Antecedent Reactivation in the Processing of Scrambling in Japanese

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Based on the results of three experiments, we argue that native speakers of Japanese are faster in deciding that a word appeared in a sentence previously read if the word was inside a scrambled constituent (contrary to prior results which we argue did not use an appropriate control sentence). The results are compatible with the proposal that a filler-gap dependency between the scrambled constituent and its base position has to be created when the sentence is processed.

1. Introduction

In previous work, we proposed that readers create a dependency between a displaced constituent and its base position in order to process sentences with non-canonical word orders in Japanese (Miyamoto and Takahashi 2002). According to the literature of filler-gap dependencies in English (Bever and McElree 1988; Gibson 1998; Just and Carpenter 1992; MacDonald 1989; inter alia), the insertion of a gap has effects that can be detected in behavioral experiments. In the present paper, we provide evidence for one such effect in scrambling, namely the reactivation of the scrambled constituent as measured by the recognition latency of a word presented at the end of the sentence.

The following section describes the filler-gap dependency model for the processing of scrambled constituents. Next, we discuss previous results investigating the reactivation of scrambled constituents. We then report the results of three experiments which support the filler-gap dependency model.

2. Filler-Gap Dependencies

As people read the words in a sentence, they not only build a partial representation for the words read thus far but also anticipate the constituents that are likely to follow. Moreover, because of working memory constraints, readers expect such constituents to occur as early in the input string as is grammatically permissible (Gibson 1998; Just and Carpenter 1992). Typical in this respect is the processing of fronted wh-phrases such as who in (1a) (adapted from Crain and Fodor 1985).

(1) Who did the child force us to sing the song for yesterday?
The wh-phrase who triggers the expectation for a gap and native speakers of English try to create such a gap at the earliest possible point, which in the case above is immediately after the verb force, as indicated by the wedge sign. Evidence for the creation of the gap at this point comes from long reading times at the next word, us, which indicates that this is not a possible position for the gap (Stowe 1986; also Miyamoto and Takahashi 2001, for a related effect in Japanese involving in-situ wh-phrases and question particles).

2.1 Filler-gap dependencies in scrambling

We propose that the processing of scrambled constituents in Japanese requires the creation of filler-gap dependencies similar to the ones created during the processing of fronted wh-phrases in languages such as English. There is, however, a crucial aspect in which the two constructions differ. In English, the wh-phrase unambiguously indicates that a gap is to be expected. In Japanese, in contrast, it is not immediately apparent that scrambling has taken place. For example, assuming that the dative-accusative order is canonical (Hoji 1985; cf. Miyagawa 1997), the accusative object flowers needs to be associated with the gap in (2a).

\begin{align*}
(2) & \quad \text{a. Mary-ga hana-o John-ni (gap)} \text{ ga} \text{ta.} \\
& \quad \text{Mary-NOM flowers-ACC John-DAT gave} \\
& \quad \text{‘Mary gave flowers to John.’} \\
& \quad \text{b. Mary-ga hana-o katta.} \\
& \quad \text{Mary-NOM flowers-ACC bought} \\
& \quad \text{‘Mary bought flowers.’}
\end{align*}

However, as (2a) is read, a gap is unlikely to be predicted as soon as flowers is processed because Mary-NOM flowers-ACC could constitute the initial fragment of a transitive clause with the accusative NP being in canonical position (as illustrated in (2b)). It is only at John-DAT that it is clear that (2a) involves a ditransitive construction in which the direct object flowers was scrambled. Hence, the search for the gap only starts at the indirect object John. Moreover, the position immediately after John is a grammatical position for the gap, and speakers of Japanese may create the gap there. In other words, the constituent John not only indicates that flowers was scrambled but it also indicates where the gap can be inserted; thus, detecting a scrambled constituent and finding the position for the gap occur virtually simultaneously. This kind of situation seems to be the rule rather than the exception in Japanese scrambling.

Implicit in the discussion above is the assumption that Japanese readers associate words incrementally creating partial syntactic representations even when the head of the phrase (e.g. the verb in a VP) has not been read yet (see Miyamoto 2001, for discussion and experimental results).

It should be clear that the present claim is restricted to the processing aspects of scrambling and does not imply that the syntactic nature of fronted wh-phrases and scrambled constituents must be the same. The present proposal
ignores the syntactic differences between the two constructions and concentrates on what they have in common, namely, the association between a dislocated constituent and its base position.

In the following section, we summarize previous psycholinguistic findings related to scrambling.

3. Previous Results

Psycholinguistic studies investigating scrambling in Japanese have often reported contradictory results. For example, in acquisition, some studies have found a significant advantage in children’s comprehension of the accusative-dative word order compared to the dative-accusative order in ditransitive constructions (Suzuki, Cho, Lee, O’Grady, Song, and Yoshinaga 1999), but another study found that children made fewer mistakes with the latter word order (Sugisaki and Isobe 2001).

There have also been contradictory results reported for reading time patterns. Although an earlier study did not find any significant differences (Yamashita 1997), there is mounting evidence that adult readers slow down when they determine that a constituent was scrambled in the input sentence (Mazuka, Itoh, and Kondo 2001; Miyamoto and Takahashi 2002).

The present paper is concerned with a third type of experiment, which is described in the following section.

3.1 Probe recognition experiments

In probe recognition experiments, participants are shown a probe word after reading a sentence, and have to decide if the probe appeared in the sentence as quickly as possible. This type of methodology has been extensively used in English to measure the activation level of constituents during the processing of sentences (Bever and McElree 1988; MacDonald 1989; McKoon and Ratcliff, 1980; inter alia). For example, readers were faster to recognize that the probe astute had appeared in (3a) than in (3b) (Bever and McElree 1988).

(3) a. Passive condition
   [The astute lawyer, who faced the female judge was suspected \{gap\} constantly.

   b. Adjective condition
   The astute lawyer who faced the female judge was suspicious constantly.

There is an ongoing debate as to what extent such results can be used to determine whether gaps are encoded as empty categories, slash features or are encoded at all in syntax (Sag and Fodor 1995; cf. Bever and McElree 1988, who claim that latency in probe recognition can be used to differentiate various types of empty categories). Regardless of how gaps are encoded, we can state that (3a) has a gap which needs to be associated with a discourse antecedent,
namely, the astute lawyer. The process of associating the gap reactivates the antecedent, thus facilitating the recognition of the probe at a later point.

3.1.1 Probe recognition in Japanese

Experimental work comparing unaccusative constructions to unergative constructions indicates that reactivation at gaps can be measured with the probe recognition task in Japanese as well (Nakayama 1991, 1995). Therefore, the filler-gap model should predict that a gap in a scrambling construction such as the one in (4a) (from Nakayama 1995, Experiment 1) should reactivate its antecedent (namely, the complex NP homework-ACC forgot student, 'the student who forgot his homework'), and recognition of the probe homework should be facilitated.

(4) a. Scrambling condition
Kyoo [shukudai-o wasureta seito]-o mondai-o today homework-ACC forgot student-ACC question-ACC
dashita sensei-ga (gap) shikatta.
posed teacher-NOM scolded
‘The teacher who posed the question scolded the student who forgot the homework today.’

b. Canonical condition
Kyoo mondai-o dashita sensei-ga shukudai-o today question-ACC posed teacher-NOM homework-ACC
wasureta seito-o shikatta.
forgot student-ACC scolded
‘The teacher who posed the question scolded the student who forgot the homework today.’

However, based on a comparison to the canonical sentence (4b), Nakayama (1995) claimed that the predicted facilitation was not observed in the scrambled (4a). After reading sentences in a center-screen self-paced reading presentation, participants in his experiment were in fact slower to recognize the probe in the scrambling condition than in the canonical condition.

The result is particularly interesting because, contrary to previous studies that did not find a significant difference between the conditions compared (e.g. Yamashita 1997), Nakayama reported a statistically significant difference that goes against the predictions of the filler-gap model that we are advocating here, therefore providing prima facie evidence that gaps are not posited in the processing of scrambled constituents, and what could be regarded as indirect evidence for the proposal that there are no gaps in the syntactic representation of scrambled sentences.

However, it is possible that a gap is posited in (4a), but that Nakayama was not able to detect reactivation therein because of his choice of control sentence. Contrary to the original studies in English, in which the probe occurred in the same linear position in the sentences compared, the probe in Nakayama’s
experiment is closer to the end of the sentence in the canonical condition. It is conceivable that reactivation is taking place at the gap in the scrambled sentence (4a), but the more recent position of the probe in the canonical sentence (4b) masks the effect. Nakayama himself reports that regardless of word order, recency was the main factor in determining probe recognition latencies in his studies (Nakayama 1995, Experiment 2).

Another problem with Nakayama’s control sentence is that it involves a temporary ambiguity. The NP headed by teacher is initially interpreted as the subject of forgot (as in Today the teacher who posed the question forgot the homework; see Inoue 1991, for the processing of relative clauses in Japanese). At student-ACC, reanalysis must take place so that this head noun becomes the subject of forgot. It is unclear at this point how reanalysis affects probe recognition, but one possibility is that it requires reactivating the NPs involved, in which case Nakayama’s result may have been tainted by the ambiguity resolution at this point (but see the discussion session of Experiment I for an argument against this possibility).

4. Experiment 1

The goal of this experiment is to determine whether the experimental results reported in Nakayama (1995) still hold when we eliminate the two confounding factors discussed above. If the filler-gap model is correct, we should obtain the opposite pattern with reaction times faster after the scrambling condition in comparison to an appropriate control sentence.

4.1 Method

4.1.1 Participants

Forty-six students from Kanda University of International Studies were paid to participate in the study. Two participants’ data were eliminated from the analyses because of their low comprehension performance (less than 50% of the test items; for the remaining 44 participants, M = 83.5%, SD = 9.6%).

4.1.2 Materials

Twenty sets with two conditions each were constructed.

The items were based on items used in Nakayama (1995) with two modifications. First, the verb in the main clause was replaced with a reversible verb (see in (5)) so that, pragmatically, either argument NP can be taken as the subject or the object. With this new design, the two conditions have exactly the same content words in the same linear order. The only difference is in the order of the italicized accusative and nominative case markers.

The second change involved the relative clause (RC) modifying the second argument head, student in (5). The RC was replaced with an adverb followed by an adjective (very smart in (5)) in order to avoid a possible misanalysis as discussed above. However, nine items were inadvertently left ambiguous in the canonical condition as can be observed in (5a). Before student has been read,
the expression very smart could be taken to modify lecturer and, therefore, re-analysis could still be taking place at student. In contrast, (5b) is unambiguous. (We return to this point in Experiments II and III.)

(5)  a. Canonical condition
Gakkoo-de mondai-o dashita kooshi-ga totemo
school-LOC question-ACC asked lecturer-NOM very
kashikoi gakusei-o mita.
smart student-ACC saw
‘The lecturer who asked the question at school saw the extremely smart student.’

b. Scrambling condition
Gakkoo-de mondai-o dashita kooshi-o totemo
school-LOC question-ACC asked lecturer-ACC very
kashikoi gakusei-ga mita.
smart student-NOM saw
‘The extremely smart student saw the lecturer who asked the question at school.’

The sentences differ in their meanings but there does not seem be an a priori advantage of one meaning over the other in relation to probe recognition (note that the sentences used by Bever and McElree 1988, shown in (3), have different thematic roles for lawyer).

The second word in each condition, question, was the probe used. Therefore, the answer to the probe recognition task is always affirmative for the test sentences. Two lists were created by distributing the 20 test stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with 40 unrelated foil items in pseudo-random order. Answers for the probe recognition task and for the comprehension question were counterbalanced for each list. One test item was eliminated from the analyses because one of its words had been omitted by mistake during the self-paced presentation.

4.1.3 Procedure

The experiment was conducted on a Power Macintosh using PsyScope (Cohen, MacWhinney, Flatt, and Provost 1993) with a button-box. Participants were timed in a phrase-by-phrase self-paced non-cumulative moving-window reading task (Just, Carpenter, and Woolley 1982).

Sentences are not segmented in Japanese texts as there are no spaces between successive words. We used bunsetsus (a content word followed in some cases by inflectional material and functional particles) as the phrasal unit for segmentation purposes. The segmentation in the sentences in (5), indicated with spaces, was the actual segmentation used in the self-paced reading presentation. Sentences were shown on a single-line without line-breaks using Japanese characters with the uniform-width font Osaka Toohaba 14. Stimuli segments
initially appeared masked with dots, and participants pressed the leftmost button of the button-box to reveal each subsequent region of the sentence and cause all other regions to revert to dots.

Immediately after the last region of a sentence was read, a probe word surrounded by underscores was presented on a new screen and participants had to decide whether it had appeared in the previous sentence by pressing one of the two rightmost buttons of the button-box. Next, participants answered a yes/no comprehension question which appeared on a new screen. Auditory feedback was provided for the comprehension question only. Data points were included in the reaction time analysis only if the participant gave correct answers on both tasks.

The experimental trials were preceded by one screen of instructions and eight practice trials. The experiment took participants approximately 15 minutes.

4.1.4 Data analysis
Analyses were conducted on the accuracy and latency of the probe recognition task, as well as on the comprehension question response accuracy and reading times. Probe recognition latencies were trimmed so that data points beyond 2.5 standard deviations from the relevant condition × region cell mean were discarded; these corresponded to less than 3.5% of the test data.

ANOVA s were conducted separately for participants (subject analysis, F1) and for items (item analysis, F2; Clark, 1973).

Reading time analyses are not reported below for space limitation reasons (see Miyamoto and Takahashi 2002, for discussion on the use of reading time measures to investigate scrambling).

4.2 Results

4.2.1 Response accuracy
The percentages of correct probe recognition did not differ between the canonical condition (94.7%) and the scrambling condition (94.6%; Fs < 1). Accuracy on the comprehension task did not differ either (canonical, 82%; scrambled, 84%; Fs < 1).

4.2.2 Reaction times on the probe recognition task
The reaction time on the probe recognition task was significantly slower for the canonical condition (904 msec) than for the scrambling condition (863 msec) in the subject analysis (F1(1,43) = 4.46, P < 0.05) as well as in the item analysis (F2(1, 18) = 5.75, P < 0.05).

As observed earlier there were nine items that were ambiguous in the canonical condition. The difference in reaction time between the canonical condition and the scrambling condition was greater for the ambiguous items than for the unambiguous items. When the two factors — word order (canonical/scrambled) and ambiguity (ambiguous/unambiguous) — were considered, there was no significant interaction in the analysis by subjects (F1(1,43) < 1) but
the interaction was marginally significant in the analysis by items (F2(1,17) = 3.84, P = 0.067).

4.3 Discussion

The faster probe recognition times in the scrambling condition is compatible with the assumption that there is a gap being processed for the scrambled constituent. The gap reactivates the NP headed by \textit{lecturer}, facilitating the recognition of the probe.

The present data suggest that the recency factor had a decisive role in the results reported by Nakayama (1995). As observed earlier, there may have been reactivation at the gap in the scrambling condition of Nakayama’s experiment, but he was unable to detect it because the probe was more recent in his canonical control.

Another concern was that the canonical items in Nakayama’s experiment were temporarily ambiguous and required reanalysis at the head of the object NP. In order to avoid this confound in the present experiment, the RC modifying the second argument NP was replaced by an adverb and an adjective. However, in nine items, the adjective was ambiguous and could have been interpreted as modifying the subject NP. This residual ambiguity may have had an effect on the probe recognition task, as the difference in reaction time between the two conditions was numerically larger for the ambiguous items. In other words, the ambiguity in the canonical condition may have delayed the recognition of the probe. However, the interaction was not statistically significant; thus, it is likely that the ambiguity did not play a crucial role in the present experiment. Nevertheless, we examine this possibility in the following experiments by eliminating the ambiguous adjectives.

5. Experiment 2

There were two goals in this experiment. First, the ambiguous adjectives used in the previous experiment were replaced with adjectives that can only be used prenominally, eliminating the reanalysis confound discussed above.

Second, the experiment included a third condition in order to investigate the effects of focus and markedness on probe recognition. Previous results for English have shown that elements in a focus position are recognized faster than non-focussed elements (Birch and Garnsey 1995); hence, it is conceivable that facilitation was observed in the previous experiment because the scrambled constituent was in focus and not because it was reactivated at the gap. The concern can also be phrased as follows. It may be necessary to provide a prior context in order to justify scrambling (see Kaiser and Trueswell 2002, for evidence on scrambling in Finnish); therefore, a scrambled constituent without a prior supporting context (or as in the present experiments, without any context at all) may be marked and consequently better remembered.
5.1 Method

5.1.1 Participants
Forty-two students from Kanda University of International Studies participated in the experiment and had not taken part in the previous experiment. Three participants’ data were eliminated from the analyses because their correct response rates in the probe recognition task were below 70% (for the remaining 39 participants, M = 93.2%; SD = 7.5%).

5.1.2 Materials
Twenty-one sets with three conditions each were constructed. The items from Experiment 1 were modified so that the second argument head noun (student in (6)) was modified by two adjectives which can only be used prenominally; this prevented a garden path from occurring in (6a), as the prenominal adjectives unambiguously indicate that another head noun will follow.

(6)  

a. Canonical condition
Gakkoo-de **mondai-o** dashita kooshi-ga
school-LOC question-ACC asked lecturer-NOM
gaikokukarano mukuchina gakusei-o mita.
abroad-from quiet student-ACC saw
‘The lecturer who asked the question at school saw the quiet foreign student.’

b. Scrambling condition
Gakkoo-de **mondai-o** dashita kooshi-o
school-LOC question-ACC asked lecturer-ACC
gaikokukarano mukuchina gakusei-ga mita.
abroad-from quiet student-NOM saw
‘The quiet foreign student saw the lecturer who asked the question at school.’

c. Focus condition
Gakkoo-de **mondai-o** dashita kooshi-koso-ga
school-LOC question-ACC asked lecturer-FOCUS-NOM
gaikokukarano mukuchina gakusei-o mita.
abroad-from quiet student-ACC saw
‘Even the lecturer who asked the question at school saw the quiet foreign student.’

The experiment included a third condition, (6c), in which the first argument noun (lecturer) was put in focus with an emphatic particle (e.g. koso, sae). If the faster reaction times in the scrambling condition of Experiment 1 were observed because the scrambled constituent was in focus, then a similar facilitation should also be observed with emphatic particles even though the word order in this case is canonical.
We assume, for present purposes, that any purported focus effect in scrambling is similar to the type of focus evoked by emphatic particles; in particular, we assume that there is no *a priori* reason to believe that focus in the two constructions should have different effects on probe recognition. Moreover, because emphatic particles without a justifying surrounding context are marked (even more so than in scrambling), we assume that this condition should also provide an opportunity to test whether markedness can facilitate memorization.

The second word in each sentence (*question*) was used as the probe. Three lists were created by distributing the test stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with 39 unrelated foil items in pseudo-random order.

5.1.3 Procedure and data analysis

The procedure and the analyses for the probe recognition data were the same as the ones used in Experiment 1. Trimming of the probe recognition data removed data points beyond 2.5 standard deviations from the relevant condition × region cell, which corresponded to less than 3.6% of the test data.

Two items were eliminated because their comprehension rates were at chance level (45.2% and 47.6% correct; for the other 19 items, $M = 83.3\%$, $SD = 11\%$). The results reported below are for the remaining 19 items.

5.2 Results

5.2.1 Response accuracy

The three conditions did not differ in probe recognition accuracy (canonical, 92.8%; scrambled, 93.7%; focus, 94.2%; $F$s < 1).

The percentages of correct responses to the comprehension questions did not differ between the canonical condition (83.6%) and the scrambling condition (80.2%; $F$s < 1). The accuracy in the focus condition (89.4%) was significantly better than in the scrambling condition ($F_1(1, 38) = 10.16, P < 0.01; F_2(1, 18) = 7.83, P < 0.05$), but it was only numerically better than in the canonical condition ($F_1(1, 38) = 2.36, P = 0.13; F_2(1, 18) = 1.96, P = 0.18$).

5.2.2 Reaction times on the probe recognition task

In the probe recognition task, reaction time in the focus condition (986 msec) was significantly slower than in the canonical condition (917 msec; $F_1(1, 38) = 7.79, P < 0.01; F_2(1, 18) = 9.43, P < 0.01$) and the scrambling condition (881.05 msec; $F_1(1, 38) = 17.77, P < 0.001; F_2(1, 18) = 19.02, P < 0.001$).

Reaction time in the scrambling condition was significantly faster than the canonical condition in the subject analysis ($F_1(1, 38) = 4.67, P < 0.05$), but not in the item analysis ($F_2(1, 18) = 1.09, P = 0.31$).
5.3 Discussion

The scrambling condition was faster than the canonical condition in the subject analysis, thus replicating the result of Experiment 1 even in the absence of ambiguous adjectives. The lack of statistical significance in the item analysis may have been caused by the relatively small number of items per condition. Experiment 3 investigates this possibility.

The focus condition with emphatic particles turned out to have slower reaction times than either of the other two conditions in the probe recognition task. This suggests that the facilitation observed for the scrambling condition in the previous experiment and partially replicated in the present experiment is unlikely to be related to focus effects. The result, however, is at odds with previous findings according to which English speakers are faster to recognize the probe medal in focus constructions as the one below, in comparison to nonfocus controls (Birch and Garnsey 1995).

(7) It was a medal that would be awarded to the new champion of the race.

A methodological difference between the two experiments may explain the conflicting results. In the English experiment, the probe used was the head of the focussed element, whereas in our experiment we used an adjective modifying the focussed head. It is unclear at this point why the effects of focus on probe recognition should vary depending on the type of probe used; however, the comprehension question performance in our experiment supports this interpretation. Comprehension questions for the focus condition were answered correctly significantly more often than for the scrambling condition (also numerically more often than in the canonical condition). This observation becomes relevant when we consider that the questions only referred to the relation between the verbs and the nominal heads in the sentences, and participants did not have to remember the exact modifiers involved. In short, when the task involves the focussed head noun (as in the probe recognition task in Birch and Garnsey’s experiment, and in the comprehension questions of our experiment), performance in the focus condition is enhanced; in contrast, when the task involves a modifier of the focussed head noun (as in the probe recognition in our experiment), performance in the focus condition declines.

6. Experiment 3

Because the advantage in probe recognition for the scrambling condition in Experiment 2 was not significant in the item analysis, we increased the number of items per condition by restricting the present experiment to the two crucial conditions.

6.1 Method

6.1.1 Participants

Thirty-five students and administrative staff from Kanda University of International Studies were paid to participate in the experiment. None of them had
taken part in the previous experiments.

6.1.2 Materials

Twenty sets with two conditions each were constructed based on items used in the previous experiment, except that in the present case, the second argument NP was modified by one prenominal adjective and there was no focus condition.

(8) a. Canonical condition
Gakkoo-de mon‘ai-o dashita kooshi-ga mukuchina
school-LOC question-ACC asked lecturer-NOM quiet
gakusei-o mita.
student-ACC saw

‘The lecturer who asked the question at school saw the quiet student.’

b. Scrambling condition
Gakkoo-de mon‘ai-o dashita kooshi-ga mukuchina
school-LOC question-ACC asked lecturer-ACC quiet

The second word in each sentence (question) was used as the probe. Two lists were created by distributing the test stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with 40 unrelated foil items in pseudo-random order.

6.1.3 Procedure and data analysis

The procedure and the analyses were the same as in Experiment 1. Trimming of the probe recognition data removed data points beyond 2.5 standard deviations from the relevant condition × region cell, which corresponded to less than 3.3% of the test data.

6.2 Results

6.2.1 Response accuracy

Probe recognition accuracy did not differ between the two conditions (canonical, 93.1%; scrambled, 95.1%; $F_s < 1.6$). Neither was response accuracy to the comprehension question significantly different (canonical, 78.2%; scrambled, 79.1%; $F_s < 1$).

6.2.2 Reaction times on the probe recognition task

Participants recognized the probe significantly faster after the scrambling condition (888 msec) than after the canonical condition (931 msec) in both types of analyses ($F_{1}(1,34) = 4.72, P < 0.05$; $F_{2}(1,19) = 12.51, P < 0.01$).
6.3 Discussion

The present result provides evidence that the recognition of a probe word is faster when it is contained in a scrambled constituent. The adjectives used were all unambiguous; therefore, there is no possibility of reanalysis having affected the results. Moreover, because the probed word occurs exactly in the same linear position in the sentences compared, there is no interference from recency effects either.

7. General Discussion

The present results provide evidence supporting the proposal that a filler-gap dependency is created when a scrambled constituent is processed. We reviewed a previous result reported by Nakayama (1995), which argued against facilitation in probe recognition after scrambled sentences. We discussed two factors that could have influenced his results, namely ambiguity and probe recency. In the experiments reported in the present paper, we eliminated those factors and observed a facilitation after the scrambled sentence, therefore providing supporting evidence for the filler-gap model (see also Nakano, Felser, and Clahsen 2000, for reactivation in long-distance scrambling). We also provided evidence in Experiment 2 that the facilitation observed is unlikely to be related to focus or markedness effects.

The present results should be investigated with respect to a number of issues. For example, the effects of case marking on probe recognition should be considered. Moreover, the effects of focus on probe recognition when the probe is the focussed head or a modifier should also be investigated.

The filler-gap model makes a number of predictions that need to be tested further. For example, it should be a common occurrence for a gap to be inserted at an incorrect position and then reinserted at a later position. In (9a), readers could initially assume that the first two arguments are part of a transitive construction with the accusative NP scrambled, therefore predicting a gap after the subject NP (as in (9b)).

(9)  a. Hana,-o Mary-ga John-ni (gap₁) ageta.
    flowers-ACC Mary-NOM John-DAT gave
    ‘Mary gave flowers to John.’

b. Hana,-o Mary-ga (gap₁) ...  
   flowers-ACC Mary-NOM
c. Hana,-o Mary-ga (gap₁) John-DAT (gap₂) ...  
   flowers-ACC Mary-NOM John-DAT

When the dative object is processed next, it becomes apparent that the fragment is more likely to be part of a ditransitive construction and consequently the position of the gap in (9b) is incorrect (similar to the discussion on the processing of the fronted wh-phrase in (1)). It is unclear at this point whether the positing of a second gap (after John as shown in (9c)) should be easier
given that a prior gap had already been posited at Mary, or whether it should be harder given that reanalysis is taking place at this point. It is also not clear whether the insertion of the first gap has any residual effect (e.g. by affecting available interpretations or their preferences).

As usual in this type of experimental work, one should be cautious in interpreting its results as revealing the exact nature of syntactic representations. There are often different ways of incorporating a competence-level proposal within a performance model, and it is virtually impossible to rule out or to give unambiguous support to such proposals based on a single experimental result. For example, it would seem premature to us to propose that the copy theory of movement (Chomsky, 1995) is supported by the present results because a gap encoded as a virtual copy of the antecedent is more likely to lead to reactivation compared to an empty category (Chomsky, 1981) or a slash feature (Gazdar, Klein, Pullum & Sag, 1985). It is generally assumed that the present type of reactivation is related to anaphoric relations in discourse and not necessarily to syntactic factors (McKoon and Ratcliff, 1980). In particular, pronouns have been shown to reactivate their antecedents (Cloitre and Bever, 1988); hence, unless one is willing to assume that pronouns are also generated through a copy of their antecedents, there is no principled reason to favor the copy theory based on the present type of data.

Although this type of experiments is unlikely to reveal how gaps are encoded in syntax, they may provide converging evidence on the location of gaps. For example, the filler-gap model can be used to test reactivation effects in VP-internal scrambling. If the accusative-dative order shown in (10a) involves scrambling and has a gap immediately after the dative NP (Hoji 1985; also Miyamoto and Takahashi 2002, for supporting reading time evidence), then recognition of the probe tall should be faster when compared to the canonical condition in (10b).

(10) a. VP-internal scrambling construction
   Isshuukan-mae-ni Yamadasan-ga [se-no-takai tomodachi]-o
   a week ago Yamada-NOM tall friend-ACC
   sensei-ni (gap1) shookai-site oita.
   teacher-DAT introduce aux(past)
   ‘A week ago, Yamada introduced a tall friend to the teacher.’

   b. Canonical ditransitive construction
   Isshuukan-mae-ni Yamadasan-ga se-no-takai sensei-ni
   a week ago Yamada-NOM tall teacher-DAT
   tomodachi-o shookai-site oita.
   friend-ACC introduce aux(past)
   ‘A week ago, Yamada introduced a friend to the tall teacher.’

Results of a preliminary study indicate that this is indeed the case, as the probe was recognized faster in the VP-internal scrambling condition (841 msec) than in the canonical condition (869 msec), although the difference was only significant in the item analysis ($F_1(1,53) = 2.85, P = 0.097$; $F_2(1,19) =$
4.96, $P < 0.05$). If confirmed by future studies, the result (together with reading time results for similar constructions; Miyamoto and Takahashi 2002) could be used to argue against claims that both word orders are canonical (e.g. Miyagawa 1997).

References


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