Processing subject and object relative clauses with numeral classifiers in Japanese
Barış KAHRAMAN† Kei TANIGAWA‡ and Yuki HIROSE‡

†The University of Tokyo/JSPS, Graduate School of Arts and Sciences, The University of Tokyo 3-8-1 Komaba, Meguro-ku Tokyo, 153-8902 Japan
‡The University of Tokyo, Graduate School of Arts and Sciences, The University of Tokyo 3-8-1 Komaba, Meguro-ku Tokyo, 153-8902 Japan
E-mail:† kahraman@phiz.c.u-tokyo.ac.jp, ‡ kei.tanigawa@gmail.com, ‡ hirose@boz.c.u-tokyo.ac.jp

Abstract In this study, using a self-paced reading task and sentence fragment completion task, we investigated the influence of matching and mismatching sentence initial numeral classifiers and relative clause (RC)-internal NPs on the processing of subject and object RCs in Japanese. The results showed that subject relative clauses (SRCs) were read faster than object relative clauses (ORCs) when the numeral classifier matched the NP within the RC. In contrast, when there was a numeral classifier mismatch, there was no statistical difference between SRCs and ORCs. Overall, our study suggests that whether numeral classifiers match NPs within RCs influences the processing of SRCs and ORCs in Japanese.

Keywords Relative clauses, sentence processing, subject and object asymmetry, Japanese, numeral classifiers

1. Introduction

Most of the previous studies on Japanese have shown that subject relative clauses (SRCs) are easier to comprehend (process) than object relative clauses (Miyanoto & Nakamura, 2003 [1]; Ishizuka, 2005 [2]; Ueno & Garney, 2008 [3]; Sakamoto & Yasunaga, 2009 [4]; Mitsugi, MacWhinney & Shirai, 2010 [5]; Sato, Kahraman & Sakai, 2010 [6]; Kahraman, Sato, Ono & Sakai, 2011 [7]; Kahraman, 2012 [8]; c.f. Ishizuka, Nakatani & Gibson, 2006 [9]; Kahraman, Ono & Sakai, 2009 [10]; Sato, Kahraman & Sakai, 2012 [11]).

(1) a. SRC

Sensei-o mikaketa gakusei-wa ichinensei-da.
teacher-ACC saw student-TOP first-grader-COP
"The student that saw the teacher is a first grader."

b. ORC

Sensei-ga mikaketa gakusei-wa ichinensei-da.
teacher-NOM saw student-TOP first-grader-COP
"The student that saw the teacher is a first grader."

Previous studies consistently reported that reading times of the head-noun gakusei-wa (student) of SRCs are faster than that of ORCs. This shows that the processing asymmetry between SRCs and ORCs in Japanese is observed when the structural ambiguity is resolved and the type of clause becomes evident. Regarding this processing asymmetry, Ishizuka (2005) argued that the predictability of SRCs and ORCs may be different, and this difference might lead to the processing difficulty in ORCs compared to SRCs [2]. In ORCs, a sentence starts with a nominative noun phrase (NP), as in canonical sentences. In SRCs, on the other hand, a sentence starts with an accusative NP. According to Ishizuka, a relative clause (RC) structure may be easier to predict in SRCs than ORCs because the sentence initial nominative NP encourages interpretation as a main clause, whereas a sentence initial accusative NP may signal the existence of an RC. However, this discussion is based on Ishizuka’s intuitions. It has not been empirically verified whether the processing of SRCs and ORCs differs when the RC predictability difference between the accusative-initial and nominative-initial structures is eliminated. To address this issue, we employed the numeral classifier mismatch paradigm proposed by Yoshida (2006) [12], and attempted

This article is a technical report without peer review, and its polished and/or extended version may be published elsewhere.

Copyright ©2014 by IEICE
to examine how match or mismatch between sentence initial numeral classifiers and NPs influences the processing of SRCs and ORCs in Japanese. In order to do this, we conducted a self-paced reading experiment and a sentence-fragment completion experiment.

This paper is organized as follows. In the next section we explain the logic of the numeral classifier mismatch paradigm. In Section 3, we show the details and results of our experiments. Finally, in Section 4, we evaluate our findings, and conclude that careful use of the numeral classifier mismatch paradigm may be an efficient tool for investigating the sources of the processing asymmetry between SRCs and ORCs in Japanese.

2. The numeral classifier mismatch paradigm

In head-initial languages like English, relative pronouns or complementizers (e.g. who, that) unambiguously signal the existence and the beginning of an RC. In a head-final language like Japanese, however, neither relative pronouns nor RC-specific suffixes (RC markers) are used. Therefore, the start of an RC is ambiguous, and its structural ambiguity is resolved at the head-noun (e.g., Mazuka & Itoh, 1995 [13]; Hirose & Inoue, 1998 [14], Yoshida, 2006 [12]). For example, a sentence fragment like sensei-o mikaketa can be interpreted as a main clause (I/somebody saw the teacher), or it can also be interpreted as a part of a subordinate clause, such as sensei-o mikaketa toki...(when I/somebody saw the teacher...), sensei-o mikaketa tame...(since I/somebody saw the teacher...) etc. In other words, the existence of an RC cannot be determined until the RC-head is encountered. This is a crucial characteristic of Japanese, and should be taken into consideration when we deal with the processing of RCs.

Yoshida (2006) pointed out that certain types of numeral classifiers may provide an unambiguous cue for an upcoming RC structure. According to Yoshida, a mismatch between the numeral classifier and an NP signals the existence of RC structure. For example, in (2a) the numeral classifier san-nin (3 persons) and gakusei (student) match. In (2b), on the other hand, there is a mismatch between the numeral classifier san-satsu (3 books) and gakusei (student).

In (2a), san-nin modifies gakusei, whereas san-satsu cannot modify gakusei (student) in (2b). According to Yoshida, this kind of semantic mismatch signals the existence of another NP, which is modified by the mismatching numeral classifier (i.e. book), and this implies the existence of an RC, the only possible structure, as illustrated in (3b).

(3) a. San-nin-no gakusei-ga shabette-iru.
   3-persons-gen student-nom chat-prog
   ‘Three students are chatting.’

b. San-satsu-no gakusei-ga yonda hon...
   3-books-gen student-nom read book
   ‘three books that the student read’

b’. San-satsu-no gakusei-ga yonda
   3-books-gen student-nom read
   ‘the student read three books’

In (3a), the sentence can be completed as a simple main clause. In (3b) however, the only way of completing the structure grammatically is producing an RC. In other words, without an RC structure, every continuation becomes ungrammatical, as shown in (3b’). Through a sentence-fragment completion experiment, Yoshida (2006) confirmed that a mismatch between the numeral classifier and an NP indeed increases the expectation for an RC structure. Moreover, using a self-paced reading task, Yoshida showed that RCs were processed more easily when there is a mismatch between the numeral classifier and NP, compared to the RCs where there is no such mismatch [12]. This indicates that the mismatch between a numeral classifier and an NP facilitates the processing of RCs in Japanese. In Yoshida’s study, the main concern was to examine the predictability of RC structures rather than to examine the processing difficulty of SRCs and ORCs. However, the numeral classifier mismatch paradigm provides an interesting test case to examine how the predictability of RC structure affects the processing of SRCs and ORCs in Japanese. If the processing difficulty of ORCs arise from their unpredictability compared to SRCs, as argued by Ishizuka (2005) [2], this difficulty should be eliminated when a mismatch between the numeral classifier and NP signals the existence of the RC. On the other hand, if the processing difficulty of ORCs in Japanese is not only due to its unpredictability, SRCs should be still easier to process, even when the mismatch between the numeral classifier and NP signals the existence of the RC. In order to examine these predictions we conducted two experiments.
3. Experiments

In the two experiments, we employed a self-paced reading task and a sentence-fragment completion task. In the self-paced reading task, we compared the reading times of SRCs and ORCs in match and mismatch conditions, and in the sentence-fragment completion task we confirmed the types of sentence structures produced in match and mismatch conditions.

3.1. Self-paced reading experiment

Aim: The aim of the self-paced reading task was to examine how a mismatch between a numeral classifier and an NP influences the processing of SRCs and ORCs. In order to do this, we used a two-by-two factorial design, preparing four conditions, as shown in (4) (i.e., matching: match vs. mismatch; RC-type: SRC vs. ORC).

Participants: Thirty-one college students, studying at the University of Tokyo participated in the experiment. They were all native speakers of various dialects of Japanese and received 1000 yen for their participation.

Materials: In (4a) and (4b), the numeral classifier hitori (one person) match the accusative and nominative NP ojisan (mister) within the RC. Therefore, there is no particular prediction for the RC structure at this point. On the other hand, in (4c) and (4d) the numeral classifier ichiwa (one bird) does not match the ojisan. Therefore, this mismatch signals the existence of a bird which can be modified only by an RC (Yoshida, 2006 [12]).

\[
\begin{align}
(4a) & \text{ a. Match-SRC} \\
& \text{Hitori-no kaikatsuna ojisan-o maneshita kiiori oumu-wa} \\
& \text{1 person-gen cheerful mister-acc imitated yellow parrot-top} \\
& \text{hakononaka-de urusaku nakihajimet.} \\
& \text{in box-loc loudly start crying} \\
& \text{The yellow parrot that imitated one cheerful mister started to} \\
& \text{squawk loudly in the box.'}
\end{align}
\]

\[
\begin{align}
(4b) & \text{ b. Match-ORC} \\
& \text{Hitori-no kaikatsuna ojisan-ga maneshita kiiori oumu-wa} \\
& \text{1 person-gen cheerful mister-nom imitated yellow parrot-top} \\
& \text{hakononaka-de urusaku nakihajimet.} \\
& \text{in box-loc loudly start crying} \\
& \text{The yellow parrot that one cheerful mister imitated started to} \\
& \text{squawk loudly in the box.'}
\end{align}
\]

\[
\begin{align}
(4c) & \text{ c. Mismatch-SRC} \\
& \text{Ichiwa-no kaikatsuna ojisan-o maneshita kiiori oumu-wa} \\
& \text{1 bird-gen cheerful mister-acc imitated yellow parrot-top} \\
& \text{hakononaka-de urusaku nakihajimet.} \\
& \text{in box-loc loudly start crying} \\
& \text{One yellow parrot that imitated the cheerful mister started to} \\
& \text{squawk loudly in the box.'}
\end{align}
\]

\[
\begin{align}
(4d) & \text{ d. Mismatch-ORC} \\
& \text{Ichiwa-no kaikatsuna ojisan-ga maneshita kiiori oumu-wa} \\
& \text{1 bird-gen cheerful mister-nom imitated yellow parrot-top} \\
& \text{hakononaka-de urusaku nakihajimet.} \\
& \text{in box-loc loudly start crying} \\
& \text{One yellow parrot that the cheerful mister imitated started to} \\
& \text{squawk loudly in the box.'}
\end{align}
\]

Procedure: In total, we prepared 24 sets of test sentences, like those shown in (4). In addition to these sentences, 96 filler sentences were used. Among these fillers sentences, 48 items were the test sentences of two other experiments. Using a Latin Square design, we divided the test sentences into four lists. Each participant was assigned to only one list, which consisted of 120 sentences. Fifty percent of these sentences were followed by a yes-no comprehension question. Using Linger 2.94, experimental sentences were presented randomly on a computer screen, as a word-by-word non-cumulative self-paced reading task.

Predictions: If the processing difficulty of ORCs is due to its unpredictability, in the match conditions the head-nouns of SRCs should be read faster than ORCs, and in the mismatch conditions, the processing difficulty of ORCs should be eliminated. In terms of statistics, there should be a significant interaction between matching and RC-type, and SRCs should be read faster than ORCs only in the match condition. If the processing difficulty of ORCs is not only due to unpredictability, SRCs should be read faster than ORCs in both match and mismatch conditions. In terms of statistics, only the main effect of RC-type should be significant.

Results: Prior to statistical analyses, we removed the trials with incorrect responses to the comprehension questions. We then removed the reading times that were longer than 2000 milliseconds (ms) or shorter than 200 ms. Finally, we calculated 2.5 standard deviations (SD) for each subject by region and removed the data points exceeding 2.5 SDs from the mean. This SD-based cutoff process affected the 3.13% of the remaining data. The mean reading times of SRCs and ORCs are shown in Fig.1 (match condition) and Fig.2 (mismatch condition).

In the first region where the numeral classifier appeared, there was a significant interaction between the matching and RC-type in the subject analysis ($F_1(1,30) = 4.89, p = .03, F_2(1,23) = 2.65, p = .12$), but there was no significant main effect of RC-type or matching. This sentence initial position is not critical for the results, and the interaction may be due to an experimental artifact. Therefore, we do not discuss this result. In region 2 and region 3, there were no significant main effects or interactions. In region 4, region 5, and region 6, where the RC and RC-head appeared, there were no significant interactions between the matching and RC-type (region 4: $F_1(1,30) = .00, p = .99, F_2(1,23) = 0.02, p = .90$; region 5: $F_1(1,30) = 1.55, p = .22, F_2(1,23) = 2.17, p = .15$).
region 6: \( F_1(1,30) = .02, p = .89, F_2(1,23) = .10, p = .76 \). In these regions, only the main effect of matching was significant (region 4: \( F_1(1,30) = 6.8, p = .01, F_2(1,23) = 5.24, p = .03 \); region 5: \( F_1(1,30) = 15.52, p = .0005, F_2(1,23) = 6.6, p = .02 \); region 6: \( F_1(1,30) = 10.85, p = .003, F_2(1,23) = 3.14, p = .09 \). These results show that RCs were read faster in the match condition than the mismatch condition.

\[
\begin{align*}
\text{Fig.1 Reading times of RCs in the match conditions} \\
\text{Fig.2 Reading times of RCs in the mismatch conditions}
\end{align*}
\]

In the spill-over region (region 7) where a locative adverb appeared, only the main effect of RC-type was significant \( F_1(1,30) = 6.13, p = .02, F_2(1,23) = 4.62, p = .04 \). This result shows that SRCs were read faster than ORCs. In order to examine the difference in the processing cost between SRCs and ORCs in the match and mismatch conditions separately, we carried out planned pair-wise comparisons. The results showed that SRCs (535 ms) was significantly faster than ORCs in the match condition by subject analysis (581 ms) \( F_1(1,30) = 5.04, p = .03, F_2(1,23) = 2.52, p = .13 \), but there was no significant difference between SRCs (556 ms) and ORCs (586 ms) in the mismatch condition \( F_1(1,30) = 2.15, p = .15, F_2(1,23) = 2.85, p = .10 \). In region 8, there was no significant interaction or main effect. In the matrix-verb position, there was only a main effect of RC-type \( F_1(1,30) = 4.28, p = .05, F_2(1,23) = 4.48, p = .05 \). Pair-wise comparisons again showed that SRCs (554 ms) were significantly faster than ORCs in the match condition (588 ms) \( F_1(1,30) = 4.42, p = .02, F_2(1,23) = 2.72, p = .11 \), but there was no significant difference between SRCs (561 ms) and ORCs (573 ms) in the mismatch condition \( F_1(1,30) = .64, p = .43, F_2(1,23) = .59, p = .45 \).

**Discussion:** There were no interactions at the critical regions. Thus, we cannot say that the prediction was supported. However, a direct pairwise comparison between SRCs and ORCs in the mismatch condition showed that the results at the spill-over region and the matrix verb are not fully incompatible with the prediction, as the difficulty of ORCs was reduced. This suggests that a mismatch between a numeral classifier and an NP is likely to have an impact on the processing of SRCs and ORCs in Japanese. By using the numeral mismatch paradigm, we had expected that the predictability of RCs would be increased due to number mismatch. In order to reevaluate the adequacy of our manipulation, we conducted a sentence-fragment completion experiment.

### 3.2. Sentence-fragment completion experiment

**Aim:** As we argued above, the mismatch between the numeral classifier and NPs might not have directly led participants to predict the RCs. To test what kinds of structures are actually predicted in the match and mismatch conditions, we conducted a sentence-fragment completion experiment.

**Participants:** Thirty college students, studying at the University of Tokyo, participated in the experiment. They were all native speakers of various dialects of Japanese and received 1000 yen for their participation in a set of experiments. They did not participate in the previous self-paced reading experiment.

**Materials:** We used the same test sentences as the first experiment, and displayed them up to the first NP, as shown in (5).

(5) a. Match-acc
Hitori-no kaikatsuwa ojisan-o
I person-gen cheerful mister-acc

(5) b. Match-nom
Hitori-no kaikatsuwa ojisan-ga
I person-gen cheerful mister-nom

(5) c. Mismatch-acc
Ichiiwa-no kaikatsuwa ojisan-o
I bird-gen cheerful mister-acc

(5) d. Mismatch-nom
Ichiiwa-no kaikatsuwa ojisan-ga
I bird-gen cheerful mister-nom

**Procedure:** There were 24 test sentences, as in the first experiment. In addition to these sentences, 36 filler sentences were prepared and pseudo randomly mixed with the test sentences. Using a Latin Square design, we divided the test sentences into four lists, and each
participant was assigned to only one list. Using Microsoft Excel, sentences were presented on a computer screen, and participants were asked to complete sentence-fragments as grammatical and natural Japanese.

**Predictions:** In the *match conditions*, since there is no semantic cue for an RC, the number (production rates) of RCs should be lower than other structures. In the *mismatch conditions*, since there is a semantic cue for the existence of RCs, the number of RCs should be very high compared to other structures (Yoshida, 2006: 206 [12]).

**Results:** Before calculating the numbers of structures we removed the ungrammatical completions, such as *ichiwa-no kaikatsuna ojisankō mita* (I/someone saw one bird mister). Moreover, we also removed the results of participants whose grammatical completions were less than 70%. In total, 463 sentences were coded as grammatical sentences. The results are as in Table 1.

**Table 1. The number of RCs and other structures**

<table>
<thead>
<tr>
<th>CASE</th>
<th>MACTH</th>
<th>MISMATCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>RC</td>
<td>NON-RC</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>(3.2)</td>
<td>(96.8)</td>
</tr>
<tr>
<td>NOM</td>
<td>1</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>(.08)</td>
<td>(99.2)</td>
</tr>
</tbody>
</table>

Percentages are shown in ()..

Table 1 shows that the participants overwhelmingly produced non-RC structures after accusative and nominative NPs in the *match condition*. On the other hand, in the *mismatch condition*, the number of RCs was higher than the number of other structures. The results of a binomial test showed that this difference was significant (in the ACC condition: $p = .0005$; in the NOM condition: $p = .001$). However, there was no significant difference between the number of RCs that were produced after accusative NPs and nominative NPs ($p = .43$).

**Discussion:** These results suggest that there is almost no expectation created for an RC when the numeral classifier matches the NP. When the numeral classifier does not match the NP, in contrast, the expectation for an RC structure increases conspicuously. However, in the *mismatch conditions*, participants also produced non-RC structures, and the production rates of RCs varied among the test items. This suggests that the RC was not the only possible completion, when a numeral classifier does not match an NP. This may be due to fact that numeral classifiers, like *hitori* (one person) and *futari* (two persons), can also be interpreted as headless possessors, as in *futari-no inu* (two persons’ dog / the dog owned by two of us). In our experiments, half of the mismatch sentences started with such numeral classifiers modifying people not animals, for the sake of counterbalance. Therefore, in contrast to the predictions of the numeral classifier mismatch paradigm (Yoshida, 2006 [12]), some non-RC structures were produced in the *mismatch conditions*. To examine whether the predictability of individual test items influenced the results of the reading experiment, we computed the production rates of RCs for each item, and included them in the model as a covariates. The results of ANCOVA showed that there were still no interactions between the matching and RC-type at the RC-head, spill-over region and the matrix verb (RC-head: $F(1,91) = .05, p = .82$); spill-over region: $(F(1,91) = .08, p = .78$); matrix verb: $(F(1,91) = .84, p = .36)$. There was only a significant main effect of RC-type at the spill-over region $(F(1,91) = 5.59, p = .02)$ and marginal main effect of RC-type at the matrix verb $(F(1,91) = 3.63, p = .06)$. These results show that even we control the predictability of RCs based on the sentence completion data, it did not affect the overall pattern of the results.

**4. General Discussion and Conclusions**

In the *match conditions*, SRCs were read faster than ORCs, as reported in previous studies of Japanese ([11]-[8]). In the *mismatch conditions*, although SRCs were read faster than ORCs, this difference was not statistically significant. This finding is different from previous studies of Japanese. However, in the *mismatch condition*, the processing difficulty of ORCs was not fully eliminated or reversed. To explore this more extensively, we conducted a sentence-fragment completion experiment. The results showed that almost no RCs were produced in the *match conditions*, while more RCs than non-RC structures were produced in the *mismatch conditions*. Moreover, the number of RCs was very similar in both *mismatch-acc* and *mismatch-nom conditions*, although the production rates of RCs (= the predictability of the RC structure) varied among the test items.

Taken together, these results indicate that the reduction in the processing difficulty of ORCs compared to SRCs in the *mismatch condition* may be due to the increase of overall predictability of the RCs. This result is partially in line with the argument of Ishizuka (2005) [2], which says the processing difficulty of ORCs may be due to their unpredictability. At the same time, however, our findings falsify Ishizuka’s claim that RCs are more predictable when the sentence initial NP is accusative compared to nominative, because almost no RC structures were produced in the *match conditions*. Therefore, in
Japanese, when there is no cue for the RC structure, ORCs are not less predictable than SRCs (see also Ueno & Garnsey, 2008 [3] and Kahraman et al. 2009 [10]), but SRCs are easier to process than ORCs. On the other hand, when there is a semantic cue for the existence of RC structure at the sentence initial accusative or nominative NP, RCs are predictable and the processing difficulty of ORCs is reduced to some extent.

As for the remaining processing asymmetry in the mismatch conditions, the following possibility can be considered. The results of sentence-fragment completion experiment showed that non-RC structures were also produced in the mismatch conditions, indicating that RCs were not the only possible structure. This implies that the reason why the processing difficulty of ORCs was not fully eliminated or reversed compared to SRCs may be due the incomplete predictability of non-RC structures in the mismatch conditions. As we explained in 3.2, when numeral classifiers modifying humans, such as futari (two persons), were presented in the sentence initial position, participants also produced sentences such as, future-no inu-ga aruite iru (two person’s dogs are walking), futari-no inu-o mita (I saw two person’s dog(s)). In the mismatch conditions, half of the test items consisted of this kind of numeral classifiers, and this might have somehow hindered the predictability of RC structures in our experiments. In other words, the manipulation of the numeral mismatch paradigm might have not worked adequately in this study. To make sure that the only possible structure is an RC, one would need to avoid the use of numeral classifiers that modify humans in the sentence initial position, and use other types of numeral classifiers that modify animals or inanimate NPs. We leave the examination of this issue for future study.

Overall, our study showed that, in Japanese, when there is no particular expectation for an RC structure, SRCs are easier to comprehend than ORCs. On the other hand, when there is a semantic cue for an RC structure, the processing difficulty of ORCs is reduced to some extent. This suggests that the predictability of RCs is likely to have an impact on the processing of SRCs and ORCs, but it is not the only source of the processing asymmetry. Moreover, our study also suggests that the careful use of the numeral classifier mismatch paradigm is an efficient tool for investigating sources of the processing asymmetry between SRCs and ORCs in Japanese.

Acknowledgments

This research was supported in part by Japan Society for the Promotion of Science (JSPS) Grant-in-Aid for Scientific Research (#25580086) to the third author. We also acknowledge the JSPS for the support to the first author (Sentence processing of Japanese and Turkish as a first and second language; Project No: 25/03004). Our special thanks go to Anna Gladkova for her help at various stages of this study. All remaining errors and shortcomings are, of course, our own.

References