# The Dependency between a Quantifier and a Bound Pronoun : Its Effects on the Processing of Relative Clauses

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# The Dependency between a Quantifier and a Bound Pronoun: Its Effects on the Processing of Relative Clauses*

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## 1. Introduction: Processing of Relative Clauses

Dependency formation is obviously one of the key topics in sentence processing research. Relative clauses as shown in (1) are a representative structure investigated quite a lot in the context of dependency formation (see Ford, 1983, Frazier, 1987, Holmes and O'Regan, 1981, among others).

(1) a. The reporter [who __ attacked the senator ] admitted the error.
b. The reporter [who the senator attacked __ ] admitted the error.

The basic observation is that, in English and many other languages, the subject relative clause (1a; SRC) is processed faster than the object relative clause (1b; ORC) (e.g., King and Just, 1991). One major account claims that ORC is difficult to process because the gap position, indicated by the underline in (1), is deeply embedded in the structure, compared with the gap in SRC (Structural Distance Hypothesis; e.g., Hawkins, 1999, O'Grady, 1997). There is also an

* Each year, at our favorite *nooha maturi* 'EEG festival' organized by Professor Tsutomu Sakamoto and his students, someone (and often more than one) talked about dependency formation. Because we are in fact one of those who have presented some experimental results on dependency formation at the meeting, and because we missed the chance to present some follow-up work to Sakamoto-*sensee*, we do so in this volume, instead. We sincerely miss him, and wonder what he would think about our work. This work is supported by JSPS Grant-in-Aid for Scientific Research (C) #15K02529 (PI: Hajime Ono), (B) #24320072 (PI: Yuki Hirose), (B) #25284083 (PI: Masayuki Asahara). We would like to thank Masatoshi Koizumi, Yoko Nakano, Kentaro Nakatani, Yuki Hirose, Manabu Arai, Hiromu Sakai, Satoshi Tomioka, Takeo Kurafuji, and the participants for *nooha matsuri* for their valuable comments and suggestions. All remaining errors are our own.

account that suggests the linear distance between the gap and the head noun of the relative clause ("the reporter") is responsible for the processing asymmetry (Linear Distance Hypothesis; e.g., Gibson, 1998, Gibson and Warren, 2004). According to this account, ORC is difficult to process because the dependency length, closely related to the number of intervening words, between the head noun of the RC and the object gap is longer than that for the subject gap.

Miyamoto and Nakamura (2003) examined the above-mentioned two hypotheses using relative clauses in Japanese like (2). Syntactic properties of Japanese allow them to create a paradigm where the Linear Distance Hypothesis and the Structural Distance Hypothesis make different predictions for the processing cost of the relative clause in Japanese.

(2) a. [obaasan-ga __ basutee-made miokutta] syoozyo-wa . . .
old.lady-NOM bus.stop-to sent.off girl-TOP
'the girl who the old lady sent off to the bus stop'

b. [ __ obaasan-o basutee-made miokutta] syoozyo-wa . . .
old.lady-ACC bus.stop-to sent.off girl-TOP
'the girl who sent off the old lady to the bus stop'

In (2), the linear distance between the gap position in the ORC and the head noun of the relative clause is shorter than the distance between the gap position in the SRC and its head noun. Being different from English relative clauses, the Linear Distance Hypothesis predicts that the ORC in Japanese be processed faster than the SRC.

Miyamoto and Nakamura (2003) showed that the reading time of the relative clause head noun in SRC was faster than that in ORC, suggesting that the Linear Distance Hypothesis made a wrong prediction. At the same time, however, they discussed some factors that may have influenced the results. For example, they noted that the Japanese readers could realize the existence of the gap in SRC when they encounter the sentence-initial accusative NP. Such a prediction is possible because, in Japanese, a nominative NP canonically occurs before an accusative NP, and such a nominative NP is missing in SRC. In ORC, the readers can predict the existence of the gap in the object position when they see the verb in the relative clause. It is not clear exactly how such a difference influences the reading time of the relative clause, but it is one confounding

factor that has to be handled with care.

## 2. Distance Effects

The results from Miyamoto and Nakamura (2003) did not show clear support for the prediction from the Linear Distance Hypothesis, which argues that the linear distance of the dependency determines its processing cost. However, as noted above, the existence of the gap in the relative clause might have influenced their results, which could neutralize the effects predicted by the Linear Distance Hypothesis. Note that both of the Linear and Structural Distance Hypotheses calculate the processing cost of the dependency in a purely representational matter. They do not say much about the incremental nature of the sentence processing. Obviously, the timing when the readers of Japanese notice the existence of the gap in the relative clause is a matter of incremental processing. It seems quite complicated how those considerations interact, unfortunately.

It should be emphasized also that those hypotheses make predictions with regard to structures other than relative clauses. For example, Ono and Nakatani (2014) investigated the processing cost related to the linear distance between the *wh*-phrase and the predicate that assigns a thematic role to the *wh*-phrase. Using the following paradigm (only shown schematically), they observed that the reading time of the verb (V1) increased when the distance between the *wh*-phrase and its predicate was long as shown in (3a), compared to (3b).

(3) a. *Wh*-NOM [ embedded clause ] V1-Q NP-TOP V2.
b. [ embedded clause ] *Wh*-NOM V1-Q NP-TOP V2.

The distance effects that are observed with *wh*-interrogative sentences indicate that the linear distance of the dependency is at least one major component that contributes to the processing cost.

Based on their observation, Ono and Nakatani (2014) propose a generalization that a dependency in Japanese shows a distance effect when it involves a quantifier. So far, the set of paradigms invested in detail is quite limited, it would be desirable to examine further cases to test whether their generalization holds true.

In fact, the experiment conducted in Ono and Ikemoto (2013) provides

data related to the generalization with respect to the distance effects. One particular issue that should be checked against the generalization above is the empirical coverage of the generalization. Most, if not all, of the paradigms tested with respect to the distance effects so far involve the dependencies with nominal elements and their predicates. If, however, an important 'ingredient' for the distance effect is an involvement of a quantifier, as Ono and Nakatani (2014) argue, then the distance effect should be observed in a dependency with a quantifier and a variable that is bound by the quantifier. In other words, the locus of the distance effects should not be limited to the position of predicates.

Ono and Ikemoto (2013) utilize the pronoun *soko* 'there', which functions as a variable when bound by a quantifier (Hoji, 1995, Hoji, Kinsui, Takubo and Ueyama, 2000, Ueyama, 1998). They use the following paradigm as shown in (4). These sentences differ with respect to the position of the pronoun *soko*. Each target sentence starts with an adjunct phrase, such as *ryokoozassi niyoruto* 'according to the travel magazine'.

(4) a. Pronoun in Subject-RC

[ soko-no okami-ga kyaku-o kantaisiteiru]
there-GEN landlady-NOM guest-ACC welcome

dono-ryokan-mo yokuzyo-no soozi-ga ikitodoiteiru
every-inn-also bathroom-GEN cleaning-NOM well-done

'Every inn where its landlady welcomes guests cleans the bathroom thoroughly.'

b. Pronoun in Object-RC

[ okami-ga soko-no kyaku-o kantaisiteiru]
landlady-NOM there-GEN guest-ACC welcome

dono-ryokan-mo yokuzyo-no soozi-ga ikitodoiteiru.
every-inn-also bathroom-GEN cleaning-NOM well-done

'Every inn where the landlady welcomes its guests cleans the bathroom thoroughly.'

The paradigm in (4) is a good test case in the following respects. First, the two conditions are different in terms of the distance between the universal quantifier *dono-ryokan-mo* 'every inn' and the bound pronoun. The distance is longer in (4a) than (4b). If the linear distance is a key factor for determining the

processing cost of the dependency, it is expected that the longer dependency renders a large processing cost. Second, the paradigm in (4) involves a relative clause structure. Although they are not SRC or ORC, the position of the pronoun that has a dependency relation with the head noun is more-or-less parallel to SRC or ORC in some relevant sense.

One clear difference is that SRC and ORC has a gap in an argument position while the relative clauses in (4) do not. But this particular point eliminates the confounding factor discussed in the previous section. If a presence of a gap somehow provides some indication that a relative clause structure is coming, and if getting such information earlier gives an advantage for the SRC, this accounts for a faster reading time of SRC in Japanese. However, because the dependent element in (4) is not a gap but a visible pronoun, readers could not realize the existence of relative clause until they encounter the head noun of the relative clause, and there is no difference between the two sentences in (4) with this respect. If those considerations go through, the paradigm in (4) allows us to measure the processing cost of the dependency between the dependent element in the relative clause and the relative clause head noun.

In their self-paced reading experiment, Ono and Ikemoto (2013) observed that the reading time of the head noun in the pronoun in the subject NP condition (4a) was longer than that in the pronoun in the object NP condition (4b). The pattern was different from the results observed in Miyamoto and Nakamura (2003) with gapped relative clauses. Assuming that there is some inherent cost associated with the dependency formation, regardless of the dependent element being the gap or the bound pronoun, the slowdown which is previously observed in ORC may not directly support the claim that the Structural Distance Hypothesis is correct.

The results observed in Ono and Ikemoto (2013) suggest that the distance effect exists not only between an NP and its predicate, but also between a quantifier and its bound pronoun. Furthermore, a dependency formation between an element inside the subject and the relative clause head noun is more costly than that between an element inside the object and the relative clause head noun, when the reader recognizes the existence of relative clause at the head noun. We would like to further examine this distance effect in this paper. First, the target sentences of the Pronoun in the Subject condition in Ono and

Ikemoto (2013) start with an adjunct phrase and the pronoun *soko*. Because the experiment does not use any context sentence preceding the target sentence, the readers could be confused about what is the referent of this pronoun. In the experiment described below, the pronoun is introduced in a slightly later position. Second, the kind of effects observed in Ono and Ikemoto (2013) is one of the initial attempts to examine the dependency relation between the quantifier and the bound pronoun. Then, it seems appropriate to test whether the same pattern emerges in a slightly different experimental material. The experiment described in the next section serves this purpose.

## 3. Experiment

### 3.1 Participants and Materials

Twenty-nine university students participated in the experiment. They were paid 800 yen for participation in the experiment, which took approximately 30-40 minutes including some paperwork and a brief instruction for the experiment.

For this experiment, 24 sets of target sentences and 50 filler sentences were prepared. A sample set of the target is shown below; two target conditions were made by manipulating the position of the pronoun *soko*. In (5a), a pronoun *soko* with a genitive marker is attached to the dative-marked NP in the relative clause. On the other hand, in (5b), the pronoun is attached to the accusative-marked NP in the relative clause. All of the predicates within the relative clause have the causative marker, *-ase*, in order to match the animacy between the dative- and accusative-marked NP.

(5) a. Pronoun in NP-DAT relative clause

sinbun-niyoruto, [kee'eesya-ga soko-no syakaihukusisi-ni
newspaper-according.to owner-NOM there-GEN caseworker-DAT
kooreesya-o kaigos-ase-ta] dono ryooyoosisetu-mo
elder.people-ACC give.care-caus-PST every care.facility-also
nyuusyosya-no kenkoo-kanri-ni tikara-o ireteiru.
user-GEN health-control-DAT power-acc is.making

"According to the newspaper, every care facility where the owner made its caseworker give care to the elder people is making a strong effort for controlling the user's health condition."

b. Pronoun in NP-ACC relative clause

sinbun-niyoruto, [kee'eesya-ga syakaihukusisi-ni soko-no
newspaper-according.to owner-NOM caseworker-DAT there-GEN
kooreesya-o kaigos-ase-ta] dono ryooyoosisetu-mo
elder.people-ACC give.care-caus-PST every care.facility-also
nyuusyosya-no kenkoo-kanri-ni tikara-o ireteiru.
user-GEN health-control-DAT power-acc is.making
"According to the newspaper, every care facility where the owner made the caseworker give care to its elder people is making a strong effort for controlling the user's health condition."

The relative clause structure in the target sentences are all headed by a universal quantifier with the form *dono N-mo* 'every N-also.' The head of the relative clause is an inanimate NP, typically a place or some kind of institution, showing the location where the causative event represented by the relative clause took place. Note that there is no missing argument within the relative clause. By manipulating the position of the pronoun *soko*, the distance between the pronoun and the universal quantifier in (5a) is linearly longer than (5b).

### 3.2 Procedure

The experiment was conducted with Linger, developed by Douglas Rohde. Linger is a program widely used for sentence processing experiments. In the experiment, sentences were presented one by one; each sentence was initially presented as a sequence of dashes. Participants read the sentences by pressing a space bar, and each word (or *bunsetu* in Japanese) appeared from left to right in a non-cumulative, moving-window manner (Just, Carpenter, and Woolley, 1982). Twenty-four sets of target sentences were distributed into 2 lists, in a Latin Square design. Fifty filler sentences were added to each list, resulting in the total of 74 sentences for each participant. Those experimental sentences were presented in a different pseudo-random order for each participant. The participants were asked to read sentences as they do in a daily life, comprehending the content of the sentences. Each stimulus sentence was followed by a yes-no question regarding the content of the sentence just presented. When the participants made mistakes, a feedback was given so that they were encouraged to stay focus on what they read.

### 3.3 Results

Based on the comprehension accuracy data, reading time data from 4 participants were eliminated whose accuracy rates were less than 60%. Also, the data from 2 target sets were excluded; the accuracy rates for those target sentences were less than 50%. The overall mean accuracy rate was 79.3% (82.4% for Pronoun in NP-ACC condition; 76.1% for Pronoun in NP-DAT condition). The difference between the two conditions with respect to the comprehension accuracy rates was significant (though barely) only in the item analysis ($F_1(1,24)=2.48$, $p>0.10$, $F_2(1,21)=4.31$, $p=0.05$), suggesting that the Pronoun in NP-dative condition was slightly more difficult than the Pronoun in NP-accusative condition.

The reading time data was trimmed by eliminating data longer than 3.5 standard deviation from the mean reading time of its region. All the wrongly answered trials were also excluded. The reading time data for the target sentences are partly summarized in Figure 1.

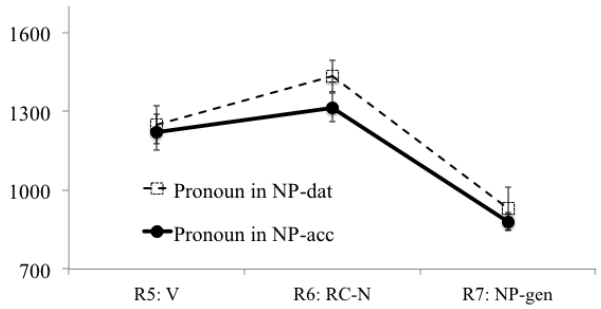


Figure 1. Mean reading time (ms) of region 5–7 (R5-7) for the target sentences.

In region 6 (the critical region), ANOVA revealed that the Pronoun in NP-dative condition was read slower than the Pronoun in NP-accusative condition, but the difference was statistically significant only in the subject analysis ($F_1(1,24)=4.77$, $p<0.04$, $F_2(1,21)=0.68$, $p>0.10$). There was no significant reading time difference in region 5 or region 7.

## 4. Discussion and Conclusion

The results obtained in the current experiment show the similar pattern as in Ono and Ikemoto (2013). The reading time of the relative clause head noun is

faster when the dependency is linearly shorter. This suggests that the processing advantage in SRC can be accounted for by some mechanism other than the Structural Distance Hypothesis. For instance, Roland, Mauner, O'Meara, and Yun (2012) argue that the processing cost of ORC is based on the inappropriate use of ORC without introducing the proper referent which is typically played by the subject inside the relative clause (see also some other explanation by interference effect: e.g., Gennari, Mirkovic, and MacDonald, 2012; Gennari and MacDonald, 2008, Gordon, Hendrick, and Johnson, 2004). If the use of relative clause in which the head noun is a quantifier eliminates (or, at least, weakens) the above-mentioned discourse requirement for ORC, the current results can be interpreted as showing the clear processing cost associated with the dependency formation itself.

Although the results obtained here are suggestive, there are some concerns that need attention in the future research. First, in the target sentences, the pronoun *soko* appears before the quantifier that binds it. Because there is no *a priori* requirement for readers to take the pronoun as a bound variable at the beginning, the reader interprets the pronoun as referential. Then, the reader has to revise their initial hypothesis about the interpretation of the pronoun. At this point it is not clear whether such a revision is costly, but the processing cost at the relative clause head noun includes some revision cost. It seems important to investigate whether and how the distance effect and the revision cost interact.

Second, the target sentences, when they are read until the region of the relative clause head noun, involve a left-edge ambiguity. The structure that is shown in (6a) is the intended one. The relative clause contains three noun phrases: nominative, dative, and accusative NPs. Crucially, the relative clause is made so that there is no gap in an argument position. On the other hand, in (6b), the relative clause contains a gap in the subject position. Then, the quantifier is a head of the relative clause, functioning also as a subject in the relative clause. The sentence-initial nominative NP is not parsed as a part of the relative clause, but as a subject in the main clause. The quantifier, then, functions, most likely, as an object in the main clause.

(6) a. Pronoun in NP-DAT relative clause
. . .[$_{RC}$ NP-NOM *soko*-GEN NP-DAT NP-ACC V ] dono-NP-mo
b. . . . NP-NOM [$_{RC}$ __ *soko*-GEN NP-DAT NP-ACC V ] dono-NP-mo

If the readers prefer the structure (6b) to (6a) when they encounter the head of the relative clause, the account entertained here needs to be reconsidered. But, such "mis-analysis" further requires the reanalysis in the following part of the sentence because there is another accusative NP in target sentences. As far as we can tell, there is no strong indication of such an effect. Furthermore, even though there is a preference for treating the nominative NP as an argument in the main clause, it seems plausible to assume that there is no difference between the two conditions with respect to the strength of such a preference. Those possibilities certainly require further investigation.

To sum up, it has been shown in the current experiment that the dependency between the head of the relative clause and the dependent element within the relative clause is more costly when the linear distant of the dependency is large. This result is contrastive against the previous finding regarding the contrast between SRC and ORC. The type of relative clause that is used in the current experiment does not have a gap in an argument position. It is suggested that the processing advantage of the SRC observed previously does not necessarily support the Structural Distance Hypothesis, and the current finding about the dependency between a quantifier and a pronoun, on the other hand, provides a strong support for the strong impact by the linear distance of the dependency.

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# 量化詞と束縛変項代名詞の依存関係：関係節処理に対するその効果

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依存関係をテーマとする多くの先行研究によって、主語関係節に比べて目的語関係節の処理コストが高いことが示されている。日本語のように関係節が主要部の名詞句に先行する言語においても同様の対比が見られることは、一見すると所謂構造的距離の仮説と呼ばれる説明が適切であるかのように感じられるが、空所の存在位置といった交絡因子になりうる要素などのために、結論は明らかではない。また、*wh* 句に関する依存関係に対しては、線形的距離が処理コストを決定していることを示す結果が得られている。本研究では、Ono and Ikemoto (2013) の先行研究に倣い、関係節を使いつつ、関係節主要部名詞の量化詞と、それによって束縛される関係節内の代名詞（変項）の依存関係を対象とした実験を実施した。束縛された代名詞（変項）が関係節内で統語的により深い位置（そして線形的には主要部名詞に近い位置）に存在する条件で、関係節主要部の名詞句の読み時間が短くなることを観察した。このことは、項位置が空所である関係節を使用した、日本語についての先行研究で観察された主語関係節の処理上の優位性は、依存関係の処理コストが一般的に構造的距離によって決定されていることを直接的に示すものではないことが示唆される。