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An ERP study of Japanese causative cleft constructions in context

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Abstract

This study examined the processing of two types of Japanese causative cleft constructions (subject-gap vs. object-gap) by conducting an event-related brain potential (ERP) experiment to clarify the processing mechanism of long-distance dependencies. The results demonstrated that the subject-gap constructions elicited larger P600 effects compared with object-gap constructions. Based on these findings, we argue that the linear distance between the extracted argument (filler) and its original position is a crucial factor in determining the processing costs in Japanese causative cleft constructions.

Keywords: sentence comprehension; dependency formation; cleft constructions; event-related brain potentials (ERPs)

Introduction

Numerous studies on sentence comprehension have engaged in clarifying the mechanism for associating long-distance words in real-time sentence processing. Among various dependencies, relative clauses and cleft constructions have attracted a considerable amount of attention because the typological differences among various languages allow researchers to explore the language-universal and language-specific aspects of sentence comprehension (Kahraman, Sato, Ono, & Sakai, 2011a, 2011b, Miyamoto & Nakamura 2003, Ueno & Garnsey 2008). For example, consider the English relative clauses and cleft constructions shown in (1-2).¹

(1) a. Subject relative clauses (SR) = S(ubject)-gap:
The reporter that <S-gap> attacked the senator admitted the error.

b. Object relative clauses (OR) = O(bject)-gap:
The reporter that the senator attacked <O-gap> admitted the error.

(King & Just 1991, 581)

(2) a. Subject cleft constructions (SC) = S(ubject)-gap:
It was **the barber** that <S-gap> saw the lawyer in the parking lot.

¹ A cleft construction is a construction derived from a canonical sentence (e.g., the barber saw the lawyer in the parking lot) by moving a constituent (i.e., filler) from its original position (i.e., gap) to the focus position.

b. Object cleft constructions (OC) = O(bject)-gap:

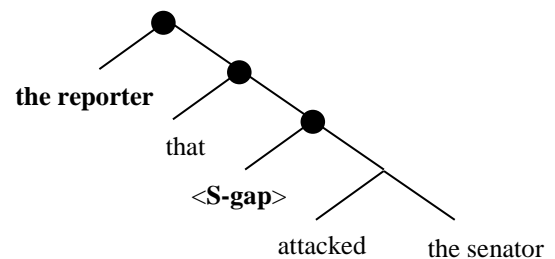
It was **the barber** that the lawyer saw <O-gap> in the parking lot.

(Gordon *et al.* 2001, 1418)

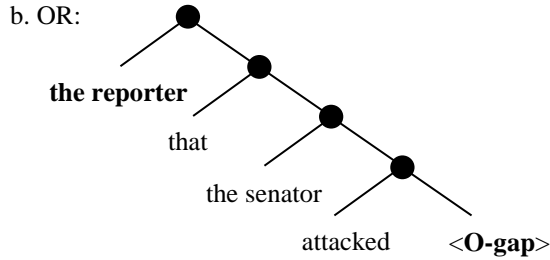
The results of earlier studies have indicated that subject-gap constructions are easier to process compared with object-gap constructions in English (i.e., S-gap preference, Ferreira 2003, Gordon, Hendrick, & Johnson 2001). Two hypotheses have been proposed to explain this preference for subject-gap constructions in English, namely, the “Structural Distance Hypothesis” (SDH) (O’Grady 1997) and the “Linear Distance Hypothesis” (LDH) (Gibson 1998, 2000). Both hypotheses share two assumptions. The first is that the major source of processing difficulties in relative clauses and cleft constructions is the integration of the displaced element (i.e., a filler) into its original position (i.e., a gap). The second assumption is that the distance between a filler and its gap determines the cost of the integration process. However, as their names suggest, the hypotheses use different characteristics of distance metrics.

SDH explains that the integration of the filler (i.e., the reporter in (3) below) and its gap becomes more difficult as the structural distance between them increases. As illustrated in (3), the S-gap is structurally closer to the filler than the O-gap is.² Thus, SDH correctly predicts the S-gap preference in English.

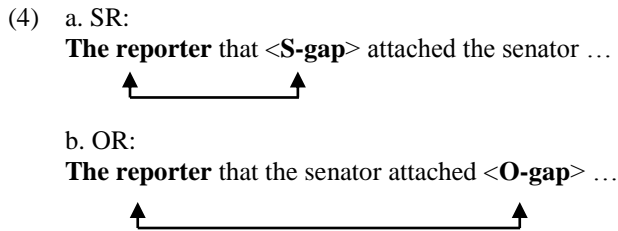
(3) a. SR:



² The structural distance is defined in terms of nodes intervening between the filler (i.e., the reporter) and its original position (i.e., <gap>), as indicated by the black dots.



In contrast, LDH accounts for the S-gap preference in terms of a linear distance between the filler and its gap. LDH predicts that the integration process becomes 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 S-gap constructions than it is in O-gap ones. Thus, LDH also predicts the S-gap preference in English.



In English, both hypotheses predict the S-gap preference. Thus, it is difficult to determine which hypothesis is more appropriate to account for the S-gap preference. To determine which of these two hypotheses is correct, it is necessary to examine languages such as Japanese. As explained below, Japanese cleft constructions provide a testing ground for verifying SDH and LDH because they offer different predictions.

Previous studies

Using the following stimuli, Yano, Tateyama, & Sakamoto (2014) evaluated the validity of these two hypotheses.

(5) **Context:**³

1. Non-verbal visual context: A picture shows that there are two persons (Ms. Takeuchi and Ms. Konishi).
2. Verbal context: Kono futari-no uchi this two person-GEN among 'among the two'

Experimental sentences:

a. **Subject cleft constructions (SCs):**

Kyonen <S-gap> Ichiro-o teatsuku
 Last year Ichiro-ACC carefully
kaihoushita-nowa **Takeuchi-san-da.**
 nursed-nowa Takeuchi-Ms.-COP

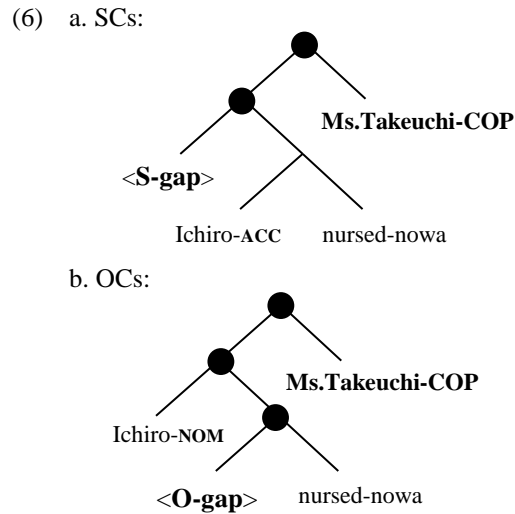
'It is Ms. Takeuchi who <S-gap> nursed Ichiro carefully last year.'

b. **Object cleft constructions (OCs):**

Kyonen Ichiro-ga <O-gap> teatsuku
 Last year Ichiro-NOM carefully
kaihoushita-nowa **Takeuchi-san-da.**
 nursed-nowa Takeuchi-Ms.-COP

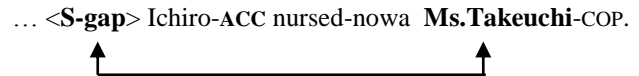
'It is Ms. Takeuchi whom Ichiro nursed <O-gap> carefully last year.'

In Japanese cleft constructions, SDH and LDH predict different results. As illustrated in (6) below, the filler (i.e., *Takeuchi-san*, 'Ms. Takeuchi') is structurally closer to the gap in SCs than it is in OCs (see Hiraiwa & Ishihara 2012 for syntactic analyses). Thus, SDH predicts that OCs would be more difficult to process than SCs.

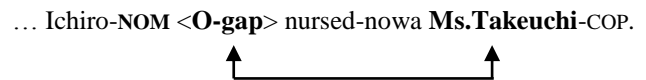


In contrast, LDH predicts that the SCs are more difficult to process than OCs are due to the longer linear distance between the filler and the gap.

(7) a. SC:



b. OC:



In sum, SDH predicts the S-gap preference, whereas LDH predicts the O-gap preference. By conducting an ERP experiment, Yano *et al.* (2014) demonstrated that the integration process is more difficult in OCs than it is in SCs at the verb-nowa (i.e., *kaihoushita-nowa*, 'nursed-nowa') position in which 'nowa' signals cleft constructions (i.e., S-gap preference). The authors argued that this result favors SDH over LDH to explain the consistent S-gap preference in English and Japanese.

³ In their experiment, context was presented to render the use of cleft construction involving focus interpretations to be felicitous.

(8) Context:

1. Non-verbal visual context: A picture shows that there are two persons (Ms. Takeuchi and Ms. Konishi).
2. Verbal context: Kono futari-no uchi
this two person-GEN among
'among the two'

(9) a. Causative subject cleft constructions (SCs):

Kyonen Kyoko-**ga** <**S-gap**> Ichiro-**o** kaihou-saseta-nowa **Takeuchi-san-da**.
Last year Kyoko-NOM Ichiro-ACC nurse-CAUSATIVE-nowa Takeuchi-Ms.-COP
'It is Ms. Takeuchi whom Kyoko let <**S-gap**> nursed Ichiro last year.'

b. Causative object cleft constructions (OCs):

Kyonen Kyoko-**ga** Ichiro-**ni** <**O-gap**> kaihou-saseta-nowa **Takeuchi-san-da**.
Last year Kyoko-NOM Ichiro-DAT nurse-CAUSATIVE-nowa Takeuchi-Ms.-COP
'It is Ms. Takeuchi whom Kyoko let Ichiro nursed <**O-gap**> last year.'

However, this experimental evidence for SDH is not tenable. Because there is no verb that can take an argument with an accusative case (i.e., *-o*) as its subject in Japanese, the accusative case at the sentence initial position (i.e., *Ichiro-o*, 'Ichiro-ACC') in (5a) signals the existence of a non-canonical sentence. Thus, the parser may have predicted that the sentence being processed must be a sentence with a non-canonical word order, such as relative clauses and cleft constructions. More specifically, in the SC condition, the parser can detect the non-canonicity of a sentence based on case information (i.e., *Ichiro-o*, 'Ichiro-ACC') before encountering "verb-nowa". In the case of the OC condition in (5b), however, the parser cannot notice that the given sentence is a non-canonical word order until encountering the cleft marker (i.e., *kaihoushita-nowa*, 'nursed-nowa'). Thus, it could be that the earlier gap detection in SCs facilitates the integration process at the "verb-nowa" position, whereas it does not in OCs. If this is the case, Yano *et al.* (2014) may have failed to properly examine the validity of SDH and LDH because they did not control the timing of the gap detection.

A good way to control the timing of the gap detection and independently examine the integration process is to use causative cleft constructions in (9), as explained below. The sentence in (10) shows an original form of causative cleft construction, from which (9a) and (9b) are produced. The causative subject and object cleft constructions in (9) are derived from (10) by extracting a subject or an object of the embedded verb (i.e., nurse), respectively. These causative cleft constructions have an advantage for controlling the timing of gap detection for the following reason.

(10) Simple causative sentence:

Kyoko-**ga** Takeuchi-**ni** Ichiro-**o** kaihou-saseta.
Kyoko-NOM Takeuchi-DAT Ichiro-ACC nurse-CAUS
'Kyoko let Takeuchi nurse Ichiro.'

In Japanese, both the sequence of "NOM (-ga) - ACC (-o)" and that of "NOM (-ga) - DAT (-ni)" in (9) can be followed by simple transitive verbs because there are two

types of transitive verbs: the accusative-taking verbs in (11a) and the dative-taking verbs in (11b).

(11) a. Accusative-taking verbs:

Kyonen Kyoko-**ga** Ichiro-**o** **home-ta**.
Last year Kyoko-NOM Ichiro-ACC praise-PAST
'Kyoko praised Ichiro last year'

b. Dative-taking verbs:

Kyonen Kyoko-**ga** Ichiro-**ni** **at-ta**.
Last year Kyoko-NOM Ichiro-DAT meet-PAST
'Kyoko met Ichiro last year.'

Previous studies on sentence comprehension argued that the parser constructs a simple structure as far as possible (Sato, Kahraman, Ono, & Sakai 2007). Thus, it is natural to assume that an unnecessary gap is not posited on encountering the second NP in (9), which indicates that the sequence of these two NPs do not induce a prediction for non-canonical constructions, such as relative clauses and/or cleft constructions. Accordingly, it is at the "verb-CAUS-nowa" phrase that the parser first recognizes the existence of a gap in both SCs and OCs, which indicates that the timing of the gap detection is controlled.

ERP Experiment

Stimuli and Procedure

In the present experiment, we presented the same contexts in (8) as Yano *et al.* (2014) prior to two types of causative cleft sentences in (9) (see footnote 3). The experimental sentences consist of five phrases, and the only difference between the conditions is the case particle (i.e., *-o/ni* 'ACC/DAT') in the third phrase. The verbs in the fourth phrase (i.e., *kaihou-saseta*, 'nurse-CAUS') are accusative-taking verbs in causative form. Thus, the canonical word order of all experimental sentences is "NP-NOM NP-DAT NP-ACC VERB" (cf. Tamaoka *et al.* 2005). To avoid the effect of animacy or thematic plausibility, all nouns were animate and proper names that are highly plausible as both

agents and patients of the verbs (i.e., they are thematically reversal).

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

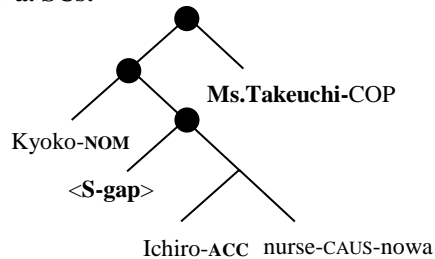
The participants were seated in a dimly lit soundproof room with a CRT monitor positioned approximately 130 cm in front of them. The presentation of stimuli occurred in a non-cumulative manner, with one word presented at a time with a stimulus onset asynchrony of 700 ms and an interstimulus interval of 200 ms. To examine the comprehension difficulties of each condition, a comprehension question regarding the content of a sentence was given at a rate of 50% of trials, and the participants responded by pressing the YES/NO button.

Prediction

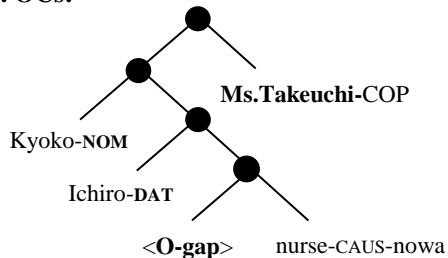
A number of studies have repeatedly observed that an ERP component termed as the P600 reflects the cost for the integration of a filler into its gap (Kaan *et al.* 2000, Phillips *et al.* 2005, Ueno & Garnsey 2008). Thus, ERPs provide an advantage for selectively keeping track of the integration process with a temporal accuracy of milliseconds.

As discussed in the previous sections, we focus on distance metric accounts, namely, LDH and SDH. As shown below, because the filler (i.e., Ms. Takeuchi) is structurally farther from the gap in OCs than it is in SCs, SDH predicts that OCs would be more difficult to process and that OCs would elicit a larger P600 compared with SCs (O’Grady 1997).

(12) a. SCs:

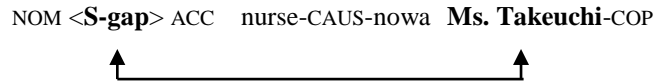


b. OCs:

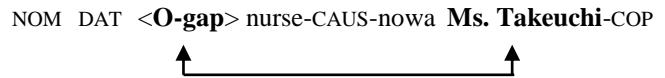


Conversely, DLT predicts that OCs are easier to process, resulting in a larger P600 for SCs than for OCs because of the shorter linear distance between the filler and its gap (Gibson 1998, 2000).

(13) a. SCs:



b. OCs:



Because the integration process occurs at the “verb-CAUS-nowa” phrase, we did not expect any processing asymmetry (i.e., no ERP effect) in the following phrase.

Participants

The participants were 12 native speakers of Japanese (11 females, $M = 21.4$, $SD = 0.8$). 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.

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. All electrodes’ impedances were maintained below 5 k Ω throughout the experiment. The EEGs were amplified with a bandpass of 0.01 to 120 Hz, digitized at 1000 Hz.

Data Analysis

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

We conducted an omnibus ANOVA including all electrodes. In addition, 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 \times ANTERIORITY. The parasagittal and temporal analyses consisted of three within-group factors: SENTENCE TYPE \times

HEMISPHERE \times ANTERIORITY. The Greenhouse-Geisser correction was applied for all effects involving more than one degree of freedom (Greenhouse & Geisser 1959).

Results

Behavioral Data

The mean accuracy of the comprehension question was 74%. The mean accuracy was marginally significant (SCs: 68%, OCs: 80%, $t(11) = -2.1283$, $p = .05674$), indicating SCs were more difficult to comprehend than were OCs.

Electrophysiological Data

Figure 1 shows the grand average ERP elicited at the “verb-CAUS-nowa” (i.e., *kaihou-saseta-nowa*). A visual inspection suggested that the ERPs of SCs (dotted line) indicate a positive-going shift in the 500–900 ms compared with those of OCs (solid line).

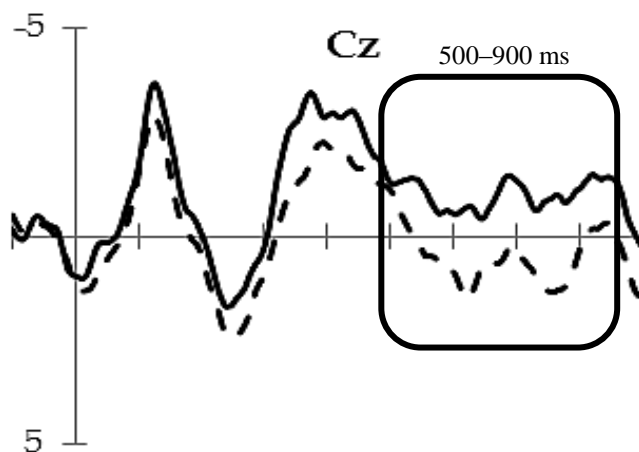


Figure 1. The grand-average ERPs for SCs and OCs

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 -5 μ V to 5 μ V. Negativity is plotted upward. The P600 amplitude in SCs (dotted line) was larger than in OCs (solid line).

A repeated-measure ANOVA analysis was conducted using the mean voltage from 500 to 900 ms after the onset of the “verb-CAUS-nowa” (i.e., *kaihou-saseta-nowa*). An omnibus ANOVA revealed that the main effect of SENTENCE TYPE was significant ($F(1, 11) = 5.4599$, $p = .0394$), which indicated that the P600 effects of SCs were larger than OCs. We also conducted additional analyses in each array. At the midline and temporal arrays, the main effect of SENTENCE TYPE was significant, without any interaction (Midline: $F(1, 11) = 6.0411$, $p = .0318$, Temporal: $F(1, 11) = 5.3037$, $p = .0418$). At the parasagittal array, the main effect of SENTENCE TYPE was marginally significant ($F(1, 11) = 4.7966$, $p = .0510$). As expected, the following phrase (i.e., *Takeuchi-san-da*, ‘Ms. Takeuchi-COP’) did not elicit a significant ERP effect in any time window (all $ps > .10$).

In sum, of the two types of causative cleft constructions, SCs elicited the more positive ERP component with a peak of approximately 600 ms, indicating that SCs elicited the typical P600 effect, which is considered an index of the integration process. Therefore, we found that it is more difficult for an SC to integrate a filler into its gap than it is for an OC in Japanese. In the next section, we discuss the results from the perspective of distance metrics.

General Discussion

The purpose of the present study was to examine the validity of SDH and the LDH. Significantly, the results revealed that the P600 amplitudes in SCs were larger than those in OCs. These effects are considered to reflect greater cost of gap-filling process. Our findings suggest the following two points.

First, the processing advantage of OCs in Japanese causative cleft constructions provides empirical support for LDH. As explained above, LDH suggests that the integration process is more costly when the elements are linearly distant. In our case, LDH correctly predicts that SCs are more difficult to process than OCs are because SCs have more intervening words between the filler and its gap, as shown in (13). In contrast, SDH predicts that the integration is more difficult when two elements are structurally distant; accordingly, OCs are expected to be more difficult, as shown in (12). Thus, our experimental result contradicts SDH.

Our result may also disprove the suggestion by Yano *et al.* (2014) that the processing advantage of subject cleft constructions is supportive evidence for SDH. As noted above, in the experiment of Yano *et al.* (2014), an accusative case at the sentence initial position may increase the predictability of a gap, which may facilitate the integration process in SCs. Because the present experiment controlled the gap predictability and then supported LDH over SDH, it seems plausible to consider that the previous result simply reflects the facilitation of the integration process due to the advantage of earlier gap detection. Interestingly, Yano *et al.* (2014) observed left anterior negativity (LAN) effects to “Ichiro-o” (Ichiro-ACC) compared with “Ichiro-ga” (Ichiro-NOM) in (5). LAN (or broadly distributed negativity) has been observed in the position in which the sentence processor notices a non-canonical word order in German (Matzke, Mai, Nager, Rüsseler, & Münte 2002, Rösler, Pechman, Streb, Röder, & Hennighausen 1998, Schlesewsky, Bornkessel, & Frisch 2003). Thus, the LAN effect of “Ichiro-ACC” observed in Yano *et al.* (2014) indicates that the appearance of an accusative NP increased the predictability for S-gap constructions. In the present experiment, however, we confirmed that no LAN effect was elicited in the third region (i.e., *Ichiro-o/ni*, ‘Ichiro-ACC/DAT’) (all $ps > .10$). Thus, the sentence processor does not notice the gap until the “verb-CAUS-nowa” phrase. In other words, the timing of the gap detection was successfully controlled in our experiment.

Second, our result is well aligned with the previous studies that controlled the predictability of a gap in a sentence and reported the results in favor of LDH (Ishizuka, Nakatani, & Gibson 2005, Ono & Ikemoto 2013, Sato *et al.* 2007). Thus, it seems plausible to consider that not only causative cleft construction but also at least some types of constructions show a preference for a shorter linear-over-structural distance.

Conclusion

To sum up, we noted the problem of the previous study (Yano *et al.* 2014) and reported that subject-gap constructions (SCs) are more costly to process than are object-gap constructions (OCs). We argued that this processing advantage of OCs provides a support for the Linear Distance Hypothesis over the Structural Distance Hypothesis in at least Japanese causative cleft constructions.

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