

# “Prediction” Reverses the Processing Difficulty of Subject and Object Relative Clauses in Japanese<sup>\*</sup>

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Keywords: sentence processing, relative clause, sources of difficulty

## 1. Introductions

Many researchers in psycholinguistics have conducted studies focusing on the processing of relative clause in various languages. Over the past few decades, two related questions have been the subject of controversy. One is about what types of relative clauses are difficult to process, and the other concerns what the source of this difficulty is for native speakers of that language.

Some researchers have reported that subject relative clauses (SRCs; 1a), in which the subject noun phrase of the clause is extracted to the head noun position, are easier to process than object relative clauses (ORCs; 1b), in which the object noun phrase of the clause is extracted to the head noun position, in English.

- (1) a. Subject relative clause (SRC)  
the reporter<sub>i</sub> [RC who \_\_\_\_<sub>i</sub> attacked the senator]  
b. Object relative clause (ORC)  
the reporter<sub>i</sub> [RC who the senator attacked \_\_\_\_<sub>i</sub>]

The difference of processing difficulty between these two types of structures has been explained by the difference in distance between the two

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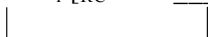
<sup>\*</sup> This paper is based on the presentation at the 90th Kyushu University Linguistics Colloquium (2014, August, 21st) and the 4th Symposium on Cognitive Science in Kanazawa (2015, March, 4th). I thank those who have given me valuable suggestions and comments.

elements that have to be integrated, —the head noun (“the reporter”) and its original position (“\_\_\_\_\_” or gap). The distance between the head noun and its gap in (1b) is longer than that of (1a). It has been argued that the longer distance in (1b) demands more working memory than (1a), and yields a larger processing cost. Here, what matters is the metric of distance between these two elements. One approach to this issue is called the “linear distance hypothesis (LDH)” (Gibson, 2000), and the other is called the “structural distance hypothesis (SDH)” (O’Grady, 1997). Plainly speaking, the former measures the distance by means of the number of intervened linguistic elements between the head noun and its gap, the latter measures the distance by means of the number of syntactic nodes between the two elements.

(2) a. linear distance hypothesis

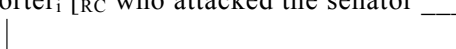
i) SRC

the reporter<sub>i</sub> [RC who \_\_\_\_\_<sub>i</sub> attacked the senator]



ii) ORC

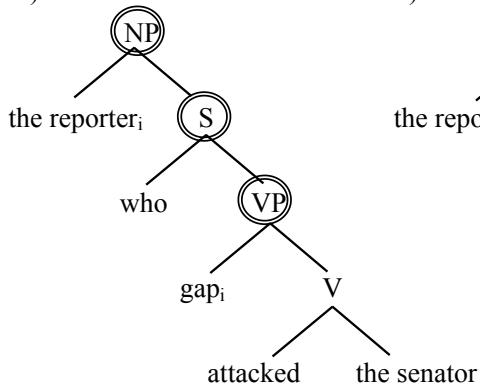
the reporter<sub>i</sub> [RC who attacked the senator \_\_\_\_\_<sub>i</sub>]



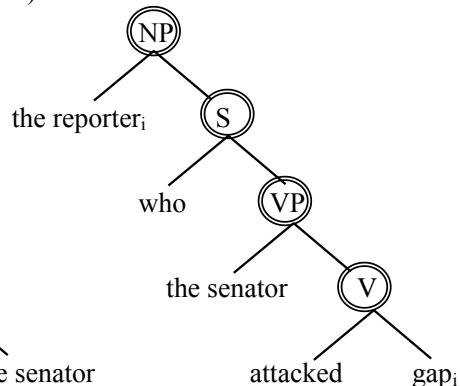
b. structural distance hypothesis

#The ⊙s indicate intervened syntactic nodes.

i) SRC



ii) ORC

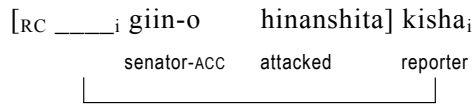


Both of the hypotheses predict that ORCs (1b) are more difficult than SRCs (1a), for the distance of the two elements is longer in (1b) regardless of whether LDH or SDH is used, as shown in (2). Thus, we cannot determine

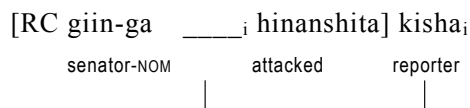
which metrics are valid for the measurement of the distance between the head noun and its gap in English.

Ishizuka (2005), however, has pointed out that we can resolve this matter in Japanese.

(3) a. SRC in Japanese



b. ORC in Japanese

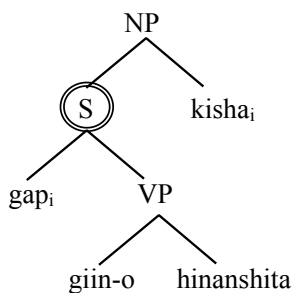


Contrary to English, the head noun of the relative clause follows its modifying clause in Japanese. In such a case, SRCs are longer than ORCs in terms of the distance between the head noun and its gap, according to the LDH, as illustrated in (3). On the other hand, according to SDH, the ORCs are longer than SRCs, as in (4).

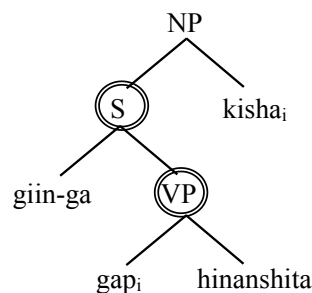
(4) Two types of relative clause structure in Japanese

#The ⊙s indicate intervened syntactic nodes.

a. SRC



b. ORC



Hence, if the difference of processing costs for two types of relative clause structures is determined only by means of the distance between the head noun and its gap, we can draw different predictions. If LDH is a valid hypothesis, the processing cost for SRCs is higher than for ORCs; on the

other hand, if SDH is valid, the ORCs are harder to process than SRCs.

Ishizuka (2005) and many other researchers have reported that ORCs are more difficult to process than SRCs, using various experimental methods (Miyamoto & Nakamura, 2003, Sato, 2011, Sakamoto & Yasunaga, 2009, Ueno & Garnsey, 2008 etc.). Based on these experimental facts, many researchers have accepted that the structural distance between the head noun and its gap determines the difference in processing difficulties for SRCs and ORCs.

This study, however, points out the possibility that the difference of processing costs for SRCs and ORCs in Japanese is not determined by the structural distance. Furthermore, we will show that ORCs are easy to process if the condition is met. Finally, we claim that processing difficulty is not only determined by the structural complexity but also by the predictability of the following structures.

## 2. Predictability of relative clause structure

This study argues whether the SDH is a valid hypothesis to explain processing difficulty of ORCs than SRCs in Japanese. In English, the larger processing cost of ORCs can be explained by both linear and structural distance. Is the explanation for the larger processing cost in Japanese ORCs then confined to the structural distance hypothesis?

Koreeda (2009), for instance, has reported longer reading times for dative-gap relative clause constructions, as in (5b), in the case of a three-place predicate being used in the relative clause. If only the structural distance is determinant of the processing difficulty, we would expect the larger processing cost for the accusative-gap relative clause (5a). Her result, therefore, suggests that the processing cost of the relative clause is not determined only by the distance between the head noun and its gap.

### (5) a. Accusative-gap relative clause

[tan'nin-ga            tenkoosei-ni \_\_\_\_i shookaishita] iinchoo<sub>i</sub>  
homeroom teacher-NOM    transfer student-DAT            introduced            leader of a class

“The leader of a class whom the homeroom teacher introduced to the transfer student.”

b. Dative-gap relative clause

[tan'nin-ga \_\_\_\_<sub>i</sub> tenkoosei-o shookaishita] iinchoo<sub>i</sub>  
 homeroom teacher-NOM transfer student-ACC introduced leader of a class

“The leader of a class to whom the homeroom teacher introduced the transfer student.”

Miyamoto & Nakamura (2003) have noted that the difference in sentence processing mechanisms for SRCs and ORCs may also explain the difference in processing costs, and not only the distance between two elements.

(6) a. [RC \_\_\_\_<sub>i</sub> obasan-o miokutta] on'nanoko<sub>i</sub>  
 woman-ACC accompanied girl

“the girl who accompanied the woman”

b. [RC obasan-ga \_\_\_\_<sub>i</sub> miokutta] on'nanoko<sub>i</sub>  
 woman-NOM accompanied girl

While the sentence processor would posit a gap at the region of *obasan-o*, “woman-ACC” (that is, the first region of the string) in the subject relative clause (6a), the reader cannot post a gap until the region of *miokutta*, “accompanied”(the second region of the string) in the object relative clause (6b). The earlier sentence processor notice the necessity of the gap, or filler-gap dependency, the smaller the cost for processing.

According to these studies, the processing difficulty of the relative clause may not only be determined by the structural distance. This requires a new experiment for comparing SRCs and ORCs in which the timing to posit the gap or to build the relative clause is controlled. In so doing, we would verify the difference of processing costs for SRCs and ORCs, and consider the reason for such.

Here, we will introduce Yoshida (2006), who has considered the predictability of relative clause structures based on the lexical congruency of two nouns. Yoshida (2006) states that a mismatch between a classifier and an adjacent noun phrase provides a strong cue for relatives (p. 227).

- (7) a. dono seito-ni tannin-wa san-nin-no toshioita  
 which student-DAT homeroom teacher-TOP three-CL.PERSON-GEN elderly  
 sensee-ga \_\_\_\_\_.  
 teacher-NOM
- b. dono seito-ni tannin-wa san-satsu-no toshioita  
 which student-DAT homeroom teacher-TOP three-CL.BOOK-GEN elderly  
 sensee-ga \_\_\_\_\_.  
 teacher-NOM

For example, the relation between the quantifier *san-nin*, “three-CL.PERSON,” and the modified noun *sensee*, “teacher,” is lexically congruent in (7a), because the classifier *nin* is used to indicate the number of nouns referring to humans like *gakusee*, “student,” and *kyoojyu*, “professor.” On the other hand, the quantifier *san-satsu*, “three-CL.BOOK” and *sensee* have an incongruent relationship, for the classifier *satsu* is used to express the number of nouns referring to books, notes, and memos (Iida, 2004). Yoshida (2006) conducted a sentence completion task to confirm the hypothesis that the incongruence between a classifier and noun can predict the relative clause. The result of the completion task is illustrated in Table 1. Table 1 shows us that in the case of lexical congruence between a classifier and noun, as in (7a), participants seldom produced relative clauses, whereas the ratio was significantly higher when the lexical relation was incongruent, as in (7b). These results indicate that the prediction of the relative clause depends on the lexical congruency between the classifier and modified noun.

Yasunaga & Niikuni (2015) have reported that semantic mismatch evokes us the predictions for the relative clauses as well, and they also have reported that the case marker draws a prediction for what types of relative clause structures will be used. Subject relative clauses and object relative

Table 1. Yoshida's (2006) results

	Relative Clause		Other	
	#	%	#	%
(7a) match	1	0.1	1,018	99.9
(7b) mismatch	851	80.05	212	19.95



Table 2. Yasunaga &amp; Niikuni's (2015) results

	RC	NRC	*	N/R
(9a) mismatch-accusative	296	0	136	24
(9b) match-accusative	1	455	0	0
(9c) match-nominative	3	453	0	0
(9d) mismatch-nominative	293	0	139	24

RC: relative clause, NRC: non-relative clause, \*: ungrammatical, N/R: non-response

elicits a relative clause structure, reproducing Yoshida's (2006) results. This could be because the sentence processor could not avoid predicting relative clauses in order to posit another noun in this grammatical position, due to the mismatch between the classifier and noun. Next, the results showed that the case marker information that attached to the noun revealing the relative clause determines the type of relative clause, —either subject relative clause or object relative clause. It seems reasonable to suppose that the strength of the prediction is not different between clause types.

This section has observed that differences in predictability may result in variable processing difficulty. We have pointed out that the difference in difficulty for SRCs and ORCs in Japanese can be explained in this way, and that the semantic incongruence between a classifier and a noun elicits the prediction of a relative clause structure. Moreover, we have shown that case marker information affects the prediction of the type of relative clause. Here, one related question arises: is the information about incongruence and the case marker referred to in on-line, real time sentence processing? We report our experimental facts in the next section.

### 3. Experiment

#### 3.1. Aim and prediction

We now address the problem that the preference for the subject relative clause shown in many previous studies is responsible for the longer structural dependencies in object relative clauses, or for the difference in predictability between subject and object relative clauses. If only a longer structural dependency determines the larger processing cost for the object relative clause, any type of object relative clause will yield a longer reading time than the subject relative clause.



### 3.2. Participants

Nineteen students from Kanazawa University participated in the experiment (19 - 23 years old). They were all native speakers of Japanese. They were told the procedure for the experiment in advance. Written informed consent was obtained from all participants prior to the experiment. They received a portion of class credit and a bookstore gift card (¥1,000) for their participation.

### 3.3. Materials

The participants read sentences that involve semantic incongruence between numeral quantifiers at Region 1 (R1) and nouns at Region 2 (R2), as in (10).

(10) a. mismatch-SRC

San-nin-no    zasshi-o    manbikishita    shoogakusei-wa  
three-CL.PERSON-GEN    magazine-ACC    shoplifted    elementary student-TOP  
keibiin-ga    hodooshita.  
security guard-NOM    caught

“The security guard caught three elementary students that shoplifted magazines.”

b. mismatch-ORC

San-satsu-no    shoogakusei-ga    manbikishita    zasshi-wa  
three-CL.BOOK-GEN    elementary student-NOM    shoplifted    magazine-TOP  
hahaoya-ga    kaeshita.  
mother-NOM    returned

“His mother returned three magazines that an elementary student shoplifted.”

The semantic mismatch between R1 and R2 can be a good predictor of relative clause structures, both in (10a) and (10b). Moreover, the reader can predict a SRC in (10a) and an ORC in (10b) by referring to case markers that are attached to the noun in R2. Generally speaking, the processing load of the relative clause structure is maximized at the region of the relative head nouns (R4). If we observe the difference in reading time for R4, in (10a) and (10b), we can conclude that the difference in integration difficulty between

Table 3. The results of the control of the lexical items

	Frequency	Familiarity	# of characters	# of morae
(10a) mismatch-SRC	3855.9	6.2	2.9	4.0
(10b) mismatch-ORC	4257.7	6.2	2.5	2.6

a head noun and its gap yields this difference in reading time.

In our experiment, we prepared 12 pairs of sentences that involve relative clause structures —12 SRC sentences like (10a) and 12 ORC sentences like (10b). An additional 72 sentences were added as distractors. In total, 96 sentences were presented in this experiment. In the present study, we directly compare the different words, such as *shoogakusei*, “elementary student,” and *zasshi*, “magazine.” To avoid a lexical effect, we controlled the frequency, the visual familiarity, the number of characters, and the number of morae, as in Table 3. The frequency and the familiarity were referred from Amano & Kondo (1999, 2000). Although it cannot be reported in detail here for lack of space, none of these indices differed statistically.

### 3.4. Procedures

We adopted a self-paced reading method using SuperLab 4.0.7b (Cedrus Inc.). After the presentation of the fixation point (★) on a CRT screen, participants read a sentence silently phrase-by-phrase while pressing a specified button (RB-530; Cedrus Inc.). Each phrase appeared at the center of the screen. After a participant pressed the button, a new phrase was presented on screen and a clock-timer began. Participants had to press the button as quickly as possible after reading each phrase, so that the clock-timer would stop and the next phrase would be presented. After a certain region was presented, the amount of time until the button was pressed was recorded. After the presentation of the stimulus sentence, each other sentence posed sentence comprehension tasks. The task was alternative-forced-choice task using a response box, whose response and reaction time were recorded after each trial. The stimuli were presented in randomized order for each participant. These procedures are illustrated in

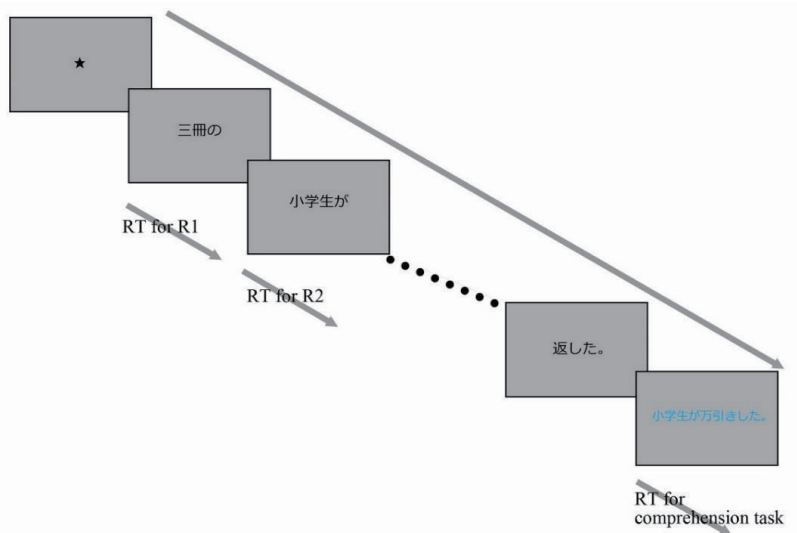


Figure 1. The procedure for the self-paced reading experiment

Figure 1. To help maintain participants' concentration, a several-minute break was given after about every 20 trials. The total duration of the experiment was around 40 minutes per participant, including the time required to give instructions, obtain written informed consent, practice, record, take breaks, and so on.

### 3.5. Results and Discussion

Only correct responses were subject to analysis. Three participants were rejected because their correct rate was less than 75% for the comprehension task in either or both the mismatch-SRC condition (10a) and the mismatch-ORC condition (10b). Prior to statistical analysis, the data was screened on the basis of the following criteria. For each participant's data, RTs exceeding an average  $\pm 2.5$ \*standard deviation were discarded. Figure 2 illustrates the averaged RT for each condition for all regions.

The repeated measures ANOVA was performed on the mean RTs for the region of the head nouns (R4). The experimental design used one factor with two levels (factor: type of relative clause; levels: (i) SRC (ii) ORC). In both the participant analysis ( $F_1$ ) and the item analysis ( $F_2$ ), the main effects of the type of relative clause were significant ( $F_1(1, 15) = 4.44, p < 0.05$ ;  $F_2(1, 11) = 5.21, p < 0.05$ ). In all other regions, the differences of RTs were

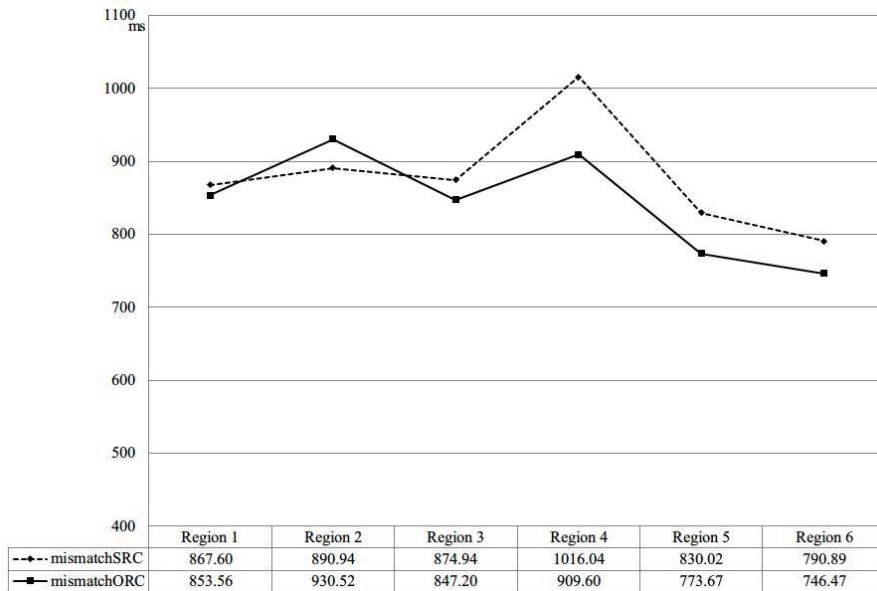


Figure 2. The result of self-paced reading experiment.

not statistically significant in either the participant analysis or item analysis ( $F_{1s} < 1$ ,  $F_{2s} < 1$ ).

The results show that ORCs are easier to read than SRCs in the case of our experimental stimulus. Particularly in the region of the relative head noun, SRCs required a longer reading time than ORCs.

#### 4. General discussion

In this study, we have dealt with the question of whether the processing difficulty for object relative clauses in Japanese can only be explained by means of the longer structural distance between a head noun and its gap. As a result of our experiment controlling the predictability of subject and relative clauses, we have shown that the object relative clause had a shorter reading time than the subject relative clause. The results suggest that the processing costs of relative clauses depend on not only the structural distance between two elements, but also other factors, such as predictability of the (type of) relative clause structures. A similar suggestion was reported by Kahraman et al. (2014) on the basis of their own experimental results. Although they did not observe a reverse effect in reading time of SRCs and

ORCs, they reported that SRCs required a reading time nearly equal to ORCs. At the very least, both studies have indicated that SRCs are not always easier to read than ORCs.

Some recent studies have reported that structural distance is not the only determining factor for processing costs in other languages. Even in languages in which ORCs are more complicated than SRCs, it has been reported that ORCs are easy to read in particular situations (Basque; Carreiras et al., 2010, English; Roland et al., 2012). From this viewpoint, we may say that researchers should consider the timing to notice the (type of) relative clause when examining differences of processing costs for the two types of relative clauses.

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## 先読みによる文処理負荷の変化：日本語の主語関係節と目的語関係節を対象に

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ここ 10 年の日本語文処理研究において、しばしば取り上げられてきた話題の一つに、「主語関係節 (SR) と目的語関係節 (OR) の処理負荷の大小とその原因」がある。そこで行われてきた議論の中心は、主語関係節 ([ gap 議員を非難した] 記者) よりも、目的語関係節 ([議員が gap 非難した] 記者) のほうが主要部名詞 (HN) と空所 (gap) との間の構造上の距離が長いために、その処理負荷が大きくなるというものであった。

本研究では、OR の困難さの原因として、HN と gap 間の構造上の距離以外に、関係節構造を含む記号列であること、およびその関係節構造の種類が何であるかの 2 つに関わる予測可能性が関わっている可能性を指摘する。そして、それらの要因を統制した場合には OR のほうが読み時間が短くなるという事実を提示する。