lexical items did not intervene between the gap and the RC verb, which made them more comparable to the materials of the present study until the RC verb, no difference was found between SRCs and ORCs. Based on their findings, Aydın and

Zagvozdkina (2019) conclude that structural distance influences the processing patterns of SRCs and ORCs, but this influence interacts with linear distance.

The current findings are in line with the predictions of the frequency-based accounts and the structural accounts. As discussed above, according to SDH, the object position is deeper in the syntactic structure of sentences compared to the subject position. Following this reasoning, the processing cost associated with ORCs should be higher than that associated with SRCs. On the other hand, the storage resources and integration resources accounts, which are based on working-memory, made different predictions for Turkish. The storage resources account capitalizes on the number of syntactic heads predicted by the reader at any given word. This was shown in the Introduction section to be equal for Turkish RCs, thus predicting no difference between SRCs and ORCs in Turkish. The integration resources account, on the other hand, attributes processing cost associated with RCs to the linear distance between dependencies; therefore, it predicted an SRC disadvantage for Turkish due to greater distance between the head noun and the gap site in Turkish SRCs. The predictions of the storage resources and the integration resources accounts appear to be incompatible with the current findings.

The corpus analysis conducted in this study also highlights frequency as a possible factor contributing to the processing difficulty associated with ORCs. As discussed above, constraint-based approaches (Gennari & MacDonald, 2008) assert that comprehension difficulty associated with a certain structure results from the competition between partially activated alternative structures, with more frequently occurring structures getting higher activation than less frequent ones. Hence, the present findings are also consistent with the frequency-based accounts such as the constraint-based approaches since ORCs were found to be less frequent and at the same time incurred more processing cost than SRCs in Turkish.

Besides the structural and frequency-based approaches, morpho-syntactic features of Turkish relative clauses might play a role in the processing differences between SRCs and ORCs, as addressed by Özge and colleagues (2010, 2015). As explained above, in Turkish, object NPs in SRCs take the canonical accusative case (as shown in 6a below) which also marks sentential objects (as in 6c), whereas subject NPs in ORCs are marked with the genitive case (as shown in 6b below) rather than the covert nominative case, which marks sentential subjects (as in 6c). One implication of this difference is that apart from marking subject NPs in ORCs, the genitive case has another function, namely, marking the possessor in possessive constructions (as in 6d). In contrast, the accusative case on SRC objects has a single inflectional function. Özge et al. (2010, 2015) discuss this case difference between the RC types as a possible factor in the late acquisition and slower processing of Turkish ORCs compared to SRCs by children and adults. This case difference might have partially contributed to the higher processing cost associated with ORCs than with SRCs in Turkish as revealed in the present study. These potential confounds regarding case differences are also present in other studies conducted in Turkish and typologically similar languages (Aydın, 2007; Aydın & Zagvozdkina, 2019; Kahraman et al., 2010). Rather than challenging the merit of such cross-linguistic research, on the contrary we believe that these morphological differences across languages call for fine-tuning of the hypotheses aiming to account for language processing largely focusing on certain aspects of linguistic structure in particular languages but not in others.

6a. Kız-ı gör-en çocuk

girl-ACC see-SRC boy-NOM

“The boy who saw the girl”

6b. Kız-ın gör-düğ-ü çocuk

girl-GEN see-ORC-3sg.POSS boy-NOM

"The boy who the girl saw"

6c. Kız çocuğ-u gör-dü.

girl-NOM boy-ACC see-PAST.3sg

"The girl saw the boy."

6d. Kız-ın kitab-ı

girl-GEN book-3sg.POSS

"The girl's book"

Another potential influence of the case difference between relative clause NPs in SRCs and ORCs relates to similarity-based interference. Since both NPs in ORCs serve a subject function in the relative clause and the matrix clause, an interference might have ensued due to similar cues associated with the referents held in memory. However, in SRCs the first NP serves as the object of the RC whereas the second functions as the subject of the matrix verb, hence no interference based on grammatical function. This interpretation of the findings based on interference is strengthened in consideration of the comprehension results. It was shown that comprehension scores were much higher for SRCs (90%) than for ORCs (76%). Indeed, the comprehension questions for SRCs were answered almost as correctly as those for fillers (91%). Since the comprehension questions for the experimental items required correct mapping of thematic relations between the NPs and the RC verb and the matrix verb, the fact that ORCs were associated with such a low accuracy rate indicates failure to establish such thematic relations. Difficulty in correctly establishing these thematic relationships might have been aggravated due to the genitive marker that non-canonically marks the subject function in ORCs, as discussed in the preceding paragraph. Therefore, it seems to be the case that the participants might have experienced similarity-based interference when mapping the two NPs in ORCs as subjects to their respective verbs.

Overall, the present findings are compatible with the common ORC processing disadvantage observed in English and other head-initial languages. However, as in the case of the robust SRC preference in English, different theoretical approaches can all account for such findings. Moreover, there are some previous studies which contest the universality of the ORC disadvantage. Specifically, some studies in Basque and Chinese failed to reveal an SRC processing advantage (Bulut et al., 2018; Carreiras et al., 2010; Chen et al., 2008; Hsiao & Gibson, 2003; Xu et al., 2019). Therefore, a possible explanation for the divergent results might be that there are multiple factors that contribute to the processing cost of relative clauses in various languages, while syntactic structure is not the only determinant of RC processing preference. These multiple factors possibly relate to dependencies among words tasking integration and storage resources, syntactic structure, structural frequency and morphological information such as case-marking in a given language, as well as discourse-level information such as context. The weightings of these different factors may change from language to language depending on the properties of the relevant language.

In the case of Chinese, because its syntax and semantics are claimed to be closely inter-related (Luke, Liu, Wai, Wan, & Tan, 2002), certain factors other than syntactic structure such as semantics and working memory may guide sentence processing dynamics more strongly (Bulut, Hung, Tzeng & Wu, 2017). In line with this argument, in a self-paced reading paradigm, Chen et al. (2008) found that working memory capacity (WMC) modulated reading times of Chinese RCs such that for low WMC readers SRCs took longer to read than ORCs whereas for high WMC readers there was no significant difference between the reading times of SRCs and ORCs. These findings lend support to the working memory-based accounts such as LDH. On the other hand, recent ERP evidence (Bulut et al., 2018) suggests that relative clause processing in head-final Chinese exhibits a complex pattern, with an SRC disadvantage indexed by a P600 component on the head noun and an ORC disadvantage on

the relativizer together with an effect of working memory, highlighting multiple factors affecting sentence processing dynamics.

As for Basque, in two self-paced reading experiments followed by an event-related potentials experiment, Carreiras et al. (2010) showed that Basque SRCs took longer to read than ORCs and that SRCs produced larger P600 than ORCs. They argue that processing complexity may be altered by language-specific aspects of grammar. Specifically, Basque is an ergative-absolutive language with marked transitive subjects and unmarked objects and intransitive subjects. This is different from nominative-accusative languages such as English, Japanese and Turkish, in which objects are marked whereas transitive and intransitive subjects are unmarked. Carreiras and colleagues claim that morphological unmarkedness might lead to processing advantage in a particular language, leading to an SRC advantage for nominative-accusative languages and an ORC advantage for ergative-absolutive languages. More cross-linguistic research is needed to disentangle the intertwined effects of morphology (e.g., case-marking), syntactic structure (e.g., word order), frequency and memory (memory capacity, integration, storage and interference) on relative clause processing.

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