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Is the Subject-Gap Preference Universal? An Experimental Study of Cleft Constructions in Japanese

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Is the Subject-Gap Preference Universal? An Experimental Study of Cleft Constructions in Japanese

Is subject-gap preference universal?

An experimental study of cleft constructions in Japanese

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1 Introduction

Numerous studies of sentence comprehension have focused on clarifying the mechanisms for associating long-distance words during on-line processing. In particular, relative clauses and cleft constructions have attracted a considerable amount of attention because the diversity of structural differences among various languages allows researchers to explore the language-universal and language-specific aspects of sentence comprehension. For example, consider the English relative clauses and cleft constructions shown in (1-2).

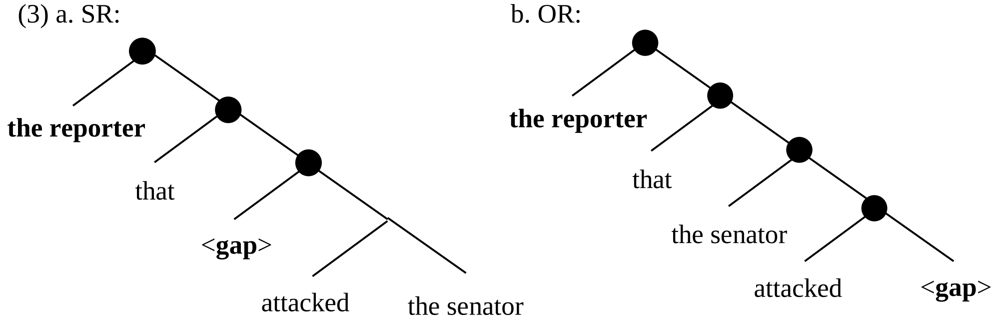
(1) a. Subject relative clauses (SR):
The reporter that <**gap**> attacked the senator admitted the error.
b. Object relative clauses (OR):
The reporter that the senator attacked <**gap**> admitted the error.
(King & Just 1991:581)

(2) a. Subject cleft constructions (SC):
It was **the barber** that <**gap**> saw the lawyer in the parking lot.
b. Object cleft constructions (OC):
It was **the barber** that the lawyer saw <**gap**> in the parking lot.
(Gordon et al 2001:1418)

The results of earlier studies have indicated that subject-extracted constructions are easier to process than object-extracted constructions in English (i.e., the subject-gap preference, Ferreira 2003, Gordon et al 2001). Two hypotheses have been proposed to account for this subject-gap preference in English, namely the "Structural Distance Hypothesis (SDH)" (O'Grady 1997) and the "Dependency Locality Theory (DLT)", often called the "Linear Distance Hypothesis (LDH)" (Gibson 1998, 2000). Both hypotheses share an assumption that one of the major sources of processing difficulties in relative clauses and cleft constructions is the integration of the displaced element (i.e., a filler, such as the reporter/barber in (1-2)) into its original position (i.e., a gap). However, as their names suggest, they use different distance metrics.

SDH explains that the integration of the filler (i.e., the reporter), and its gap becomes more difficult as the structural distance between them increases. As illustrated in (3), the subject-gaps are structurally closer to the gap than the object-gaps. Thus, SDH can correctly predict the subject-gap preference in English.

(3) a. SR: b. OR:



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By contrast, LDH accounts for the subject-gap preference in terms of the linear distance between the filler (i.e., the reporter) and its gap. LDH predicts that the integration of the filler and its gap will become more difficult as the linear distance between them increases. As shown in (4), the linear distance between the filler and its gap is shorter in subject-extracted constructions than in object-extracted constructions. Thus, LDH also predicts the subject-gap preference in English.

(4) a. SR:
The reporter that <**gap**> attached the senator admitted the error.

b. OR:
The reporter that the senator attached <**gap**> admitted the error.

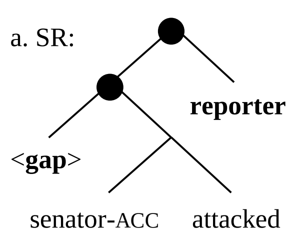
2 Previous Studies

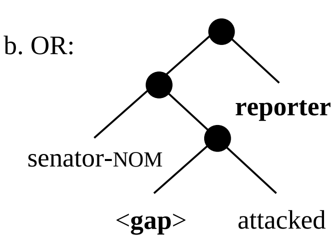
In Japanese, Miyamoto and Nakamura (2003) and Ueno and Garnsey (2008) reported that subject relative clauses are easier to process than object relative clauses.[1]

(5) a. SR:
[<**gap**> shinnin-no giin-o hinanshita] **kisha-ni-wa** naganen-no aibou-ga
[new-GEN senator-ACC attacked] reporter-DAT-TOP long-term-GEN colleague-NOM
ita.
existed.
'The reporter [(who) attacked the new senator] had a long-term colleague'

b. OR:
[shinnin-no giin-ga <**gap**> hinanshita] **kisha-ni-wa** naganen-no aibou-ga
[new-GEN senator-NOM attacked] reporter-DAT-TOP long-term-GEN colleague-NOM
ita.
existed.
'The reporter [(who) the new senator attacked] had a long-term colleague'
(Ueno & Garnsey 2008:659)

This consistent subject-gap preference is explained best by SDH (O'Grady 1997). This hypothesis predicts that, in all languages, subject-extracted constructions will be easier to process than object-extracted constructions because hierarchically higher subjects are closer to the gap position than lower objects are.

(6) a. SR:


b. OR:


Conversely, LDH incorrectly predicts the object-gap preference in Japanese because the linear distance between the filler (i.e., the reporter) and its gap is smaller in object-gaps than in subject-gaps.

[1] A similar subject-gap preference was also observed in relative clauses in Turkish, Chinese, and Korean (Hsiao and Gibson 2003, Kahraman 2012, Kwon 2008), although some problems have been noted (cf. Ishizuka et al 2006).

(7) a. SR:
[<**gap**> shinnin-no giin-o hinanshita] **kisha**-ni-wa....

b. OR:
[shinnin-no giin-ga <**gap**> hinanshita] **kisha**-ni-wa....

In contrast to the results of studies supporting the subject-gap preference, Kahraman et al (2011a) reported experimental evidence for an object-gap preference in Japanese cleft constructions. Consider the following examples in which the OCs were read more rapidly than the SCs at the embedded verb position (e.g. *kaihoushita-nowa*, 'nursed-nowa').

(8) a. SC constructions:
Kyonen [<**gap**> sobo-o inaka-de kaihoushita-nowa **shinseki**-da-to] haha-ga it-ta.
Last year Grandma-ACC village-LOC nursed-nowa relative-COP-COMP mother-NOM say-PAST
'Mother said it is the relative who nursed my grandmother last year at the village.'
b. OC constructions:
Kyonen [sobo-ga <**gap**> inaka-de kaihoushita-nowa **shinseki**-da-to] haha-ga it-ta.
Last year Grandma-NOM village-LOC nursed-nowa relative-COP-COMP mother-NOM say-PAST
'Mother said it is the relative whom my grandmother nursed last year at the village.'
(Kahraman et al 2011a:141)

SDH predicts that the integration process may be more difficult in OC than in SC because the structural distance is longer in the object-gap than in the subject-gap. Thus, this result of the object-gap preference may refute SDH.

The result of the object-gap preference supporting LDH, however, could be accounted for by the "transitional probability (TP)" of SC/OC, independent of the integration process (Kahraman et al 2011b). The TP is a conditional probability statistic that measures the predictability of adjacent elements (Thompson and Newport 2007). The formulation is defined as follows:

(9) Probability of Y | X = frequency of XY / frequency of X

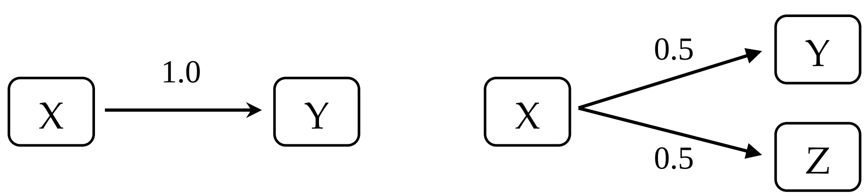


Figure 1. Transitional Probabilities.

For example, if an element Y always follows an element X, then the TP of Y at X is 1. If the frequency of another element Z following X is the same as that of Y, then the TP of Y at X is 0.5. In the latter case, the temporal uncertainty regarding subsequent elements increases relative to the former case because the parser cannot determine whether Y or Z appears next at the point of X. That is, the TP indicates the degree of certainty with which the parser can predict the upcoming element. Accordingly, such uncertainty or ambiguity causes additional difficulties for the parser when processing the input.

Examining data in the corpus data, Kahraman *et al*. (2011b) indicated that the TP of SCs for "NP-ACC + verb-nowa" sequences was 0.57, whereas the TP of OCs for "NP-NOM + verb-nowa" was 0.75.

Sequences	Total number	Clefts within total number	Transitional probability
NP-ACC + transitive verb-nowa	357	SC: 205	**0.57** (205/357)
NP-NOM + transitive verb-nowa	114	OC: 86	**0.75** (86/114)

Table 1: Transitional probabilities of SC and OC in Japanese (Kahraman et al 2011b:70).

The value 0.57 indicates the percentage of SC among the "NP-ACC + verb-nowa" constructions. In other words, the percentage of "non-SC" is 0.43. Meanwhile, the percentage of "non-OC" among the "NP-NOM + verb-nowa" constructions is 0.25. This difference between non-SC (0.43) and non-OC (0.25) indicates that the ambiguity of the former is much higher than that of the latter. Because the constructions containing "verb-nowa" in Japanese are not restricted to SC and OC, they are often interpreted as other cleft constructions and non-cleft constructions.[2] For example, non-argument elements, such as locative phrases and adjective phrases, are allowed to follow "verb-nowa."

(10) a. Locative phrase constructions:
Kyonen Ichiro-ga/o teatsuku kaihoushita-nowa jikka-dat-ta.
Last year Ichiro-NOM/ACC carefully nursed-nowa family house-COP-PAST
'It was in the family house that Ichiro nursed carefully/nursed Ichiro carefully.'
b. Adjective phrase constructions:
Kyonen Ichiro-ga/o teatsuku kaihoushita-nowa taihen-dat-ta.
Last year Ichiro-NOM/ACC carefully nursed-nowa hard-COP-PAST
'It was hard for Ichiro to nurse carefully/nurse Ichiro carefully.'

Because the "verb-nowa" sequence is not always interpreted as a part of cleft sentences, the parser's uncertainty regarding the subsequent elements at the "verb-nowa" position may have affected the processing cost. Kahraman et al (2011b) suggested that the asymmetrical degree of this uncertainty of SCs/OCs may account for the observed object-gap preference. However, the question remains. Kahraman et al (2011a) argued that the integration process starts at the pre-filler region (i.e. *kaihoushita-nowa*, 'nurse-nowa') in Japanese clefts, which also generates an additional processing cost. If this argument is correct, the results of the object-gap preference can be interpreted in the following two ways. One possibility is that a larger gap-filling cost due to longer linear distance in favor of LDH, together with a larger cost due to TP, caused additional difficulties for the parser in processing the SCs, resulting in a significant OCs processing advantage. The other possibility is that the gap-filling process in OCs was more costly than in SCs due to the larger structural distance in favor of SDH; however, the effect was overridden by that of TP effect, which rendered the costs of the gap-filling process undetectable. In other words, under conditions of an unbalanced TP, it is not evident whether the cost of the integration process is larger in SCs or OCs at the "verb-nowa" position. Unless we eliminate the structural ambiguities at the point of the "verb-nowa" position, we cannot properly examine the validity of SDH or LDH in terms of their integration costs independently from consideration of the asymmetrical effects of TPs in cleft constructions.

One way to avoid confounding the effect of TP with that of the integration process is to control the TP so that it is equal in both SCs and OCs. Accomplishing this allows the potential effect of the structural ambiguities to be separated from the effect of integration (i.e. gap-filling) costs. Only when we eliminate the effect of structural ambiguity are we able to evaluate the validity of SDH and LDH. As such, this problem deserves further investigation.

In the next section, we report our experimental results and provide evidence that subject-gaps

[2] For the sake of simplicity, hereafter, we call cleft constructions other than SC and OC, as well as non-cleft constructions, "non-cleft constructions."

are easier to process than object-gaps. We then discuss the present and previous results in terms of the universality of sentence comprehension mechanisms.

3 ERP Experiment

3.1 Method

As noted in the previous section, the "verb-nowa" constructions in Japanese are not necessarily interpreted as cleft sentences. The existence of such non-cleft sentences would have contributed to the asymmetry of the TP between the SC and the OC. Thus, we must ensure that the "NP-ACC + V-nowa" sequence is interpreted as the SC and that the "NP-NOM + V-nowa" sequence is interpreted as the OC. In this experiment, we added contexts that enable the parser to expect cleft structures, and we avoided temporal structural ambiguities.

(11) Context
1. Non-verbal context: A picture shows that there are two persons (Mr. Takahashi and Mr. Nagata).
2. Verbal context: Kono futari-no uchi
these two-GEN among
'among the two'

Experimental sentences
a. SC constructions:
Kino <**gap**> Koji -o kibishiku hinanshita-nowa **Takahashi -san**-da.
Yesterday Koji-ACC harshly blame-nowa Takahashi -Mr.-COP
'It is Mr. Takahashi who blamed Koji harshly yesterday.'
b. OC constructions:
Kino Koji -ga <**gap**> kibishiku hinanshita-nowa **Takahashi-san**-da.
Yesterday Koji-NOM harshly blamed-nowa Takahashi -Mr.-COP
'It is Mr. Takahashi whom Koji blamed harshly yesterday.'

In the given context, the focused position can be filled only with the corresponding subject or object of the embedded verb (i.e. *hinanshita*, 'blamed'). Therefore, non-cleft constructions result in unacceptable constructions, as exemplified in (12).

(12) a. *Kono futari-no uchi kino Koji-ga/o kibishiku hinanshita-nowa taihen-dat-ta.
This two-GEN among yesterday Koji-NOM/ACC harshly blamed-nowa hard-COP-PAST
Lit. 'Among the two, it was hard for Koji to blame harshly / blame Koji harshly.'
b. *Kono futari-no uchi kino Koji-ga/o kibishiku hinanshita-nowa jikka-dat-ta.
This two-GEN among yesterday Koji-NOM/ACC harshly blamed-nowa family house-COP-PAST
Lit. 'Among the two, it was in the family house that Koji blamed harshly/blamed Koji harshly.'

With this manipulation, we ensured that the TP was controlled between SCs and OCs when the parser encountered the embedded verb. That is, their TPs are equally estimated as 1. This equality of the TP makes it possible to examine the integration costs of gap-filler dependency independently from the effect of structural ambiguity.

3.2 Stimuli and Procedure

The experimental sentences consist of five phrases, and the only difference between the conditions is the case particle (i.e. ga/o 'NOM/ACC') in the second phrase. To avoid the effects of animacy or thematic plausibility, all nouns were animate, and proper names were used because they are highly plausible as both agents and patients of the embedded verbs (i.e. thematically reversible).

In addition to the 64 pairs of cleft sentences, the same number of dummy sentences with relative clauses was added to the stimuli. These stimuli were distributed into two lists, such that the participants saw either the SC or the OC of the same pair. The lists and response buttons were counterbalanced among the participants. The stimuli were presented randomly among the participants using Presentation 16.3 (Neurobehavioral Systems, Albany, CA, USA).

The participants were seated in a dimly lit soundproof room with a CRT monitor positioned approximately 130 cm in front of them. The presentation of the stimuli occurred in a non-cumulative manner with one word at a time at a stimulus onset asynchrony of 700 ms and an inter-stimulus interval of 200 ms followed by fixation. To determine whether the participants read the sentences carefully, a comprehension question regarding the content of the sentence was given in every three trials, and the participants responded by pressing the YES/NO button.

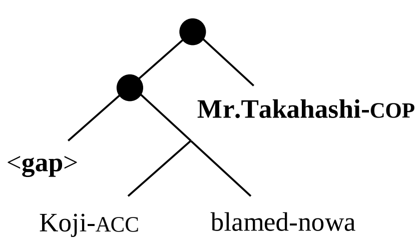
3.3 Prediction

The context avoids temporal structural ambiguities between cleft and non-cleft constructions and facilitates the processing of the cleft construction at the embedded verb. If there is actually a difference of integration (i.e. gap-filling) costs between SCs and OCs, then we expect that asymmetries of processing load are incurred at the verb-nowa position, at which the word *nowa* signals a cleft structure.

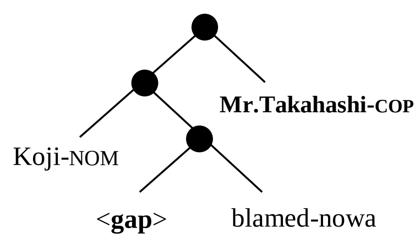
If subject-object asymmetry is observed, then this asymmetry may reflect the difference in cost of integrating a filler into its gap. In this experiment, we used event-related potentials (ERPs). A number of studies have repeatedly observed an ERP component called the P600 related to the integration of a filler into its gap (Kaan et al 2000, Phillips et al 2005, Ueno and Garnsey 2008). Thus, ERPs provide an advantage for selectively keeping track of the integration process with a temporal accuracy of a few milliseconds.

Previous studies have argued that several factors affect the relative difficulties in gap-filling parsing. As discussed above, we focus on distance metric accounts, namely, the Structural Distance Hypothesis (SDH) and the Linear Distance Hypothesis (LDH). According to SDH, SCs are easier to process, and OCs may elicit a larger P600 compared to SCs because the filler is structurally closer to the gap in SCs than in OCs (O'Grady 1997, see Hiraiwa & Ishihara 2012 for syntactic analyses).

(13) a. SCs:



b. OCs:



Conversely, LDH predicts that OCs will be easier to process, resulting in a larger P600 for SCs than for OCs because of the shorter linear distance between the filler and its gap in OCs than in SCs (Gibson 1998, 2000).

(14) a. SC constructions:
… <**gap**> Koji-ACC …blamed-nowa **Mr.Takahashi**-COP

b. OC constructions:
… Koji-NOM <**gap**> …blamed-nowa **Mr.Takahashi**-COP

3.4 Participants

The participants were 16 native speakers of Japanese (10 females and six males, M = 21.64, SD = 1.38). All participants were classified as right-handed based on the Edinburgh handedness inventory (Oldfield 1971) and had normal or corrected-to-normal vision. None of the participants had a history of reading disabilities or neurological disorders. Written informed consent was obtained from all participants prior to the experiment, and the participants were paid for their role in the study.

3.5 Electrophysiological Recording

EEGs were recorded from 19 Ag electrodes (Nihon Kohden, NE-113A) located at Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, T6, Fz, Cz, and Pz according to the international 10-20 system (Jasper 1958). Additional electrodes were placed on the left side of and beneath the left eye to monitor horizontal and vertical eye movement. The linked earlobes served as a reference. The impedances of all electrodes were maintained at less than 5 kΩ throughout the experiment. The EEGs were amplified with a bandpass of 0.01 to 60 Hz and digitized at 1000 Hz.

3.6 Data Analysis

Trials with large artifacts (exceeding ±80 μV) were automatically removed for further analysis. Any EEG was filtered off-line with a 30Hz low-pass filter. The ERP was quantified by calculating the mean amplitude for each participant in all conditions in time windows of 0–900. The baseline was set to 100 ms before the stimulus onset.

The statistical analyses were conducted separately at the midline (Fz, Cz, and Pz), parasagittal (F3, F4, C3, C4, P3, and P4), and temporal (Fp1, Fp2, F7, F8, T3, T4, T5, T6, O1, and O2) arrays. The midline analysis consisted of repeated measures ANOVAs with two within-group factors: SENTENCE TYPE × ANTERIORITY. The parasagittal and temporal analyses consisted of three within-group factors: SENTENCE TYPE × HEMISPHERE × ANTERIORITY. The Greenhouse-Geisser correction was applied for all effects involving more than one degree of freedom (Greenhouse and Geisser 1959). In these cases, we report the original degrees of freedom and the corrected *p*-value.

3.7 Results

3.7.1 Behavioral Data

The mean accuracy of the comprehension question was 87.1%. The mean accuracy did not differ for SCs and OCs (SCs: 89%, OCs: 91%, t (15) = -0.9072, p = 0.3787). Because all participants answered the questions correctly above a 70% accuracy rate, all of the noiseless electrophysiological data obtained from the 16 participants were used.

3.7.2 Electrophysiological Data

Figure 2 shows the grand average ERPs elicited at the verb-nowa (e.g., *hinanshita-nowa*, 'blamed -nowa'). A visual inspection suggested that the ERPs of OCs indicated a positive-going shift in the 550–800 ms compared with those of SCs.

A repeated-measure ANOVA was conducted using a mean voltage from 550 to 800 ms after the onset of the verb-nowa (i.e. *hinanshita-nowa*). At all arrays, the main effect of SENTENCE TYPE was marginally significant, indicating that the ERPs of OCs were more positive than those of SCs (midline: F (1, 15) = 3.1887, p = 0.0944, parasagittal: F (1, 15) = 4.1628 p = 0.0593, temporal: F (1, 15) = 3.5190, p = 0.0803). The interaction of SENTENCE TYPE with other factors was not significant in all arrays (all ps >.10). The peak latencies of P600 effects were not significantly different from one another (SCs: 618 ms, OCs: 620 ms, midline: F (1, 15) = 0.1639, p = 0.6913, parasagittal: F (1, 15) = 0.0042, p = 0.9493, temporal: F (1, 15) = 0.2175, p = 0.6477). We confirmed that there is no difference in the ERPs from the preceding region, namely, the adverbial phrases (i.e., *kibishiku*, 'harshly') (all ps > 0.10). Therefore, the P600 effect at the region in question cannot be attributed to the spill-over effect (Ishizuka et al 2006).

We also performed a repeated-measure ANOVA using a mean voltage from 300–500 ms and from 500–800 ms after the onset of the following region (i.e. *Takahashi-san-da*, 'Mr. Takahashi-COP'). However, no reliable difference was obtained.

In summary, out of the two types of cleft constructions, OCs demonstrated the more positive

ERP component, with a peak of approximately 600 ms. This result indicates that OCs elicited a typical P600 effect, which is considered to be an index of the process for integrating a filler into its gap. Therefore, we found that OCs were more difficult to process than SCs in Japanese (i.e. the subject-gap preference). In the next section, we will discuss the results from the perspective of distance metrics.

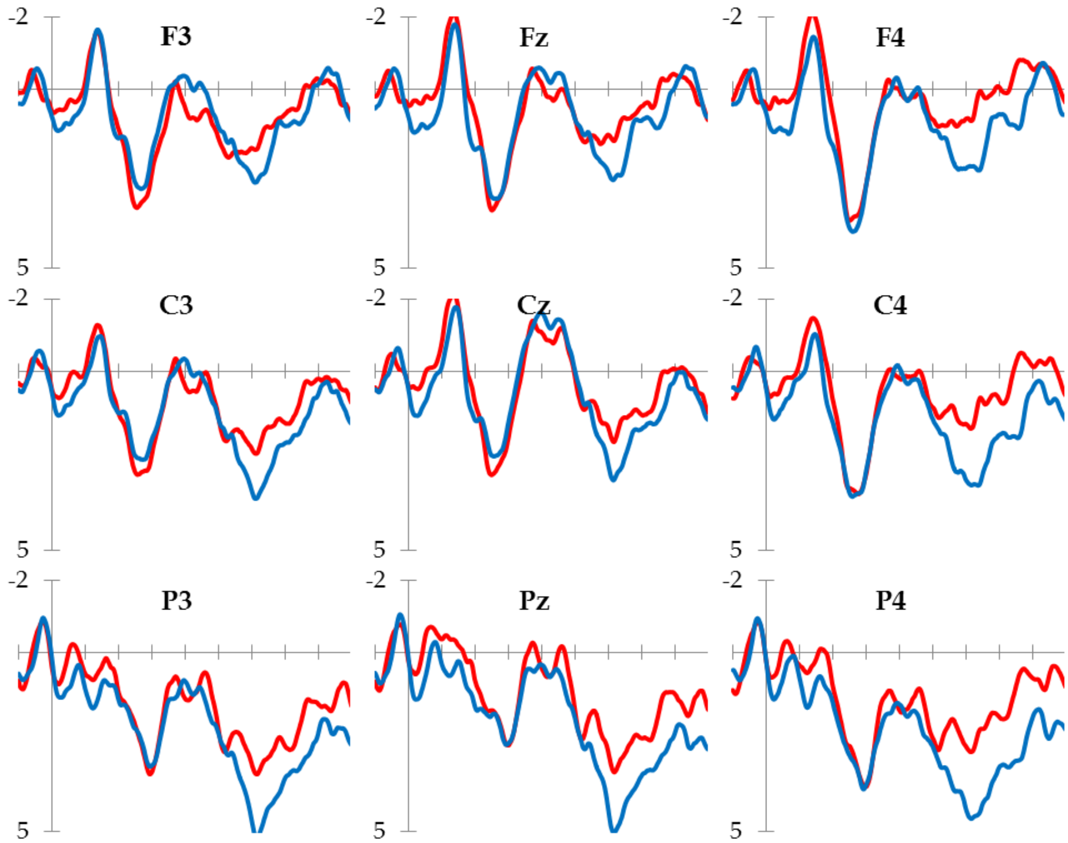


Figure 2. The grand-average ERPs for SC and OC at the embedded verb. The X-axis represents the time course from -100 to 900 ms, and each hash mark represents 100 ms. The Y-axis represents the voltage from -2 μV to 5 μV. Negativity is plotted upward. The P600 amplitude in OCs (blue line) was larger than in SCs (red line).

4 General Discussion

The purpose of the current study was to explore whether a subject-gap or object-gap is preferred during the on-line comprehension of Japanese cleft sentences when an appropriate context is provided. Significantly, the results revealed that the P600 amplitudes in OCs were larger than those in SCs, indicating that SCs are easier to process. These effects are considered indicative of the greater cost of associating a gap with a filler in accordance with previous works. Our findings suggest the following three points.

First, the SC advantage in Japanese clefts is consistent with that in previous studies of other languages reporting the subject-gap preference. LDH (Gibson 1998, 2000) suggests that the structural integration of two elements is more costly when the elements are linearly distant. In our case, LDH predicts that SCs are more difficult to process than OCs because SCs have more intervening referential words between the filler and its gap, as shown above (see (14)). Consequently, this account contradicts the results of our ERP experiment.

On the contrary, the results provide support for SDH (O'Grady 1997). This account predicts that the integration is more difficult when two elements are structurally distant; accordingly, OCs are expected to be more difficult because the object gap is located in a lower position than the subject gap (see (13)). However, one could argue that the relative frequency of SCs/OCs could have an effect on the present result. According to Kahraman et al (2011b), SCs are significantly more frequent than OCs in Japanese (Table 1). Nevertheless, this argument appears to become a circular question. Are SCs more frequent as a result of a processing advantage, or does a high frequency facilitate the processing of SCs? To disentangle these possibilities, further study is necessary to understand whether frequency data can be accounted for independently of processing load.

Second, our experimental data suggested that the integration cost (i.e. the P600 effects) is larger in OCs than in SCs, indicating a subject-gap preference, whereas Kahraman et al (2011a) observed an object-gap preference in Japanese clefts. How can the difference be explained? Because Kahraman et al (2011a) presented stimuli without appropriate contexts, temporal structural ambiguities may have caused the greater difficulty with SCs in their experiment, as these have a strong enough effect on sentence processing to override the integration cost.

Finally, the sentence processor incrementally constructs gap-filler dependencies even before the filler appears when the marker (i.e. *nowa*) signals cleft sentences (see Kahraman et al 2011a for a similar discussion). This pre-filler gap-filling parsing is indicative of the predictive nature of sentence comprehension in Japanese and in general.[3]

5 Conclusion

Through the investigation of cleft constructions in Japanese, this study has explored how language comprehension mechanisms function during the processing of long-distance dependency. The results clearly demonstrated that the integration process in SCs is easier than in OCs under conditions in which the transitional probabilities of these constructions were controlled. Thus, SDH seems to account for the consistent subject-gap preference in Japanese (Miyamoto and Nakamura 2003, Ueno and Garnsey 2008) and in other languages.

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[3] We confirmed that there is no significant difference in any time window in the comparison of the S-*pro* construction and O-*pro* construction without a 'nowa' as shown below. This result indicates that the P600 effects observed in cleft constructions reflect that *gap-filler* integration when 'nowa' signals cleft structure, rather than the processing difference of *pro*-insertion when transitive verbs signal the presence of S-*pro* and the O-*pro* respectively.

a. S-pro constructions:
  Kino *pro* Koji -o kibishiku hinanshita …
  Yesterday Koji-ACC harshly blame
  '(Someone) blamed Koji harshly yesterday.'

b. O-pro constructions:
  Kino Koji -ga *pro* kibishiku hinanshita ....
  Yesterday Koji-NOM harshly blamed
  'Koji blamed (someone) harshly yesterday.'

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