Processing object relative clauses in the context
Another support for the discourse function account
for the processing load asymmetry

Atsushi Sato†  Barış Kahraman†  Hiromu Sakai†
† ‡ Graduate School of Education, Hiroshima University
E-mail: †  ‡ [asato1983, hsasaki]@hiroshima-u.ac.jp  ‡ eiyuheiwa@yahoo.co.jp

Abstract  Roland et al. (2007, 2008) argued that the processing load asymmetry between object and subject relative clauses (ORCs/SRCs) arose from discourse factors rather than structural factors. According to Fox and Thompson (1991), the discourse function of ORCs is to anchor a newly introduced noun to the context. The lack of appropriate context thus makes the processing of ORCs more difficult than that of SRCs. We conducted a self-paced reading experiment using Japanese relative clauses and observed that grounding to the context resolved the processing asymmetry between ORCs and SRCs. The result thus provides another support for the discourse function account.

Keyword  Anchoring, Context, Discourse, Grounding, Relative clause, Sentence processing, Topic

1. Introduction

‘... The types of music that I don’t like are opera, and screaming heavy metal ...’ (Roland et al. 2007)

People often use relative clauses (RCs) for introducing a new discourse referent (‘the types of music’) by using discourse topic (‘I’) [1]. In general, personal pronouns refer to entities that are topical. Many researchers have found an extinguished difficulty in processing of object relative clause (ORC) when RC-internal NP is pronominal [2, 3, 4]. Roland et al. [5, 6] hypothesize that the asymmetry in RC processing is derived from the functional dissatisfaction of ORC. We conducted an experiment inspired by Roland et al.’s insight and found results in support for their functional account.

1.1. Hypotheses for relative clause processing

The inquiry into RC processing was initiated by examining the source of difficulty in forming filler-gap dependencies [7]. Dominant hypotheses were based on structural factors, such as linear distance [8] and structural depth [9].

As the research had progressed, however, other factors were found that showed significant impact on the processing difficulty [Animacy: 10, 11, 12; Frequency: 13]. In addition to these studies, Roland et al., proposed a new view, which takes the discourse function of RCs as the factor that determines the processing difficulty of ORCs.

1.2. More on Roland et al. (2007)

The hypothesis proposed by Roland et al. is based primarily on Fox & Thompson’s idea [1]. They argued that ORCs are typically used for grounding modified NP in the discourse context, and subject relative clauses (SRCs) for other purposes, such as supplying additional information about the modified NP. Then, when the embedded NP is not grounded, ORCs will incur more processing difficulty than that of SRCs.

According to Roland et al., previous researches that found relative difficulty in ORCs did not supply appropriate contexts and this functional dissatisfaction might have caused delay in ORCs. In order to test the effect of appropriate context, Roland et al. conducted an experiment using two contexts (appropriate vs. neutral, see Table 1). They found no difference at RC combined region (3 and 4) in appropriate condition. In neutral condition, reading time of ORCs was significantly longer than that of SRCs.

Table 1  Example of Roland et al. (2008)

<table>
<thead>
<tr>
<th>Appropriate condition</th>
<th>Neutral condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>The banker was friendly.</td>
<td>There was a dinner party Saturday night.</td>
</tr>
<tr>
<td>RC SRC The lady that visited the banker enjoyed the party.</td>
<td>ORC The lady that the banker visited enjoyed the party.</td>
</tr>
</tbody>
</table>

2. Importance of research on Japanese

Although Roland et al’s [5, 6] results are in favor of their discourse-based account, their support is not strong enough due to the head-initial nature of English relative clause. Since the head noun precedes the relative clause, it is not clear at which point the head noun is ‘grounded’...
in the context. As a result, we are not sure whether the processing load observed in Roland et al’s experiment reflects the lack of appropriate context for grounding head noun into the context.

In addition, the reading time increase is mainly observed at the RC-internal NP region in the neutral condition (squared region in the example below).

(1) The lady that [he banked] visited ...

(2) The lady that visited [he banked] ...

The RC-internal subject is already mentioned in the appropriate condition, whereas it is newly introduced in the neutral condition. Although Roland et al. [6] reported that the repetition of non-topic NP rather leads to ‘repeated noun penalty’, it does not exclude the possibility that the repetition of topic NP is mainly responsible for the reduction of processing difficulty. It would be desirable if the same effect is observed in a region which does not contain the repeated NP.

In short, the discourse-based account can be supported more effectively if we can measure the processing load of the relative clause at the region that is more directly related to the discourse ‘grounding’ process and does not contain the repeated NP. We can provide ideal experimental material for these respects by using Japanese relative clauses.

Since Japanese relative clauses are strictly head-final, it is reasonable to assume that the grounding of RC head must take place in the head noun region (squared region in the example below). The reading time increase at this region must be directly related to the grounding process.

(3) gakusei-ga hihansi-ta kenkyuusya student-NOM criticize-PAST researcher “the researcher that the student criticized”

(4) gakusei-o hihansi-ta kenkyuusya student-ACC criticize-PAST researcher “the researcher that criticized the student”

In addition, since the head noun itself does not appear in the previous context, the effects of NP repetition can be strictly controlled. We can thus present more direct support for the discourse-based account using Japanese materials.

Finally, the results of experiments using Japanese materials provide insight into the universality of the discourse-based account. Since Japanese is often argued to be a discourse oriented language [14], it might be that context effects are more robust in Japanese.

Based on these considerations, we conducted an experiment using Japanese relative clauses.

3. Experiment

3.1. Method

3.1.1. Participants

42 graduate and undergraduate students from the Hiroshima University participated in the experiment.

3.1.2. Materials

20 experimental items were used with 4 conditions. Each item contains 3 sentences (Pre-RC, RC, and
Wrap-up sentences, see Table 1). These items were
divided into 4 lists by Latin square design. Each list was
combined with 48 filler sets. Filler sets contained 2 or 3
sentences.

In the appropriate condition, first sentence introduced a
person as the topic in discourse (nihonzin-no daigakuinsei
“Japanese graduate student”), and the introduced noun
re-appeared at second sentence as a subject/object in a RC.
In the neutral condition, humans were not used in the first
sentence, but were used in a relative clause in the second
sentence. In the appropriate context condition, for the
naturalness of RC sentences, and in order to avoid the
repeated noun penalty, we used “sono (that)”. RC
sentences were divided into regions as follows; Region1
(\{sono/nihonzin-no\}), Region2 (daigakuinsei-{o/ka}),
Region3 (kihansi-ta), Region4 (rikigaku-no), Region5
(kenkyuusya-wa), Region6 (okotte), Region7 (kaizyou-o),
Region8 (ato-ni-si-ta).

Before the experiment, we conducted a norming study
in order to test the plausibility of the used materials. 26
sets of relative clauses were compared in pairs by \(t\)-test.
As a result 4 sets were significantly different, and 2 sets
were excluded due to low acceptability. The total number
of excluded items is 6.

3.1.3. Procedure

We used a word-by-word self-paced moving window
paradigm. Whole sentences were presented to the subjects
word-by-word. We used a DELL laptop, and the
experiment was conducted on Linger Ver.2.84 software
(developed by Dough Rohde). Yes/No questions followed
the end of each set of sentences.

3.2. Results

3.2.1. Data Trimming

Analysis for reading times was conducted only on
correct responses. 3 subjects and 1 item were excluded
because of low comprehension accuracy (subjects: < 70%;
item: < 60%) and the data exceeding 2 SD was also
excluded. In total, the excluded data comprises 3.8% of
all data.

3.2.2. Comprehension Accuracy

Overall accuracy was 89%. ANOVA reveals no reliable
difference in accuracies [RC type: \(F_1(1, 38) = 0.05, MSe = 0.07, p > .10, F_2(1, 18) = 0.41, MSe = 0.79, p > .10\);
Context type: \(F_1(1, 38) = 1.39, MSe = 0.07, p > .10, F_2(1, 18) = 2.54, MSe = 0.79, p > .10\], and No interaction
was found \([F_1(1, 38) = 0.16, MSe = 0.07, p > .10, F_2(1, 18) = 1.22, MSe = 0.79, p > .10]\).

3.2.3. Reading time

Reading time analyses were conducted only on the RC
sentences. The critical region is 5 (relative head region).
At region 5(kenkyuusya-wa “researcher-TOP”), the main
effect of RC type was significant \([F_1(1, 38) = 18.244, MSe = 150.135, p < .01, F_2(1, 18) = 4.202, MSe = 205.876, p = .05]\). The main effect of context type was
significant only in subject analysis \([F_1(1, 38) = 9.252, MSe = 150.135, p < .05, F_2(1, 18) = 2.899, MSe =
205.876, p = .11]\). The relatively small number of items
might have some influence on the results of the item
analysis. The simple main effect analyses showed the
following pattern. The RC type had no effect in the
appropriate condition \([F_1(1, 38) = 1.59, MSe = 141.001, p > .10, F_2(1, 18) = 1.06, MSe = 184.881, p > .10]\). In the

![Fig. 1 Mean reading times in the appropriate condition](image1)
SRC, subject relative clause; ORC, object relative clause

![Fig. 2 Mean reading times in the Neutral condition](image2)
SRC, subject relative clause; ORC, object relative clause
4. Discussion

4.1. Region 3

The appropriate context eliminated the processing asymmetry between SRCs and ORCs. Ueno & Garnsey [15] argued that the parser is surprised by the initial O-marked NP of the sentence and this surprise effect would be spilt over the verb region. If their argument is on the right track, a grounded referent reduces the markedness of the initial O-marked NP of the sentence.

4.2. Region 5

These results are naturally accounted for by the discourse function hypothesis by Roland et al. [5]. The appropriate context greatly reduced the processing load of ORCs as shown in Fig. Since ‘grounding process’ seems to occur at the RC head region in Japanese, it is reasonable to think the processing load reduction observed in our experiment is initiated by the appropriate context.

As an alternative to Roland et al.’s discourse function hypothesis, Mak et al. [11, 18] proposed a topichood hypothesis. Their hypothesis assumes that an entity that has higher topicworthiness in an RC is regarded as a syntactic subject. According to the topichood hypothesis, in the appropriate condition, RC-internal NPs are higher in topicworthiness and the parser analyzes them as the subject of the RC. This prediction accelerates the processing of ORCs in the appropriate context because RC-internal NPs are actually in the syntactic subject position.

The topichood hypothesis share some intuition with discourse function hypothesis and equally effective in explaining English data. The results of our experiment, however, cannot be easily explained by the topic hypothesis because Japanese relative clauses are head-final and reading time difference is observed not at the RC internal NP position but in the head noun position. Since topichood hypothesis is concerned about processing of the subject NP in RCs, it cannot explain the processing difficulty of the head noun.

Finally, although the effect turns out to be not significant, we observed 57 ms difference between SRCs and ORCs in neutral condition. This might be caused by structural factor [9]. Dependency Locality Theory (DLT) [8] predicts ORCs are easier to process than SRCs in Japanese. This prediction is inconsistent with experiments in Japanese. But Warren & Gibson [4] revised DLT; discourse status also affects the integration cost. Although it predicts that ORCs are basically easier in
Japanese, DLT might be right under the condition that the discourse status of NP is equal like Ishizuka et al. observed [19]. It might be argued that reduction of processing load of ORC is not the effect of context but the effect of anaphoric expression “sono (that)”. In some researches [2, 13], the processing load of ORCs is reduced or eliminated even under the isolated sentences when RC-internal NPs are pronoun. We leave this possibility open for future research.

Van den Broek [20] and his colleagues [21] argued that during discourse processing, the inference has a special role on bridging sentences. Because the sentences in the neutral condition might be more distant than those of the appropriate condition, the backward inference, which bridges between discourse and a newly introduced sentence, incur heavier processing load in the neutral condition than in the appropriate condition, and this cognitive load might be responsible for the results in our experiment. If the second sentence is headed by “Kaizyou-de (at the hall)”, the backward inference might be easier and, as a result, the cognitive load can be reduced.

(5) gakkai-ga kaisai-sare-ta.
   conference-NOM hold-PAS-PAST
   “The conference was held.”

Kaizyou-de gakusei-{o/ga} hihansi-ta
   hall-LOC student-{ACC/NOM} criticize-PAST
kenkyuusya-wa ...
   researcher-TOP
   “The researcher that {criticized the student/the student criticized} at the hall ...”

If the difference of the cognitive load for bridging between the first and second sentence in each condition is the main source of the difficulty observed in our experiment, the use of “Kaizyou-de” in the second sentence should eliminate the processing difficulty in neutral condition. We leave this unanswered question for a further study.

5. Conclusion

In this study, we presented a new set of supporting data for the discourse function account for the processing difficulty using head-final Japanese relative clauses. Combined with the previous research using head-initial relative clauses in English or Dutch [5, 6, 18], our result indicated some universal characteristics of the discourse function of object relative clauses. Further research is needed to clarify the exact nature of discourse function of relative clauses and their relationship to topichood [11, 18], inference [20, 21], or other discourse related concepts.

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