1 Introduction

Over the past 20 years, researchers have found convincing evidence showing that sentence processing is incremental in head-initial languages like English. In head-final languages, since a verb comes at the end of the sentence, some researchers assumed that the parser must wait to see a verb in order to assign thematic roles (e.g., Pritchett, 1992). However, previous studies in Japanese showed that based on the information from case markers, the parser predicts upcoming constituents, and immediately makes decisions about the argument structure of the sentence even before the verb appears (e.g., Kamide & Mitchell, 1999; Miyamoto, 2002). In other words, sentences are processed incrementally (with no delay) even in head-final languages.

Another evidence for the incrementality of sentence processing in head-final languages was provided from the study of structures that involve a filler-gap dependency such as scrambling sentences (e.g., Aoshima, Philips and Weinberg, 2004; Miyamoto & Takahashi, 2004). These studies have shown that as soon as the parser identifies the filler, it postulates a gap and
immediately starts to construct a dependency. Thus filler-gap dependencies are processed incrementally in head-final languages as well. However, in the case of structures such as relative clauses (RCs), the order of the filler and the gap is reversed in head-final languages compared to that in head-initial languages. In this kind of structures, the gap precedes the filler. We will refer a dependency where the gap precedes the filler as gap-filler dependencies. From the existing data in Japanese, it is hard to judge whether gap-filler dependencies are also processed incrementally as in filler-gap dependencies. To the best of our knowledge, the issue of incrementality of gap-filler dependencies remains unsettled.

In the present study, Turkish subject and object relative clauses (SRCs / ORCs) are used to investigate whether gap-filler dependencies are processed incrementally. Specifically, we examine whether the parser postulates a filler as soon as it determines the gap-site, or it starts to construct a gap-filler dependency after it encounters the filler. In order to answer this question, we conducted two sentence-fragment completion experiments and one self-paced reading experiment. The results of the sentence-fragment completion experiments revealed that when Turkish native speakers read the RC-verb, they overwhelmingly produced RCs. Furthermore, the results of the self-paced reading experiment revealed that SRCs were read faster than ORCs, and the processing asymmetry was observed only at the embedded verb position. These results demonstrate that there is a strong forward prediction for RC-head (filler) at the embedded verb, and this is rapidly reflected in the online sentence processing as well, indicating that as soon as the parser determines the gap-site, it incrementally starts to construct a gap-filler dependency even before the filler appears. We will thus conclude that not only filler-gap dependencies, but also gap-filler dependencies are processed incrementally.

The organization of the paper is as follows. In Section 2, we will give a brief overview of the processing studies on filler-gap dependencies in English and Japanese. Next in Section 3, we will review RC processing studies in Japanese, and illustrate why it is hard to verify the incrementality of gap-filler dependencies. Then we will point out that Turkish provides a good test case. In Section 4, we will give the details and the results of sentence-fragment completion and self-paced reading experiments. In Section 5, we will argue that as soon as the parser determines the gap-site at the RC-verb position, it immediately postulates a filler, rather than waiting for the filler to start constructing a dependency. Moreover, from a cross-linguistic perspective, we will claim that onset timing of gap-filler dependency might differ among head-final languages like Japanese and Turkish, and verb morphology (existence of relative clause markers) would be a crucial factor for this difference. Section 6 concludes the paper.

2 Online Processing of Filler-Gap Dependencies

Many languages include constructions like WH-questions in which some argument of a verb is displaced from its original position to another place in the sentence. In the field of sentence processing, a displaced element is referred to as a filler, and its original (canonical) position is referred to as a gap.

(1) Which game do you like to play ___ now?
   \[\text{filler} \quad \rightarrow \quad \text{gap}\]
Filler-gap dependencies are found in clefts, focus sentences, RCs, topic sentences and WH-questions. In order to understand the meaning of this kind of constructions, the parser needs to link the filler and the gap. This refers to filler-gap dependency (e.g., Fodor, 1989; Hawkins, 1999). Previous studies in English showed that as soon as the parser identifies the filler, it immediately postulates a gap at the first possible position in the sentence, rather than waiting for an empty argument position to start constructing a filler-gap dependency (Crain & Fodor, 1985; Frazier & Clifton, 1989; Stowe, 1986). For example, Crain & Fodor (1985) compared the reading times of *us* in sentences like (2a) and (2b) through a self-paced reading experiment.\(^1\)

(2)  a. The little girl had expected *us* to sing those songs for Cheryl at Christmas.
   b. Who had the little girl expected *us* to sing those songs for ___ at Christmas?

The results showed that *us* was read slower in (2b) than in (2a), and they argued that the parser immediately posits a gap as soon as the filler is identified, then the difficulty arises since the direct object position is filled with an overt pronoun (i.e., filled gap effect). These results support the incremental processing of filler-gap dependencies over delayed processing in head-initial languages.\(^2\)

In recent years, several studies focused on the processing of filler-gap dependencies in head-final languages (e.g., Aoshima et al., 2004; Miyamoto & Takahashi, 2004) and reported results in support for incremental processing. For example, Aoshima et al. (2004) compared reading times of scrambled WH-phrase sentences (3a) with control sentences (3b) in Japanese.

(3)  a. Dono-kodomo-ni hahaoya-wa otetudaisan-ga titoiya-ni obento-o
    which-child-DAT mother-TOP housekeeper-NOM father-DAT lunch-ACC
    watasita-to iimasita-ka?
    handed-COMP told-Q
    ‘To which child did the mother tell that the housekeeper handed lunch to the father?’

  b. Dono-kodomo-ga hahaoya-ni otetudaisan-ga titoiya-ni obento-o
    which-child-NOM mother-DAT housekeeper-NOM father-DAT lunch-ACC
    watasita-to iimasita-ka?
    handed-COMP told-Q
    ‘Which child told the mother that the housekeeper handed lunch to the father?’

In this study, the main region of interest was the embedded dative NP *titoiya-ni* (to father). Aoshima et al. (2004) assumed that if the scrambled dative WH-phrase *dono-kodomo-ni* (to which child) is associated with the embedded clause before *titoiya-ni* (to father) appears, the parsers should be surprised to encounter the second dative NP in (3a). In the control condition (3b) on the other hand, there is no need to associate nominative WH-phrase *dono-kodomo-ga* (which child) with the embedded clause, because it stays in-situ.

The results of self-paced reading experiment showed that the embedded dative NP was read slower in (3a) than (3b). Aoshima et al. (2004) argued that the slowdown at *titoiya-ni* in (3a), is the Japanese counterpart of filled gap effect in English (Crain & Fodor, 1985; Stowe, 1986), and

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1 In (2) and (3) we partially simplified the original sentences.
2 These results were also replicated in Stowe (1986), Frazier & Clifton (1989), and in Dutch as well (Frazier, 1987; Frazier & Flores d’Arcais, 1989)
relative clauses

reflects the immediate gap postulation, and hence incremental processing of filler-gap dependencies in Japanese. Overall, the results of these studies in both head-initial and head-final languages show that once the parser recognizes a filler, it immediately postulates a gap, and attempts to link the filler with the gap. However, as we pointed out in the Introduction, in the case of RCs, the order of the filler and the gap differs between head-initial and head-final languages. While the filler precedes the gap in head-initial languages like English, the gap precedes the filler in head-final languages like Japanese.\(^3\)

\[(4) \text{The teacher who the student saw } \underline{\text{was smoking a cigarette.}}\]

\[(5) \text{Gakusee-ga } \underline{\text{mi-ta}} \text{ sensee-wa tabako-o suitte-i-ta.}}\]

\begin{verbatim}
 student-NOM see-PAST teacher-TOP cigarette-ACC smoke-PROG-PAST
\end{verbatim}

‘The teacher who the student saw was smoking a cigarette.’

There are good reasons for assuming that gap-filler dependencies are processed in a different way from filler-gap dependencies. First, identifying a filler seems relatively easy, compared to a gap; a filler is an overt element. Then, in the processing of filler-gap dependencies, as soon as the parser identifies a filler, it can rapidly postulate a gap. However, since gaps are, by definition, unpronounced (empty) elements, the parser might not be able to identify a gap as easily as a filler. Second, the pro-drop property is often found in head-final languages like Japanese. If the detected unpronounced element turns out to be a pro, a filler does not appear in the sentence. In this regard, it seems reasonable to assume that the parser might start to construct a gap-filler dependency when it identifies the filler. This means that the processing of gap-filler dependencies is delayed in comparison with the processing of filler-gap dependencies.

Alternatively, if preference for incremental processing is universal, the parser immediately postulates a filler when it identifies the gap-site. In head-final languages, it is still not fully understood which one of these possibilities are attested. As we will show in Section 3, it is hard to distinguish between these possibilities through existing data in Japanese, whereas Turkish provides a good test case.

## 3 Processing Relative Clauses in Head-Final Languages

In European languages, it is well documented that SRCs ‘The professor who saw the student...’ are easier to process than ORCs ‘The professor who the student saw...’ (e.g., Dutch: Mak et al., 2006; English: King & Just, 1991; French: Holmes & O’Regan, 1981), and it is assumed that the processing asymmetry between SRCs and ORCs reflects a relative ease / difficulty of establishing a filler-gap dependency (c.f., Gibson, 1998; O’Grady, 1997).

Previous studies in Japanese and Korean have also investigated the processing difficulty of SRCs and ORCs (Japanese: Ishizuka, 2005; Miyamoto & Nakamura, 2003; Sakamoto & Yasunaga, 2009; Ueno & Garnsey, 2008; Korean: Kwon, 2008)\(^4\). The results of self-paced reading studies in Japanese consistently showed that SRCs are easier to process than ORCs, and

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\(^3\) Henceforth italic letters are used for the filler, and underline is for the gap in examples.

\(^4\) In these studies, the main concern was to distinguish between the competing hypotheses such as Dependency Locality Theory (Gibson, 1998) and Structural Distance Hypothesis (O’Grady, 1997), and to explain where the processing asymmetry comes from.
the processing asymmetry is always observed at the RC-head (e.g., gakusee in (6)). However, from these results it is hard to judge when the parser starts to construct a gap-filler dependency.

(6) a. SRC: ___ Sensee-o mita gakusee-wa tabako-o sutte-i-ta.
    teacher-ACC saw student-TOP cigarette-ACC smoke-PROG-PAST
    ‘The student who saw the teacher was smoking a cigarette.’
b. ORC: Sensee-ga ___ mita gakusee-wa tabako-o sutte-i-ta.
    teacher-NOM saw student-TOP cigarette-ACC smoke-PROG-PAST
    ‘The student who the teacher saw was smoking a cigarette.’

In Japanese, neither relative pronouns nor relativizer morphemes (RC-markers) are used. Previous studies on Japanese RCs pointed out that the parser can determine the structure of RC only at the head-noun, because the main clause interpretation is strongly preferred at the embedded verb position (e.g., Hirose & Inoue, 1998; Mazuka & Itoh, 1995; Miyamoto, 2002). This means that the existence of RC is determined when the parser encounters the filler. From these structural properties and results above, the following two interpretations, regarding the incrementality of gap-filler dependencies, are possible.

(7) **Incremental possibility:** When the parser realizes the gap, it immediately postulates a filler and starts to construct a gap-filler dependency even before the filler appears.

(8) **Non-incremental possibility:** Although the parser realizes the gap, it would not immediately postulate a filler, and when the filler is first identified, the parser starts to construct a dependency.

If (7) is the case, the processing of gap-filler dependency takes place without any delay, and hence incremental in head-final languages. On the other hand, if (8) is the case, the processing of gap-filler dependency is not incremental. Since the existence of RC is determined at the RC-head, and processing asymmetry is also observed at this point, it is hard to distinguish between incremental and non-incremental possibilities in Japanese. In order to clarify the incrementality of gap-filler dependencies, we need to examine other head-final languages, in which the parser could possibly determine the gap-site and upcoming filler, even before the filler appears. As we will explain below, Turkish would provide a good test case, because unlike Japanese, RC-markers are used, and this would allow the parser to determine the gap-site and recognize the upcoming filler earlier than in Japanese.  

In Turkish, a head-final language, the relative clause precedes the head-noun. In addition, case markers are used. In SRCs the embedded object bears an accusative case marker. In ORCs, unlike Japanese, the embedded subject obligatorily bears a genitive case marker in Turkish. Moreover, different RC-markers are used for SRCs and ORCs. In SRCs, the suffix An, which is basically used to relativize the subject, is attached to the embedded verb. In ORCs the suffix DIK

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5 RC-marker (adnominal suffix) is attached to the RC-verb in Korean. However, the same suffix is used for all types of RCs (no distinction between SRCs and ORCs) (Sohn, 1999). Moreover, the previous study showed that the processing asymmetry between SRCs and ORCs is observed in both RC-verb and RC-head (Kwon, 2008). From this data, it is hard to judge how the parser processes gap-filler dependencies in Korean. Thus future study is needed to explore why the processing asymmetry is being observed in different positions.

6 If the embedded object is a non-specific (indefinite) noun like ‘kitap okuyan öğrenci’ (the student who reads a book), it does not bear an overt case marker. However the issue of specificity is beyond the scope of this paper.
Relative Clauses Processing before the Head Noun

with a subject agreement suffix is attached to the embedded verb, and this RC-marker is used when a non-subject element is relativized (e.g., Kornfilt, 1997, 2000; Underhill, 1972).7

(9) a. SRC: ___ Öğretmen-i gör-en öğrenci sigara içi-yor-du
Teacher-ACC see-SR student cigarette smoke-PROG-PAST
‘The student who saw the teacher was smoking a cigarette.’

b. ORC: Öğretmen-in ___ gör-düğ-ü öğrenci sigara içi-yor-du
teacher-GEN see-NSR-3s student cigarette smoke-PROG-PAST
‘The student who the teacher saw was smoking a cigarette.’

A fundamental difference between Turkish and Japanese is the use of RC-markers. In Japanese, due to the lack of RC-markers, only at the RC-head can the parser determine the existence of an RC. Thus, the processing asymmetry between SRCs and ORCs would have been observed at this point. In Turkish on the other hand, due to the use of RC-markers the parser could possibly determine the existence of an RC at the embedded verb, even before the head-noun (filler) appears. Therefore, Turkish provides a good opportunity to test the incrementality of gap-filler dependencies.

If the parser indeed determines the existence of an RC (the gap-site), and immediately postulates a filler at the embedded verb due to the RC-markers, the processing asymmetry between SRCs and ORCs (if any) should be observable at the embedded verb position. We can then conclude that the processing of gap-filler dependencies starts even before the filler appears, and hence incremental. Based on these considerations, we set up the following research questions, and conducted two sentence-fragment completion experiments (Experiment 1 and 2) and a self-paced reading experiment (Experiment 3).

(10) Research Question 1: Do Turkish native speakers determine the existence of RCs (gap and filler) even before the RC-head (filler) appears?

(11) Research Question 2: Does a processing asymmetry between SRCs and ORCs exist in Turkish, and if so, when is this asymmetry observed?

4 Experiments

4.1 Experiment 1

Experiment 1 attempts to answer the question whether Turkish native speakers can realize the existence of RCs before the head-noun appears. Since we wanted to make sure that there is no strong prediction for RCs before the RC-verb appears, we did not present the RC-verb.

(12) a. ACC: Fabrika-da ustabaşı-ni
Factory-LOC foreman-ACC

7 Due to the vowel harmony and consonantal assimilation, An and DIK appear in various forms. In the present study, we glossed An, as ‘SR’ (subject relative) and DIK, as ‘NSR’ (non-subject relative).
We set up two conditions (accusative vs. genitive) as in (12). In Experiment 1, a sentence-fragment starts with a locative noun, followed by an accusative or genitive noun. Experimental stimuli were 16 sets of target fragments and 40 filler fragments. Target fragments were divided into 2 lists so that each list contains the same number of fragments from each condition, and two versions were prepared from each list by pseudo-randomly ordered in two different ways. Thirty-seven undergraduate students at Çanakkale Onsekiz Mart University participated in the experiment. They were all native speakers of Turkish, and their mean age was 21 (SD=1.27). Sentence-fragments were listed on paper, and the participants were asked to complete sentence-fragments during class. Each participant was assigned to one list.

4.1.1 Results and Discussion

Since some of the fragments were skipped, not completed fully or grammatically unacceptable (52 cases in total), 540 completed sentences were submitted for further analyses. Sentences were classified into two groups, as RCs and non-RC sentences. Then we compared the production rates of RCs with non-RC sentences, and SRCs with ORCs as well. Table 1 shows the proportion of the completed sentences.

Table 1: Numbers and production rates of RCs and non-RCs in Experiment 1

<table>
<thead>
<tr>
<th></th>
<th>RCs</th>
<th>Non-RC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>63 (24%)</td>
<td>202 (76%)</td>
<td>265</td>
</tr>
<tr>
<td>GEN</td>
<td>40 (15%)</td>
<td>235 (85%)</td>
<td>275</td>
</tr>
<tr>
<td>Total</td>
<td>103 (19%)</td>
<td>437 (81%)</td>
<td>540</td>
</tr>
</tbody>
</table>

A chi-square test of independence showed the relation between case markers (ACC or GEN) and produced sentence type (RC or non-RC) was significant ($\chi^2 (1) = 7.45 \ p < .01$). Test of goodness of fit which assumes equal production rates between RCs and non-RC showed that the number of RCs was significantly smaller in both ACC-condition ($\chi^2 (1) = 72.91 \ p < .01$) and GEN-condition ($\chi^2 (1) = 138.27 \ p < .01$). Residual analysis showed that the number of RCs in the ACC-condition was higher than that in the GEN-condition ($p < .05$).

These results showed that the number of non-RC sentences was much larger than that of RCs. Most of the non-RC completions were simplex sentences (148 cases in the ACC-condition, 186 cases in the GEN-condition, respectively). Other completions were complex sentences, such as:

(i) Sergi-de ressam-ı yap-tığ-ı resim-ler için öv-dü-ler
   Exhibition-LOC painter-ACC do-NSR-3sg picture-3pl for praise-PAST-3pl
   ‘At the exhibition, people praised the painter for the paintings that he drew.’

(ii) Parti-de hakim-in yanında otur-an adam benim amcam.
    Party-LOC judge-GEN next sit-SR man my uncle.
    ‘The man who is sitting next to the judge at the party is my uncle.’
as conjunction sentences, adjunct clauses, complementizer clauses in both conditions. Assuming that the production rate of a particular construction reflects its predictability (Den & Inoue, 1997), we can thus say that there is no strong prediction for RCs when the RC-verb is not presented. At the same time, if we compare the number of RCs in two conditions, Turkish native speakers expect more RCs when they encounter an accusative noun than a genitive noun. This may be due to the fact that a gap, namely a missing subject, can be detected in the ACC-condition but cannot be detected in the GEN-condition. This detected gap might have made easier to assume a filler and produce RCs in the ACC-condition than the GEN-condition. Ishizuka (2005) argued in her study on Japanese RCs that, the sentence-initial accusative noun elicits a stronger expectation for an RC construction than the sentence-initial nominative noun. In this respect, Ishizuka’s assumption might also be valid for Turkish. In Experiment 2, we then confirmed how Turkish native speakers’ preferences change when they see an RC-verb.

4.2 Experiment 2

Experiment 2 was conducted to confirm whether there is a strong prediction for RCs when the RC-verb is presented. The experimental material was almost identical to Experiment 1. An RC-verb with a subject relative suffix was presented after the accusative noun, while an RC-verb with a non-subject relative suffix was presented after the genitive noun. All RC-verbs are transitive verbs.

(13) a. ACC: Fabrika-da ustabaşını izle-yen__________________.
    Factory-LOC foreman-ACC watch-SR

b. GEN: Fabrika-da ustabaşını izle-diğ-i__________________.
    Factory-LOC foreman-GEN watch-NSR-3s

Twenty-two undergraduate students at Çanakkale Onsekiz Mart University participated in the experiment (they were all native speakers of Turkish, and they did not participate in Experiment 1 (mean age: 20, SD=0.87)). The procedure was identical to Experiment 1.

4.2.1 Results and Discussion

There were a small number of completions (only three) that were skipped or ungrammatical. We submitted the remaining 349 completions for further analyses. Sentences were classified as in Experiment 1. Table 2 shows proportion of RCs and non-RC sentences.

<table>
<thead>
<tr>
<th></th>
<th>RCs</th>
<th>Non-RC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>171 (97%)</td>
<td>5 (3%)</td>
<td>176</td>
</tr>
<tr>
<td>GEN</td>
<td>171 (99%)</td>
<td>2 (1%)</td>
<td>173</td>
</tr>
<tr>
<td>Total</td>
<td>342 (98%)</td>
<td>7 (2%)</td>
<td>349</td>
</tr>
</tbody>
</table>
Since the number of non-RC completions was smaller than 10, we performed Fisher’s Exact Test, and the relation between the case markers and the sentence type was not significant (p > .05). Test of goodness of fit showed that number of RCs was significantly larger in both ACC-condition (χ² (1) = 156.57 p < .01) and GEN condition (χ² (1) = 165.09 p < .01). These results show that irrespective of case marker type, the participants produced RCs when they read the verb with a RC-marker.

Experiment 1 showed that although Turkish native speakers produced some SRCs and ORCs, the number of non-RC completions was much larger. On the other hand, Experiment 2 showed that when Turkish native speakers read the verb with a RC-marker, they produced SRCs and ORCs almost at the rate of 100%. We can thus say that Turkish native speakers can determine the existence of an RC and predict the up-coming RC-head at the RC-verb position. In other words, the existence of the gap can be determined and the upcoming filler is strongly predicted at the RC-verb position. This result leads us to the following prediction. That is, if the parser immediately postulates a filler, as soon as it determines the gap, the processing asymmetry between SRCs and ORCs should be observed at the RC-verb position, not at the RC-head. In Experiment 3, we test this prediction through a self-paced reading experiment.

4.3 Experiment 3

The aim of this experiment was to test whether there is a processing asymmetry between SRCs and ORCs, and if so, when this asymmetry is observed (at the RC-verb or RC-head). Our predictions for the results are as follows.

(14) **Incremental prediction**: If the parser postulates a filler and starts to construct a gap-filler dependency as soon as the gap is determined, the processing asymmetry between SRCs and ORCs will be observed at the RC-verb.

(15) **Non-incremental prediction**: If the parser starts to construct a gap-filler dependency when it reaches the filler, the processing asymmetry will be observed at the RC-head.

In order to test these possibilities, we prepared two conditions as in (16). In the SRC condition, a sentence starts with an accusative noun, followed by an RC-verb with subject relative suffix, and an adjective intervenes between the RC-verb and the RC-head. In the ORC condition, a sentence starts with a genitive noun, followed by an RC-verb with non-subject relative suffix. Other parts of the sentences are identical to the ones in the SRC condition.

(16) a. **SRC condition**:  
Ustabaşı-
ACC izle-yen yetenekli işçi söylenenler-i harfiyen yap-
PROG-PAST-yor-
PROG-PAST-du.  
Foreman-
ACC watch-
SR skillful worker commands-
ACC completely do-
PROG-PAST-yor-
PROG-PAST-du.  
‘The skillful worker who watched the foreman has always obeyed the commands fully.’

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9 In the ACC-condition, all RC completions were SRCs; in the GEN-condition all RC-completions were ORCs, and all of these RCs were with a lexical head (Turkish has headless RCs like ‘parayı veren ()’ ((the person) who gave/gives the money), which consist of a modifier clause without a head-noun (Kornfilt, 1997, p. 63)).

10 In self-paced reading studies, effects are sometimes carried over to the following region (spill-over effect). We inserted an adjective between the RC-verb and the RC-head, to see effects clearly even when a spill-over occurs.
b. **ORC condition:**
Ustabaşin izle-diğ-i yetenekli işçi söylenenler-i harfiyen yapı-yor-du.
Foreman-GEN watch-NSR-3s skillful worker commands-ACC completely do-PROG-PAST
‘The skillful worker who the foreman watched has always obeyed the commands fully.’

Prior to the experiment, we prepared 32 sets of SRC and ORC sentences, and conducted a norming study in order to eliminate semantic naturalness bias (i.e., *The policeman arrested the burglar* vs. *The burglar arrested the policeman*). In the norming study, 68 undergraduate students at Çanakkale Onsekiz Mart University participated (they did not participate in any of the three experiments). We prepared 4 counterbalanced lists and asked the participants to evaluate naturalness of the sentences (1: unnatural – 5: very natural) as in (16). The results of paired *t*-tests showed that semantic bias was found in 6 items (*p* < .05). Also, acceptability ratings of 2 items were lower than 3. We excluded 8 items from the experimental material. Overall acceptability rating was 3.51 for SRC and 3.54 for ORC condition.

In Experiment 3, we used 24 sets of SRC and ORC sentences and 72 filler sentences. We divided the experimental materials into 2 lists by a Latin Square design. Each participant was assigned to one list, and read 12 SRC and 12 ORC sentences with 72 filler sentences, ordered randomly. Thirty-five native speakers of Turkish participated in the experiment. They were either undergraduate or graduate students at Çanakkale Onsekiz Mart University who did not participate in any of the previous experiments (mean age: 23, SD=4.28). Sentences were presented on a computer monitor using Linger 2.94 (developed by Dough Rohde) in a word-by-word, non-cumulative reading task (Just, Carpenter and Woolley, 1982). After reading a sentence, the participants answered a yes-no comprehension question. Before the experiment, the participants were given a practice set of 6 sentences.

### 4.3.1 Results and Discussion

Statistical analyses for the reading times were conducted only on sentences wherein comprehension questions were correctly answered by the participants. The accuracy rate was 93% for SRCs and 92% for ORCs (*Fs* < 1). We removed the data from two participants and one item from data analysis because of their low accuracy rates (< 80%). Before comparing reading times, we discarded the data whose reading time was shorter than 250ms or longer than 2500ms and the data was further trimmed by excluding the data exceeding 3 SDs. This trimming process affected 4.5% of the reading time data. Average reading times of each word in two conditions are as shown in Fig. 1. Main region (word) of interest is RC-verb (region 2) and RC-head (region 4).

The results of ANOVA for repeated measures revealed that the main effect of the RC-type was significant only at the RC-verb position (region 2) (*F*₁(1,32) = 16.17, *p* < .01; *F*₂ (1,22) = 4.76, *p* < .05). In other regions, reading times between the SRC and ORC conditions did not differ significantly. This demonstrates that SRC verbs were read faster than ORC verbs (55 ms). In Turkish, ORC verbs are always longer than SRC verbs in terms of the number of letters. One may think that word length caused the processing asymmetry at the RC-verb. In order to eliminate this possibility, we calculated the residual reading times that allow us to see the reading times per letter (Frazier & Clifton, 1989). The results of ANOVA showed that the main effect of

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11 *F*₁ is used for subject analysis, and *F*₂ is used for item analysis.
RC-type was significant at the RC-verb only by subject analysis [$F_1 (1,32) = 6.58, p < .05$; $F_2 (1,22) = 2.01, p < .17$]. In other regions there was no significant difference. This indicates that SRC verbs were faster than ORC verbs, even when the word length was controlled.

![Relative Clauses in Turkish](image)

Fig. 1 Reading times for per region in Experiment 3.

Experiment 3 showed that SRCs were read faster than ORCs at the embedded verb position, and there was no significant difference in any other regions. This result indicates that SRCs are easier to process than ORCs in Turkish and supports our incremental prediction (14) over non-incremental prediction (15). In the next section, we will discuss the results of the three experiments in more detail.

5 General Discussion

In the present study, we attempted to answer the following research questions: (1) Do Turkish native speakers determine the existence of an RC before the RC-head appears, and (2) When is the processing asymmetry (if exists) between SRCs and ORCs observed? Major findings from the three experiments can be summarized as follows.

(I) Participants produced some RCs, even if they did not see the RC-verb; but the number of non-RC completions was much larger than RCs (Experiment 1).

(II) Participants produced RCs in nearly 100% of the cases, when sentence-fragments were presented with RC-verbs (Experiment 2).

(III) Participants read SRCs faster than ORCs (Experiment 3).

(IV) The processing asymmetry was observed as early as at the RC-verb (Experiment 3).

In the present study, we assume that the production rate of RCs reflects their predictability (Den & Inoue, 1997). Experiment 1 and 2 showed that Turkish native speakers can indeed predict the upcoming RC-head, when they encounter an RC-verb. In other words, the existence of the gap and the upcoming filler seem to be determined at the embedded verb position even before the RC-head appears, which indicates that the use of overt RC-markers is crucial. As it is clear from the production rates of SRCs and ORCs in Experiment 2, RC-markers do not only tell that a RC is being processed, but they also tell what kind of RC is being processed.
Experiment 3 revealed that SRCs were easier to process than ORCs. This result is consistent with the previous studies in head-initial and head-final languages (Dutch: Mak et al., 2006; English: King & Just, 1991; French: Holmes & O’Regan, 1981; Japanese: Ishizuka, 2005, Miyamoto & Nakamura, 2003; Sakamoto & Yasunaga, 2009; Ueno & Garnsey, 2008; Korean: Kwon, 2008). However, unlike Japanese and Korean, the processing asymmetry was observed only at the RC-verb position. These results show that the strong forward prediction for RCs observed in Experiment 2 is also reflected in online sentence processing in Turkish. At the RC-verb position, as soon as the grammatical function of the gap is determined, a processing asymmetry between SRCs and ORCs emerged. This indicates that the parser does not postpone the determination of an RC construction until the RC-head, and when it determines the gap, it immediately postulates a filler too. In other words, the parser starts to construct a gap-filler dependency from the RC-verb position, and hence the processing of gap-filler dependencies is also incremental as in the case of filler-gap dependencies.

It is important to consider what kind of structure is actually expected from a verb with a RC-marker. In Turkish, it does not necessarily predict RCs with an overt head, because headless RC constructions are possible, and the suffix DIK can also be used for adjunct clauses or noun complement clauses in Turkish (Kornfilt, 1997). However, in the present study, the participants completed sentence-fragments as SRCs and ORCs with an overt head, when they encountered the transitive embedded verbs, rather than producing an adjunct or noun complement clauses. This indicates that when Turkish native speakers encounter a transitive verb with the marker An or DIK, they primarily expect an RC construction with an overt head, rather than other types of construction. Therefore, a strong forward prediction exists for an RC-head (filler) at the RC-verb position in Turkish.

Let us turn to potential confounding factors. Since an SRC verb followed an accusative noun, and an ORC verb followed a genitive noun in Experiment 3, one may think that processing difficulty of the ORC verb simply reflects a kind of surprise effect, rather than the processing difficulty of gap-filler dependencies. After encountering a genitive noun, one would expect to encounter another noun, whereas one can easily predict a verb after an accusative noun. Although this possibility cannot be rejected from the results of present study, in another study (in progress) we conducted a self-paced reading experiment, inserting an adverb between the embedded noun and RC-verb. This manipulation increased the expectation for a verb even after a genitive noun, but ORC verbs were still read slower than SRCs, and there was no significant difference at the RC head-noun. This indicates that the processing asymmetry at the RC-verb indeed reflects the processing difficulty of gap-filler dependencies, rather than a surprise effect.

Another factor which might have influenced the result is an adjective modifier inserted before the RC-head. Unlike Japanese and Korean, there was no processing asymmetry at the RC-head. We attributed this difference to the immediate filler postulation at the RC-verb. Since the expectation of the filler has been fully established when the parser encounters the RC-verb, it is not surprising to see the actual RC-head noun. However, one may still think that the adjective between the RC-verb and the RC-head might have affected the processing ease of the RC-head, and consequently there was no difference between SRCs and ORCs, because an adjective heightens the expectation for a noun. Our study in progress again showed that there is no difference at the RC-head, even an adjective between the RC-verb and RC-head is removed. Thus, the processing symmetry at the RC-head reflects the immediate filler postulation, rather than the effect of an adjective.

12 See footnote 10 for the reason why we inserted adjectives before the RC-head.
Next we will discuss cross-linguistic differences in RC processing among head-final languages. Previous studies in Japanese have reported that Japanese native speakers also produce SRCs and ORCs more than 80% when they read until the embedded verb (Kahraman, Ono and Sakai, 2009; Ueno & Garnsey, 2008). Nevertheless, the processing asymmetry was always observed at the RC-head. In the case of Korean, to the best of our knowledge there is no reported sentence-fragment completion study, but the processing asymmetry was observed at the RC-verb and RC-head (Kwon, 2008). Why is it then that the position where processing asymmetry is observed differs among these languages? One possibility is that such difference might be derived from cross-linguistic variation with respect to the information available in making prediction for upcoming constructions.

Inoue & Fodor (1995) proposed information-paced parsing, and claimed that differences in the timing of decision making between the languages would be attributable to language specific differences in the ebb and flow of information. In Japanese RCs, case-markers are used, but no RC-markers are used. On the other hand, in Turkish and Korean RCs, both case markers and RC-markers are used. Our study showed that Turkish speakers can determine the existence of the RC construction at the RC-verb in online sentence processing. In Japanese on the other hand, although native speakers predict RCs at quite high rates when they encounter the verb (Kahraman et al., 2009), since the gap can also be interpreted as a pro, information from case-markers and the verb alone might not be strong enough to determine the RC, and to be sure they might prefer to see more conclusive information such as the head-noun. Thus the processing asymmetry between SRCs and ORCs would have been observed only at the RC-head. In Korean, since the same adnominal suffix is used for all types of RCs, even though the parser realizes the existence of an RC at the embedded verb position, it cannot strongly predict the type of RC and prefer to see the head-noun. Thus, the processing asymmetry might have been observed both at the RC-verb and the RC-head in Korean. Hence, the position where the processing asymmetry is observed might differ among Japanese, Korean and Turkish, and the existence and the type of RC-markers as well, would be responsible for this cross-linguistic processing difference.

Finally, we will mention issues related to RC processing left untouched in this study. In RC processing studies, one of the main concerns is to explain the source of the processing asymmetry between SRCs and ORCs. Many hypotheses have been put forward such as Dependency Locality Theory (DLT: Gibson, 1998), Structural Distance Hypothesis (SDH: O’Grady 1997), and probabilistic accounts (e.g, Levy, 2008). Since our main concern was to test the incrementality of gap-filler dependencies, we could not focus on explaining possible factors which might lead to the processing asymmetry. At this point, what we can say clearly is that DLT cannot explain our results, because it predicts that ORCs should be easier to process than SRCs in Turkish. On the other hand, SDH, which basically assumes that the depth of embedding a gap is the determining factor of the processing difficulty, can account for the present results, because the gap-site in ORCs is always more deeply embedded than in SRCs. However, as we mentioned in Experiment 1, Ishizuka (2005) argued that, a sentence initial accusative noun elicits a stronger expectation for an RC construction than a sentence initial nominative noun, and the processing asymmetry between SRCs and ORCs might simply reflect this expectation difference. The results of the Experiment 1 showed that the participants expected more RCs when they encounter an accusative noun than a genitive noun. In this respect, Ishizuka’s assumption might be applicable to Turkish data as well, and the observed asymmetry in Experiment 3 may be due the differences in predictability of SRCs and ORCs at the sentence initial position, rather than the embedding depth of a gap. Alternatively, both factors might also be interacting. In the future
studies we need to test the validity of structural and probabilistic factors and whether they are interacting too, in order to deepen our understanding of human sentence processing.

6 Conclusions

In the present study, using Turkish SRCs and ORCs, we examined whether gap-filler dependencies are processed incrementally in head-final languages. We argued that if the parser postulates a filler as soon as it determines the gap at RC-verb position, the processing asymmetry between SRCs and ORCs, which is assumed to reflects a relative ease / difficulty of establishing a filler-gap dependency (Gibson, 1998; O’Grady, 1997), would be observed at the RC-verb. In order to test this assumption, we conducted sentence-fragment completion experiments and self-paced reading experiment. Results of the sentence-fragment completion experiments showed that Turkish native speakers strongly predict upcoming RC-head at the embedded verb position. Results of the self-paced reading experiment showed that this strong forward prediction is also reflected in the online sentence processing. These findings suggest that in order to construct gap-filler dependency, Turkish native speakers do not wait until the RC-head, and as soon as the gap is determined, they immediately postulate a filler, and starts to construct a gap-filler dependency even before the filler appears. Therefore the processing of gap-filler dependencies is also incremental as in the case of filler-gap dependencies. Finally it seems that in addition to case markers, verb morphology is also a crucial source for decision making and incremental processing of gap-filler dependencies in head-final languages.

References


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