
INTERFERENCE AND SUBCATEGORIZATION INFORMATION: A CASE OF PRE-VERBAL NPs IN JAPANESE *

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1 Introduction

One of the central goals of sentence processing is to correctly parse the incoming sequence of words and build syntactic representations to reach an interpretation. Along the way, the parser has to determine numerous syntactic dependencies, which is one of the main problems of the structure building process (Frazier, 1979, Gorrell, 1995, Crain & Fodor, 1985). Take (1) as an example (taken from Lewis, Vasishth & Van Dyke, 2006); (1a) contains a long distance wh-dependency. The sentence-initial wh-phrase what must be linked to the position (which is often called a “gap” in the literature) where a non-wh counterpart (such as the present) would appear (marked with an underline).1 Such an association seems necessary in order to determine the thematic role for the fronted wh-phrase. Even in the case of a single clause example (1b), the head noun of the subject the toy must be associated with the verb arrived that appears several words away from the subject. Because the distance between the subject and the verb is potentially quite large, the dependency formation should not be a simple task even in a single clause. It is clear now that syntactic structure building is full of dependency formations.

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1 There is some debate regarding to exactly what element the wh-phrase has to be associated with (i.e., with gaps or verbs; e.g., Pickering & Barry, 1991). Here we followed the discussion elaborated in Phillips & Wagers (2007) that there is, at this point, no comprehensive account for the way of encoding the relevant dependency relation. Thus, although we describe the phenomenon by using the term ‘gap’, we should set the issue aside because the choice does not seem to have an influence on our claims here.
(1) a. What does Melissa believe that her uncle in Bogotá sent __ for her?
   b. Melissa knew that the toy from her uncle in Bogotá arrived today.

It has been found in the literature that the difficulty associated with the dependency formation is directly linked to the difficulty of sentence processing, suggesting that the parser has a particular tendency when dealing with various syntactic dependencies in real time. A pioneering work by Stowe (1986) showed that the parser prefers that the dependency with a wh-phrase be short though the grammar certainly allows long distance dependencies (see also Crain & Fodor, 1985, Traxler & Pickering, 1996). It has been suggested that such a preference comes from the interaction between the sentence processing mechanism and the working memory system (Gibson, 2000, Wagers, 2008).

Although there are a lot of unsolved issues that have to be investigated with respect to the precise relation between the sentence processing mechanism and the working memory system, McElree (2006) recently argued that our memory system, which can famously hold 7 ± 2 items in a buffer has a very severe limitation in terms of the current focus of attention: the memory system has a subdomain called “focal attention,” whose capacity is much more restrictive than that of the working memory in general. One distinct property of the focal attention is that while items in the focal attention can be accessed very rapidly, items in other memory domains must be accessed rather slowly. He further suggested that the number of items to which we can pay serious attention is probably no more than two; in other words, the focal attention can only accommodate very few items simultaneously.

Based on such a suggestion from the working memory literature, some researchers argued that the parser processes various dependencies in a sentence based on a process called “memory retrieval” (Lewis, 1996, Lewis, et al., 2006). For example, consider example (1b) again; when the parser encounters the verb *arrived*, the parser needs to search for and inspect the information of the candidates for the subject in memory. This suggests that the association between the subject and the verb cannot be established instantaneously just by attaching the verb into the parsed structure (or the process of “attaching the verb into a structure” is a label comprising various processes). Rather, a (slow) memory retrieval process has to be implemented because the head of the subject *the toy* cannot be found in the focal attention.

Lewis et al. (2006) argued that this retrieval is performed based on certain cues generated by the verb. Consider example (1b) again to illustrate how cue-based retrieval works, further limiting our discussion to a simple case, such as the relation between the subject and the verb. When the parser encounters the subject *the toy*, the subject is encoded in memory with some cues for later retrieval (such as “this is a nominative NP and needs a predicate”). Then the parser encounters the verb *arrived*, which triggers a “cue-generation” (such as “this verb needs a nominative subject-NP”) and the parser looks for the matching cues in memory based on these generated cues. One important property of this system is that elements in memory similar to the retrieval target *the toy* in one way or another function as distractors, which causes so-called “similarity-based interference effects.” In other words, when other materials in memory, such as *Melissa, her uncle, and Bogotá* (all of them being NPs), are similar to the retrieval target in some partially matched cues, the parser takes more time to retrieve the target.

There are numerous research questions to be investigated. In the illustration above, it is still unclear exactly what kind of information or features are encoded when NPs are processed. In addition, various implementations seem to be possible regarding the exact mechanism for
encoding and retrieval. Similarity-based interference will play a crucial role in answering those questions.

So far, we have made the observation that cue-based memory retrieval is one of the central components in sentence processing. Study of cue-based memory retrieval is getting more attention these days because it enables us to make clear the connection between the model of syntactic structure building and the domain general working memory system. It should also be clear that investigating the exact mechanisms of encoding and retrieval constitutes a very important empirical problem in the field. Below, we will briefly review some empirical findings regarding “similarity-based interference effects”. We will review one study about semantic interference, and another about syntactic interference (Van Dyke, 2007, Van Dyke & McElree, 2006, Van Dyke & Lewis, 2003). Then we will proceed to discuss a phenomenon called pre-verbal attachment in Japanese (Kamide & Mitchell, 1999, Miyamoto, 2002). Incremental processing based on the sequence of NPs is one of the key phenomena in Japanese sentence processing, but we would like to further elaborate the implications of the incremental structural commitment from the viewpoint of cue-based memory retrieval. Specifically, we will explore a case of clause boundary insertion triggered by the sequence of a topic-marked NP and a nominative NP. We argue that this sequence of NPs leads the parser to encode the topic-marked NP as the subject of the verb that takes a CP as a complement. We will examine this claim in a self-paced reading experiment using the similarity-based interference effect as an index. We will show that an interference effect is observed when the parser reads the verb that takes a CP as a complement such as *yoboo-suru* “demand” as the embedded verb. We will also discuss some further implications of the results obtained from the experiment.

2 Similarity-Based Interference

The basic idea of similarity-based interference is quite simple. Every time we use information stored in memory, we at first need to retrieve such information from our memory; similarity-based interference occurs when materials stored in memory are in some way similar to the retrieval target (the item to be retrieved). The materials causing interference effects are called “distractors.”

Here is one common example: imagine that you parked your car in a parking lot of a large shopping mall. When you have done your shopping, you need to recall where you parked your car. The retrieval target is the location of your car, and potentially there is a lot of information that functions as distractors for successful memory retrieval. Memory retrieval could be difficult if entrances from the parking lot to the mall looked similar; you have parked your car in different sections of the lot previously; or this is the third shopping mall you visited on that day.

Van Dyke & McElree (2006) showed convincingly that interference effects have a major influence on sentence processing. They used the memory load paradigm, where the participants of the experiment have to memorize a series of words before reading a sentence. In one of their trials, the participants had to memorize three words [table, sink, truck] and read a sentence in (2). Van Dyke & McElree (2006) found that the reading time of the verb *fixed* in (2b) was slower than that of the verb *sailed* in (2a). They argued that the slowdown in (2b) was caused by a semantic similarity interference, because the words in memory [table, sink, truck] were all fixable items and semantically similar to the target word *the boat*. On the other hand, since the
three words in memory are not what people can sail in (2a), they did not cause an interference effect.

(2)  
   a. TABLE, SINK, TRUCK  
       It was the boat that the guy who lived by the sea sailed in two sunny days.  
   b. TABLE, SINK, TRUCK  
       It was the boat that the guy who lived by the sea fixed in two sunny days.

There is other work showing that syntactic properties, such as a grammatical function or case, cause interference. Van Dyke & Lewis (2003) used sentences such as (3a) and (3b), and found that the verb region was complaining was read slower in (3b) than in (3a). Note that (3a) and (3b) are different in the number of the nominative NP in the structure, and in that (3b) contains an extra nominative NP (see Wagers (2008) for the critical review of this manipulation. They argued that the syntactic property of being a subject or nominative NP the warehouse partially matches the syntactic properties of the target, which causes interference for the memory retrieval of the target the resident.²

(3)  
   a. [The worker] was surprised that [[the resident] who was living near the dangerous warehouse was complaining about the investigation].  
   b. [The worker] was surprised that [[the resident] who said that [[the warehouse] was dangerous was complaining about the investigation]].

There are only a few studies investigating properties of similarity-based interference effects in Japanese (Lewis & Nakayama, 2002, Uehara, 1997, Uehara & Bradley, 2002). These studies focused on showing that the repetition of similar constituents (namely, nominative NPs) slows down the parser, and argued that NPs bearing the same case-marker participate in the similarity-based interference in languages like Japanese. In the next section, we will review a well-established parsing preference in Japanese and illustrate that similarity-based interference will play a crucial role in scrutinizing the nature of the structural commitment of the parser with respect to the sequence of the topic-marked NP and the nominative NP.

3 Pre-verbal Attachment in Japanese

One of the major corner stones in Japanese sentence processing research is that the parser can actively predict the yet-to-be seen sentence structure based on the information from the sequence of case-marked NPs (Mazuka & Itoh, 1995, Aoshima, Phillips & Weinberg, 2004, among others). The verb at the end of the clause will eventually reveal a lot about the sentence structure, but the parser can incrementally build structure before encountering the verb.³ For example, Kamide & Mitchell (1999) and Miyamoto (2002) argued that the sequence of a topic-marked NP and a

² One may wonder how the linear relation should matter between the retrieval target and the distractors. In general, the distractors may precede or follow the target, and in the literature there is some debate regarding when the positional difference would matter. But, in this paper, we will slightly simplify the discussion, and pretend that the positional difference is relatively minor at this point.

³ Of course, there are lots of sentences that contain various kinds of structural ambiguities, but it is nevertheless true that the verbs provide very rich information about the argument structure, hence the structure of the whole clause.
nominative NP leads the parser to insert a clause-boundary between the two elements, as illustrated below.⁴

\[ \text{NP-TOP} \quad \text{NP-NOM} \quad \ldots \quad \text{verb} \]

Under the clause-boundary insertion analysis, it is probably safe to assume that each of those NPs is taken as a subject of a clause, but the way in which the embedded clause S2 is attached to the matrix clause S1 relates to the issues as to how detailed a structure the parser can build, and whether the parser can predict the specific type of matrix verb with this amount of information. Of course, one of the most plausible analyses seems to assume that the embedded clause S2 is a sentential complement of the matrix verb, but structurally there are multiple possibilities of how the embedded clause S2 relates to the matrix clause S1.

For example, the parser may assume that the nominative NP after the topic-marked NP is the subject of the embedded clause, and the embedded clause could be some kind of adjunct clause. In (5a), the nominative NP is the subject of the embedded clause, and the embedded clause is a temporal adjunct clause, not a complement clause. Then, the parser may be able to leave the type of matrix predicate unspecified, because, being an adjunct clause, the embedded clause has no major impact on the subcategorization information of the matrix predicate; this kind of adjunct clause does not provide a strong cue for the parser regarding the type of matrix predicate. Example (5b) illustrates a case where the nominative NP is the subject in the relative clause. The relative clause S2 modifies the object NP of the matrix predicate. This is a grammatically possible analysis for the parser to adopt, but it is well known that the parser tends to avoid a relative clause structure if possible, probably because it is structurally quite complex (see e.g., Hirose & Inoue, 1998).

(5) a. \([\text{CP}_{S1} \quad \text{NP-wa} \quad [\text{CP}_{S2} \quad \text{gakusee-ga} \quad \text{kaetta atode}] \quad \text{heya-o} \quad \text{soozisita}]\]
   teacher-TOP student-NOM left after room-ACC cleaned
   ‘The teacher cleaned the room after the student left.’

b. \([\text{CP}_{S1} \quad \text{NP-wa} \quad [\text{NP} \quad \text{CP}_{S2} \quad \text{gakusee-ga} \quad \text{katta}] \quad \text{susi-o} \quad \text{tabeta}]\]
   teacher-TOP student-NOM bought sushi-ACC ate
   ‘The teacher ate the sushi which the student bought.’

Suppose that the parser assumes that the embedded clause S2 is a sentential complement of the matrix verb because it is structurally the simplest one. Then such an analysis has at least two implications for the parser’s hypothesis about the ultimate structure of the current input. First, the parser may posit that the type of matrix verb is a verb that takes a clausal complement CP. Second, the parser may encode that the topic-marked NP in the matrix clause is the subject of the verb that takes a clausal complement CP. Note that this is very specific encoding information. If true, this shows that information encoded in the pre-verbal NPs includes not only a syntactic property of being a nominative subject, but also the subcategorization information of the verb (i.e., the verb takes a complement CP) that would be associated with the nominative subject.

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⁴ Obviously, there are a lot of alternative ways to analyze the nominative NP after the topic-marked NP. One of the structurally simplest ways to parse this nominative NP is to analyze it as a nominative object for a stative predicate, such as kowai ‘be scared of’. This structural analysis is simple especially in terms of the number of clauses involved. See Kamide & Mitchell (1999) and Miyamoto (2002) for their discussion why the parser prefers the bi-clausal analysis over the mono-clausal analysis.
4 Experiment

In order to examine whether the subcategorization information is included in the encoding information of the topic-marked NP, we tested if the matrix NP causes an interference effect when the parser encounters a verb whose subcategorization information partially matches the encoded information of the matrix NP. We thus conducted a self-paced reading experiment of the moving-window style to examine whether the pre-verbal NPs encode the subcategorization information for the upcoming verb for later retrieval.

4.1 Participants, Materials, and Procedure

Thirty-eight undergraduate students from Mie University participated in the self-paced reading experiment that took about 30 minutes. We prepared 24 sets of target sentences, which were distributed into 4 lists according to the $2 \times 2$ factorial design. Target sentences in each list were mixed with 68 filler sentences that included target sentences of an unrelated experiment and other sentences relatively similar to the target sentences, in order to mask the aims of the experiment from the participants. Sentences were presented pseudo-randomly, and the participants read sentences in a self-paced reading (moving window style) task setup, such that each sentence was presented word-by-word. Most of the sentences appeared on a single line, and the sentences were segmented as shown in (6). Participants were instructed to read the sentences at the speed they do normally. Each sentence was followed by a comprehension question asking about the content of the sentence, in order to make sure that the participants paid attention to the task.

A sample set of the target sentences is shown below. The first factor we manipulated was the position of the embedded clause. In the Center-Embedded conditions (6ac), the embedded clause was nested between the matrix subject and the matrix verb. In the Preposed conditions (6bd), on the other hand, the embedded clause was preposed to the sentence-initial position. Another factor we manipulated was the type of verb used in the embedded clause. In the NP-V conditions (6cd), the verb in the embedded clause was a transitive verb that takes an accusative NP only as its complement. In the other conditions (6ab), a particular class of verbs was used in the embedded clause that can take either an NP or CP as its complement. We call this class of verbs NPCP-verbs.

(6) a. Center-Embedded, NPCP-Verb condition

Tenin-wa₁ [zyoorenkyaku-ga₂ zakkaya-no₃ tentoo-de₄ syoohin-no₅ nesage-o₆ yooboosita-to]₇ hikaesitu-de₉ hanasitei-ta₉ clerk-TOP₁ [regulars-NOM₂ goods.shop-GEN₃ front-at₄ goods-GEN₅ discount-ACC₆ demanded-C]₇ lobby-in₉ was.talking₉

“A shop clerk was saying at the backroom that frequent shoppers demanded some discount of the goods in front of the variety goods shop.”
Condition (6a) was a crucial one; this is the condition in which we predict that the interference effect will emerge due to the encoding information of the matrix topic-marked NP. By using a verb whose subcategorization frame states that this verb takes either NP or CP as its complement, we examined whether an interference effect will emerge. If the encoding information of the matrix topic-marked NP includes the information of the NP being a subject of the CP-taking verb, we expect that the interference effect will be observed at the embedded verb region. We will compare the reading time of the verb in (6a) against (6b), where no distractor is present and hence we predict there will be no interference effect at all. This comparison is not, however, perfect. This is because the reading time of the verb is influenced by the position of the clause, and in general, a verb is read faster when the clause is placed in a nested fashion (Nakatani & Gibson, 2010). Therefore, reading time differences between (6a) and (6b) would be a sum of the predicted interference effect plus the clause-position speed up effect.

It seems necessary to independently measure the size of the speed up effect due to the clause position, so that we can estimate the magnitude of the interference effect found between (6a) and (6b). We therefore prepared conditions (6c) and (6d). In these conditions, we used a verb that takes only NP as a complement. Conditions (6c) and (6d) are necessary, and at the same time useful in order to measure the speed-up effect due to the clause position because the comparison between (6c) and (6d) does not involve any relevant interference situations. Therefore, what we ultimately need to compare is the difference between the difference observed in (6a) and (6b) against the difference observed in (6c) and (6d).
4.2 Results

Comprehension accuracy data and reading time data of each region were entered into a repeated-measures ANOVA with clause position (Center-Embedded vs. Preposed) and verb type (NP-verb vs. NPCP-verb) as within-subject factors. No participant was excluded from the analysis because the accuracy rates for the comprehension questions from each participant were all above 75%. Mean comprehension accuracy was 92.4% ((a) Cent.Emb-NPCP, 85%; (b) Preposed-NPCP, 96%; (c) Cent.Emb-NP, 91%; (d) Preposed-NP, 98%), and there was a main effect of clause position ($F_1(1,37)=18.29$, $p<.01$, $F_2(1,23)=13.83$, $p<.01$), due to a better accuracy rate for preposed conditions and there was also a main effect of verb type ($F_1(1,37)=6.83$, $p<.02$, $F_2(1,23)=5.25$, $p<.04$). Comprehension questions for the NP-verb conditions were answered more accurately than those for the NPCP-verb conditions. There was no interaction between the two factors ($F_8<1.4$).

For the reading time data, reading times longer than 2500 ms were discarded, and only the reading time of the trials in which the comprehension question was answered correctly was included. The reading time results are shown in Figure 1. The y-axis shows the reading time, and x-axis shows the regions in the test sentence. Table 1 is also provided to illustrate the reading time data in region 7, which contains the embedded verb, and is the critical region of the sentence.

![Figure 1. Reading time data per region](image)

$(\text{NP-TOP}_1) [\text{NP-NOM}_2 \text{ Mod}_3 \text{ PP}_4 \text{ Mod}_5 \text{ NP-ACC}_6 \text{ Verb-to}_7 (\text{NP-TOP}_8) \text{ PP}_9 \text{ Verb}_10)^5$

Region 1 was missing from the Preposed conditions (bd) because the matrix subject NP was presented after the preposed embedded clause. Therefore, the material in region 1 in the Center-Embedded conditions (ac) was presented as region 8 in the Preposed conditions (bd).
interference effect thus occurs... this verb... that take... explanation, w... NPCP... embedded position... effect and the comparison between th... associated with the s... processing conditions, the parser can realize that it deal... signals to... embedded ve... interpretation of the results... source of this Gibson & Wolf, 2005, kind of... 4.3 Discussion... what is most intriguing... is exactly the kind of verb that takes a CP complement and does need a subject NP. An interference effect thus occurs because the sentence-initial topic-marked NP becomes a distractor
for the successful retrieval of the nominative NP in the embedded clause. Assuming that the clause-position effect is a ubiquitous phenomenon, the reading time of the embedded verb in (6a) was expected to speed up, but the interference effect led the reading time of the embedded verb in the opposite direction (i.e., slowdown); since those two effects balanced each other to some extent, we did not observe a major speed-up effect between the NPCP-verb conditions. On the other hand, although the encoding information of the sentence-initial topic-marked NP in (6c) was the same as the NP in (6a), the retrieval cues generated by the embedded verb kaihusita ‘opened’ in (6c) did not match as closely as in (6a). Note that the embedded verb in (6c) is a verb that takes an NP as its complement, not a CP complement. Therefore the sentence-initial topic-marked NP in (6c) did not function as a major distractor for the retrieval of the nominative NP in the embedded clause, due to smaller overlap between the encoding information of the topic-marked NP and the retrieval cues generated by the verb.6

This finding has several implications for sentence processing in Japanese. First, assuming that the interference effect occurred due to the encoding information of the matrix topic-marked NP, our results indicate that the parser assumes that the embedded clause is a CP complement. This shows that the structural prediction of the parser is much more concrete than just having a clause-boundary between the two NPs, given the presence of the sequence of the topic-marked NP and the nominative NP. Our results show that the parser can incrementally build a structure with specific details.

Second, our results suggest that the subcategorization information of the predicate can be included as the encoding information of the NP. In our case, the subject NP in the matrix clause encodes not only the feature of being NP and subject, but also the information that the to-be-associated predicate is a CP-taking verb. This helps us to build a model of sentence processing with cue-based retrieval that has a particular set of features for encoding NPs. Third, note that this subcategorization information is only available after the parser encounters the nominative-marked NP. So, when the parser initially sees the topic-marked NP, the information about the predicate type can be unspecified and later added.

Since only a few people have worked on the on-line processing of interference effect in Japanese, many questions arise. Our results suggest that encoding NP includes subcategorization information like “this verb takes a CP complement”. But note that, in our experiment, the verb was used in an NP-taking context, preceded by an accusative NP. One may wonder why the property of CP-taking is used as a retrieval cue. We can put forward a few possibilities. First, we may hypothesize that both subcategorization frames (i.e., both NP-taking and CP-taking) are always active. The subcategorization information is a lexical property of a given verb. The syntactic context does not change the lexical property of the verb itself. Second, most, (if not all) NPCP verbs used in our experiment (such as tuutisuru ‘notify’ and hookokusuru ‘report’) actually allow both the accusative NP and a complement CP at the same time as example (7) illustrates. This example illustrates that the use of the accusative NP does not eliminate the possibility of the verb taking a complement CP. Thirdly and finally, it could be the case that the CP-taking property of the verb was included in retrieval cue since the verbs used in the experiment are used quite frequently with the subcategorization frame of {CP-taking} in general. Due to frequency, this particular information was always active regardless of the syntactic context. We plan to run some more experiments to test those possibilities in the future.

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6 It is too strong to claim that there is no interference effect at all. Being a syntactic category of NP, the matrix subject would increase the cost of retrieval of the relevant subject by the embedded predicate. Nonetheless, such an interference effect would be present even in (5a), and it could be that the magnitude of the effect is relatively small.
(7) Butyoo-wa syatyoo-ni sono mondai-o [kikai-ga kosyoosita-to] manager-TOP president-DAT that.problem-ACC [machine-NOM broke]-C hookokusita reported

“The senior manager reported the problem to the president that the machine broke."

3 Conclusion

To sum up, the literature on sentence processing now has to take into consideration the relation between the syntactic parser and the working memory system. This is why the cue-based parsing mechanism is getting more attention. In this connection, we discussed a clause boundary insertion phenomenon in Japanese. This seems to be an interesting area in which to investigate the cue-based memory retrieval in Japanese. In the experiment, we saw a syntactic interference effect, presumably due to the encoding information of the sentence-initial topic-marked NP. We argue that this suggests that the subcategorization information of verb can be used to encode an NP. Finally, our results imply that the encoding information may be further added as the parser processes further input.

References


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