THE PROCESSING OF EMPTY SUBJECTS IN ENGLISH AND JAPANESE

TSUTOMU SAKAMOTO*
MATTHEW WALENSKI†

*Faculty of Letters
Kyushu University
Fukuoka, Japan

†Department of Linguistics
University of California, San Diego
La Jolla, California

1. INTRODUCTION

The present chapter is concerned with the mechanism by which the parser identifies the correct antecedent of a gap. In particular, we will discuss the particular construction involving the case of a subject gap in control structures (PRO, within the generative literature). We take a crosslinguistic perspective, in keeping with the themes of this book, and compare the results of experiments from both English and Japanese. In this chapter, we pursue this idea and propose a "theta-checking strategy" that can explain the universality of antecedent identification in control structures, as well as differences between English and Japanese concerning the processing of these empty subjects. Essentially, this strategy claims that information is used by the parser as soon as it becomes available. This follows from universal characteristics of the parser, with the acknowledgement that the time course of information availability, as well as the salience of particular cues, differs from language to language. In sections 2 and 3 we will review the experimental literature that has been put forward for these constructions in English and Japanese,
respectively. Section 4 compares the results obtained from the two languages, and acknowledges criticisms of earlier work in this area. Section 5 examines a proposal from the linguistic literature regarding the identification of PRO, which is incorporated into the parsing strategy outlined in section 6. Section 7 discusses the types of parsers that could be used to explain these findings.

2. PROCESSING OF EMPTY SUBJECTS IN ENGLISH

One type of gap that has been identified within the generative tradition (cf. Chomsky, 1982) is PRO, which appears as the subject of nonfinite clauses in English. However, one question that has yet to be answered, both within grammatical and parsing theories, is how the antecedent of PRO is identified. Within a generative framework, one analysis for these structures is that a given verb will assign control of PRO to one of its arguments (Jackendoff, 1972), provided that PRO is uniquely identified with one of these arguments (this has been termed “obligatory control”).1 One verb class that has been identified in this respect assigns control to its subject (subject control), whereas another type of verb assigns control to its object (object control). In other cases, when the verb does not uniquely specify an argument to be the controller of PRO, the situation is less clear (this has been termed “nonobligatory control” by Williams, 1980, and will not further concern us here).

Frazier, Clifton, and Randall (1983) (see also Clifton and Frazier, 1986) tested English control structures to determine the strategy used by the parser to identify the antecedent of the subordinate subject. Consider the following examples from Frazier et al.:

(1) Recent Filler (Subject control) Sentence
Everyone liked the woman who\textsubscript{1} the little child\textsubscript{2} started [PRO\textsubscript{2} to sing those stupid French songs for trace\textsubscript{1} last Christmas].

(2) Distant Filler (Object control) Sentence
Everyone liked the woman who\textsubscript{1} the little child forced trace\textsubscript{1} [PRO\textsubscript{1} to sing those stupid French songs last Christmas].

In the recent filler sentences, (1), the verb start, a subject control verb, assigns its subject the little child to be the controller of PRO. Notice that of the two possible fillers, the woman and the little child, it is the little child that is closer (by number of intervening words) to the subject gap. Hence, the actual filler is also the more recent filler. For the distant filler sentences, (2) above, the verb force assigns its object the woman to be the controller of PRO. In these sentences, the actual filler is the more distant of the two possible fillers. Frazier et al. hypothesize
that if temporal recency is a factor in the identification of the antecedent, so that a more recent filler is preferred over a more distant one, then sentences for which the recent filler is also the actual filler will produce faster reaction times (RTs) in a comprehension “got-it” task than sentences for which the recent filler is not the actual filler. The experimental results by Frazier et al. (given in Table 1) showed that distant filler sentences required more processing time and produced more errors than the recent filler sentences. Frazier et al. explained these findings with what they called the Most Recent Filler (MRF) strategy, which is stated as (p. 196):

The MRF strategy: During language comprehension a detected gap is initially and quickly taken to be co-indexed with the most recent potential filler.

Frazier et al. imply that the MRF strategy applies only when the parser does not have reliable information about the correct filler for a gap. In the absence of lexical control information, the MRF strategy is claimed to apply. This strategy assigns the nearest potential filler to a gap. This initial choice by the parser is later overridden by lexical information supplied by the verb if necessary. It is this error-correcting procedure that causes the longer processing time in the distant filler sentences. Furthermore, Frazier et al. imply that the parser does not recognize a gap as a possible filler for another gap (this is termed the “Lexical Filler Only” hypothesis in Sakamoto, 1991, 1996).

This account has two important consequences: first, lexical control information is not immediately available, and second, that in the meantime the parser relies on a heuristic strategy based on temporal recency. Consistent with this finding, Nicol (1988) found, using an on-line cross-modal priming technique, that identification of the missing subject of a subordinate clause (PRO) was slow and inaccurate. Specifically, she found that immediately following the gap in such a sentence, the controller of the empty subject has not yet been identified. Though Nicol makes no specific claims concerning a recency strategy, her findings suggest that there is no immediate commitment on the part of the parser to identify an antecedent. So although control information may be delayed, there may be no strategy used by the parser in the meantime.
3. PROCESSING OF EMPTY SUBJECTS IN JAPANESE

Working in Japanese, Sakamoto (1991, 1995a, 1995b, 1996) conducted a series of experiments to test the MRF hypothesis. Japanese offers two advantages over English. First, verbal control information is necessarily delayed, since Japanese is a verb-final language. Second, Japanese allows scrambling of arguments, so that either argument of a control verb may be put in a recent filler or distant filler position.

Sakamoto tested both subject control (3a) and object control (3b) verbs using nominalized subordinate clauses. Subjects were instructed to listen to each sentence and respond by naming the person who is going to be in Tokyo. An example of each type of sentence is given in (3):

(3) a. Subject control

\[
\text{Tosio-ga ototoi Junko-ni [PRO Tokyo iki]-o}
\]
\[
\text{Tosio-NOM day before yesterday Junko-DAT Tokyo going-ACC}
\]
\[
tegami-de hakuzyoosita. letter-by confessed.
\]

'The day before yesterday, Tosio confessed to Junko by mail that he would go to Tokyo.'

b. Object control

\[
\text{Tosio-ga kissaten-de Junko-ni [PRO Tokyo ryokoo]-o}
\]
\[
\text{Tosio-NOM café-at Junko-DAT Tokyo travel-ACC}
\]
\[
hakkirito meireisita. clearly ordered
\]

'At the café, Tosio clearly ordered Junko to travel to Tokyo.'

The results of experiment 1 (given in Table 2), in which experimental sentences have "subject–object" order, showed that object control sentences were easier to process than subject-control sentences (666 − 607 ms = 59 ms, \( p < .05 \)).

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>S-control</th>
<th>O-control</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction time (ms)</td>
<td>666</td>
<td>607</td>
<td>59 ((F(1,22) = 6.23, p = 0.021))</td>
</tr>
<tr>
<td>Consistency (%)</td>
<td>88.9</td>
<td>90.2</td>
<td>-1.3 ((F(1,22) = 0.491, p = 0.491))</td>
</tr>
</tbody>
</table>
objects in this experiment were also the more recent fillers. Thus, the results of this experiment are compatible with the hypothesis that the MRF strategy applies to Japanese control structures. However, another possible explanation is that the parser prefers to assign control to an object initially. A second experiment by Sakamoto was designed to compare these two hypotheses.

In this experiment, the order of the subject and object NPs was switched, so that in the object-control sentences the object was the distant filler, and in the subject-control sentences the subject was the recent filler. The materials are given in (4) below:

(4) a. Subject control

\[
\text{Junko-ni ototoi Tosio-ga [PRO Tookyoo iki]-o}
\]
Junko-DAT day before yesterday Tosio-NOM Tokyo going-ACC
tegami-de hakuzyoosita.
letter-by confessed.

'The day before yesterday, Tosio confessed to Junko by mail that he would go to Tokyo.'

b. Object control

\[
\text{Junko-ni kissaten-de Tosio-ga [PRO Tookyoo ryokoo]-o}
\]
Junko-DAT cafe-at Tosio-NOM Tokyo travel-ACC
hakkiritto meireista.
clearly ordered

'At the café, Tosio clearly ordered Junko to travel to Tokyo.'

If the MRF strategy is correct, then the results should be the opposite of the previous experiment. If object control is preferred, then the results should come out the same as in the previous experiment.

The results of experiment 2 (given in Table 3), in which experimental sentences have "object–subject" order, revealed that not the most recent lexical filler but the object was preferred as a controller, even when it was the distant lexical filler (749 – 648 ms = 101 ms, p < .05).

| TABLE 3 |
| RESULTS OF OBJECT–SUBJECT ORDER EXPERIMENT IN JAPANESE |

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>S-control</th>
<th>O-control</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction time (ms)</td>
<td>749</td>
<td>648</td>
<td>101 (F(1,16) = 7.93, p = 0.0124)</td>
</tr>
<tr>
<td>Consistency (%)</td>
<td>84.4</td>
<td>90.8</td>
<td>-6.4 (F(1,16) = 3.01, p = 0.102)</td>
</tr>
</tbody>
</table>
The findings of the above two experiments indicate that the processor favors object controllers regardless of their surface positions in the sentence. The results of this work indicate that recency is not the deciding factor, but in fact that there is a preference for the parser to choose object control initially.

On the other hand, one possible way to maintain the MRF strategy would be to admit the existence of a movement trace in the “object—subject” sentences, which could be recognized by the parser as a possible filler. However, this conflicts with Frazier et al.'s assumption that only lexical fillers may be recognized by the parser (Lexical Fillers Only hypothesis). See Sakamoto (1996) for a full discussion of the consequences of abandoning this hypothesis to maintain the MRF strategy for both English and Japanese.

4. COMPARISON OF ENGLISH AND JAPANESE

Now, let us consider again the English and Japanese examples relevant to our discussion, beginning with Frazier et al.'s materials (repeated here as [5] and [6]):

(5) Recent Filler (Subject control) Sentence
    Everyone liked the woman who₁ the little child₂ started [PRO₂ to sing those stupid French songs for trace₁ last Christmas].

(6) Distant Filler (Object control) Sentence
    Everyone liked the woman who₁ the little child forced trace₁ [PRO₁ to sing those stupid French songs last Christmas].

Crain and Fodor (1985) (see also Ford and Dalrymple, 1988; Fodor, 1988; and Nicol, 1988) noted that Frazier et al.'s distant filler sentences contain two adjacent gaps, whereas the recent filler sentences have only one gap following the verb. They claim that the recent filler sentences are faster because they are easier. That is, processing one gap is easier and takes less time than processing two gaps. A second possible explanation (Fodor, 1988) has to do with the differences in thematic function of the controller between the matrix and subordinate clauses. In a subject-control sentence (recent filler) like (5), the subject of the matrix clause is also the subject of the subordinate clause, so no revision of function is necessary. In an object-control sentence like (6), the matrix object becomes the subordinate subject; it is this revision of function that is hypothesized to lead to the observed difficulty. Another way to look at it is that the extracted element does not have the same function in the two types of sentences. For a recent filler (subject-control) sentence like (5), the extracted NP the woman forms a filler-gap dependency that is independent of the dependency created by PRO and its controller. However, for a distant filler (object control) sentence like (6), the extracted element is involved
with both the filler-gap dependency created by its extraction, as well as with the control relationship necessitated by PRO, as in this case the extracted element is also the controller.

Keeping in mind the three possible explanations mentioned above, let us consider the cases in Japanese. For the Japanese experiments, four sentence types were used. These consisted of a subject-control verb and an object-control verb in an SOV sentence frame, and these same verb types again in an OSV sentence frame. These are shown below as (7a/b) and (7c/d), respectively.

(7) a/b. *Taroo-ga Hanako-ni [PRO Tookyoo iki]-o yakusokusita/susumeta.*
    c/d. *Hanako-ni, Taroo-ga trace, [PRO Tookyoo iki]-o yakusokusita/susumeta.*

The Japanese comparison of “subject–object” and “object–subject” order reflects the English in that there is a difference in the number of gaps involved. However, this difference in Japanese is not confounded with respect to subject or object control as it is in English. Both SOV and OSV word-order types are given in the Japanese experimental items in both subject- and object-control constructions. Therefore, even if double-gap constructions are more difficult to parse, this difficulty will affect the amount of time it takes for the parser to recognize the controller in Japanese in both control constructions equally.

What is left to be explained is why, for Japanese, both one gap (subject–object order) and two gap (object–subject order) constructions prefer object control rather than subject control when both a subject and object are present. We explain this by assuming that in both Japanese and English, object control is preferred as an initial choice by the parser. It therefore becomes plausible to assume that although the Japanese data picked up an object controller preference (comparing subject-control to object-control constructions), the Frazier et al. data for English picked up the difficulty of processing the double-gap constructions in object-control structures (compared to the single-gap subject-control constructions), and did not directly reflect the processing of the control dependency.

Nakayama (1996) reports on the interpretation of empty subjects in embedded clauses by Japanese children. The experimental results showed that empty subjects with matrix object interpretation are more accurately identified than those with matrix subject interpretation. This result may support the hypothesis that there is a universal tendency for object control.

Note that there is no a priori reason why object control is preferred. Even in English, however, there are some observational facts that exhibit object preference. First, for verbs that allow both a subject and an object, the majority are object control. Verbs such as *promise*, that both allow an object and show subject control, are very rare. Also, the class of verbs that allow either subject or object control (such as *expect*), allow subject control only if the (optional) object is not present; otherwise object control is the rule. Second, there is some evidence from
language acquisition facts (C. Chomsky, 1969; Cohen, 1983, 1987) that also suggests a preference for object control in English.

Frazier et al. claim that the “recency” preference is one instance of a more general “saliency” preference. If recency is the salient factor in English and object control is the salient factor in Japanese, then this saliency explanation could account for both the English and Japanese experimental results reported here. As Gorrell (1995) correctly mentions, this line of argument would be plausible from a broad cognitive viewpoint. However, it is important to explain where this saliency comes from (i.e., how this general cognitive saliency is realized in our linguistic knowledge). This issue will be considered in the following sections.

5. THEMATIC HIERARCHY

If we admit that object control is universally preferred, the next question is why this is so. We will consider this issue in terms of thematic relations. Nishigauchi (1984) claims that a Goal role is chosen as the controller in the following examples:

(8) a. Bill bought for Susan1 a large flashy car [PRO1 to drive].
   b. John1 received from Susan a book [PRO1 to read].

Nishigauchi claims that the indirect object denotes the Goal in (8a), since the Theme (a large flashy car) moves to the indirect object Susan. On the other hand, the subject is assumed to be the Goal in (8b) because the movement of the Theme (a book) is directed toward the subject (John). This difference in control behavior is explained by the difference of predicate (buy vs. receive), which governs the control relation.

However, there are cases in which no Goal is specified in a sentence. Consider the following examples from Nishigauchi:

(9) John1 owns a car [PRO1 to carry his own belongings in].
(10) They deprived Mary1 of the money [PRO1 to pay her rent with].

Nishigauchi argues that the subject of verbs such as own, retain, and so on is associated with the thematic relation of Location, which is specified as what the Theme (e.g., a car in [9]) belongs to. On the other hand, the object of verbs like deprive, cure, and so on is assumed to bear the thematic relation of Source, from which the Theme (e.g., the money in [10]) is transferred.

To summarize, if Goal is specified in a sentence, it is always chosen as a controller. When only Location or Source is specified, then that thematic role serves
as controller. Nishigauchi thus claims that there is a hierarchical relation among the thematic roles chosen as controller, shown below:

(11) The Primary Location Hierarchy
    1. Goal  \gg\  2. Location, Source

Nishigauchi's proposal regarding the general tendency for Goal antecedents does have some limitations, as he himself notices. In English, the promise-type obligatory control verb does not demonstrate a Goal preference. For instance, in “John promised Mary [PRO to go to Tokyo],” the object Mary should be the antecedent of PRO, since she is the Goal of John’s promising, but this is not the correct interpretation. Furthermore, in a gerund construction like “John admitted to Mary [PRO having eaten the cake],” the indirect object Mary is not the controller despite being the Goal to which John admitted something. In Japanese, all the subject-control sentences are counterexamples to the general thematic preference for Goal. In these sentences, as in a promise-type sentence in English, the subject is the controller despite the fact that the object is the Goal. Thus, if there is a Goal preference, it seems to be overridden by specific lexical features of subject-control verbs.

Nishigauchi's claim is based on an analysis of English, which is a head-initial language. However, Nishigauchi's proposal can account for the experimental findings in Japanese. Verbs carry a lot of information (e.g., subcategorization information, argument structure information, thematic structure information, etc.) that is useful for the parser. Based on verb information, the parser can expect what kind of theta-role is to be assigned to a given NP. (See, among others, Carlson and Tanenhaus, 1988, and Pritchett, 1992, for the argument that parsing is performed through theta-role assignment.) Because of the head-final characteristics of Japanese, however, the Japanese parser cannot utilize verb information in the early stage of parsing. Thus, Nishigauchi's claim is in need of some modification to deal with cases in Japanese sentence processing. Instead of verb information, the parser relies on information carried by nouns (i.e., grammatical case information). If the parser ignores information available from the Case-marking particle or delays utilization of this information, the parser must wait until the final verb appears. With this "wait-and-see" strategy, the parser will make no mistakes in determining the controller. This means that there should be no difference in RTs between subject- and object-control sentences. This contradicts our experimental findings. Therefore, it is reasonable to assume that the parser uses information from the Case marker before the final verb appears. The assumption made here is that the parser uses available information when it has a chance to do so.

Recall that in the Japanese examples used as experimental sentences, objects were marked with the dative particle, -ni (meaning roughly 'to' or 'toward'). This dative marker may facilitate the interpretation that the object denotes a Goal. Thus
it could be assumed that the parser recognizes the object as the Goal and prepares to parse the given sentence as an object-control sentence. This expectation by the parser is satisfied by an object-control verb but not by a subject-control verb. Then, why does the particle -ni facilitate a Goal interpretation of the NP it attaches to? A very suggestive study has been done by Sadakane and Koizumi (1995). They argue that there are several homophonous particles -ni that can be distinguished by syntactic tests. By these tests, four types of -ni are found: the dative case marker, the postposition ni, the ni of ni insertion, and a form of the copula. Although these four types of ni can be differentiated by these syntactic tests, they mention that there is an ambiguous case between a Case marker and a postposition. Consider the following example:

(12)  *Hokuto-wa Mika-ni hanataba-o okutta*
     Hokuto-Top Mika-NI bouquet-Acc sent
     ‘Hokuto sent a bouquet to Mika.’

Sadakane and Koizumi argue that “Hokuto caused a bouquet to go to Mika with the intention of transferring possession of it to her, with Mika being an affected goal (the affected reading), or it may simply mean that Hokuto caused a bouquet to go to Mika, with Mika being a ‘mere’ goal (the nonaffected reading).” The idea of “affectedness” indicates that the referent of an NP with a particle is affected in the action denoted by the verb (predicate/sentence). In the above example, the point is whether Mika is affected by the action of sending a bouquet. It must be noticed that the difference between the two readings is not binary but a matter of degree.

What is important for our discussion is that the referent of the NP is an affected goal, since under that interpretation -ni would have to be interpreted as a Case marker, not as a postposition. The sentence-final verb determines whether the ni-marked NP is a goal or not. However, the parser encounters the NP before the verb, so if the parser is to make assumptions about the theta-role of the NP before it gets to the verb, it must be able to interpret the function of -ni (Case marker or postposition in this example) before it gets to the verb. But, given that there are four types of particle -ni, how can the parser make the correct decision concerning the Case and theta-role of a ni-marked NP?

One possible way to answer this question would be to appeal to frequency. That is, the particle -ni is most frequently used as a dative Case marker with a Goal theta-role. Sadakane and Koizumi mention that data from Japanese children show that Case markers are acquired earlier than postpositions. Thus, there may be present in speakers from an early age this association between the particle -ni, the dative Case marker, and the Goal theta-role. Until the end of the sentence, the parser does not have the information that determines the grammatical properties of the particle -ni. Without the grammatical information the parser could rely on its association until more information becomes available.
Another explanation would assume that there is a schema (or Construction), which forces an expectation for a specific type of sentence. For example, the sequence, ‘Taroo-ga Hanako-ni ringo-o’ induces the appearance of a specific type of verb (e.g., ageta [gavel]). The basis of this induction is that the string “NP-ga NP-ni NP-o” facilitates an interpretation of the sequence as “Nominative Dative Accusative.” It is further assumed that this set of Cases induces an interpretation of the argument roles of the NPs as “Agent Goal Theme.” This argument follows the idea of the so-called “Canonical Sentoid Strategy,” which is formulated by Fodor, Bever, and Garrett (1974, p. 345) as follows: “whenever one encounters a surface sequence NP V (NP), assume that these items are, respectively, subject, verb, and object of a deep sentoid.” As is well known, there has been a lot of discussion concerning this kind of perceptual strategy (cf. Kess, 1992; Pritchett, 1992). Although most of the discussion does not favor heuristic strategies, we believe that such strategies, insofar as they are based on our linguistic knowledge, may be used by the human parser. In other words, it would be more precise to use the term expectations, that are formed by the human parser based on linguistic information available at the time of processing. Returning to our experimental setting, we assume that the parser formed a top-down expectation for an object-control verb, and that it was either the ni-marked NP itself or the construction-specific sequence of Case markers that forced the parser to expect a verb that allows an affected reading of the ni-marked NP.

6. THETA-CHECKING STRATEGY

Returning to our experimental setting in Japanese, we claim that the parser is ready to assign a Goal theta role to an NP that is Case marked with the dative -ni. At this point, the parser commits itself to a decision about the thematic structure of the sentence. The first commitment is confirmed by late information provided by a final object-control verb and is not confirmed by a subject-control verb. The failure of this confirmation in subject-control sentences causes longer processing times than in object-control sentences. This strategy could be summarized as follows:

(13) Theta-checking strategy: Assign a tentative theta-role using Case information, and check it using verb information.

The parser in Japanese knows that the tentative decision can be wrong, because the grammar of the language makes explicit that other information, which could be incompatible with previous information, will come at the end of the sentence. However, the parser does not “wait and see” until the end of the sentence. This kind of wait-and-see, or delayed parser is made unrealistic when some aspects of
the cognitive architecture (e.g., the limitations of short-term memory) are considered. There is no clear answer concerning how long the parser has to (and/or can) wait until it gets the decisive information.

The very basic parsing strategy proposed here is that the parser makes use of available information whenever it has a chance to do so. Namely, for both a head-initial language (e.g., English) and a head-final language (e.g., Japanese), the parser utilizes theta-role information, the only difference being the way in which the parser gets this information. In the former case, the parser relies on the theta-role information available from a verb. In the latter case, the parser uses theta-role information available from a noun via a Case-marking particle. Of course, both sources of information are available in both types of languages (though the distribution of the sources of information does vary).

The scenario is very simple. When the parser gets a verb that assigns certain theta-roles, the parser expects to encounter NPs with those theta-roles. When the parser gets an NP with a certain theta-role (as indicated by Case markings or other strategies), it expects to encounter a verb that can assign that theta-role. When mismatches occur, the parser needs to take time (which can be experimentally observed) to sort out and correct the conflict. Consider the following examples (cf. Inoue and Fodor, 1995; Pritchett, 1992):

(14) a. Todd gave [NP the boy] [NP the dog] bit a bandage ?? : Garden Path
       b. Todd gave [NP the boy] [the dog bit e_i] a bandage.

(15) a. [NP Bob -ga] [NP Mary -ni] [NP ringo -o] tabeta inu-o ageta.
       -NOM -DAT -ACC ate dog-ACC gave
       ‘Bob ate an apple to Mary gave a dog??’ : Garden Path
       b. [NP Bob -ga] [NP Mary -ni] [NP [S e_i ringo-o tabeta] inu_i-o ageta.
       -NOM -DAT apple-ACC ate dog-ACC gave
       ‘Bob gave Mary the dog that ate the apple.’

In (14a), when the parser gets the verb gave, it expects that two NPs will follow; one for the Goal theta-role and another for the Theme. This expectation is tentatively satisfied at the point where the dog is attached to the parse tree. However, when the parser gets the second verb, bit, which requires an Agent and a Patient NP, the initial attachments cannot be maintained, as there aren’t enough NPs to go around. Therefore, the parser must reanalyze the string as in (14b), where one of the NPs, the boy, in effect does double duty, as both the Goal of give and the Patient of bit.

In (15a), when the parser gets three NPs in succession, it expects to encounter a three-place predicate such as give, which can take an Agent, Goal, and Theme argument, and would be consistent with the pattern of Case markings on the NPs. This expectation is not satisfied because tabeta ‘ate’ is a two-place predicate that cannot subcategorize for three NPs, but can only take an Agent and Theme argument. On encountering the following noun, inu ‘dog’ the parser must reanalyze
(15a) to (15b) resulting in a (mild) garden-path effect (but see Mazuka and Itoh, 1995, for a different view).

It is often mentioned that the garden-path effect in Japanese is not as strong as the one in English (e.g., Mazuka et al., 1989). This is explained in the proposed framework as follows. In English, the verb (or predicate) is practically the only source of information that determines the theta-role of an NP. In Japanese, there are two sources of information that are useful for indicating the theta-role of an NP—the Case-marker and the verb (predicate). The English parser has to determine the theta-role of an NP when it gets a verb (predicate), whereas the Japanese parser has a chance to do it twice. In other words, the English parser is more confident than the Japanese parser in the sense that the former has only one information source and the latter has two information sources, which might be incompatible with each other. Since the Japanese parser is less confident with its theta-role assignments, it is more ready to remedy its first incorrect decision upon encountering the second source of information. See Inoue and Fodor (1995) for this “confidence-remedy” argument in Japanese parsing. However, the point is that the parser in both types of language uses theta-role information as soon as it can. Yamashita (1995) reports an experimental result that “indicates that by receiving the information up to the verb, the subjects expected how the syntactic structure unfolds” (p. 344).

7. MODELS OF THE HUMAN PARSER

Let us briefly consider what kind of parser can account for (or is compatible with) the findings of the experiments reported here. Here we restrict the discussion to issues of “parallel/serial/delayed,” and “top-down/bottom-up” processing. These issues have been well discussed in the literature and are directly relevant to the basic design of the parser. If the parser is strictly parallel, it will process both the subject-control and the object-control options at the same time. We should expect to see no differences in RTs between these two types of sentence if this is the case. In a similar vein, if the parser delays its decision until it can get decisive information, the parser will not make mistakes. Neither the parallel nor the delayed (wait and see) processing model can account for why there is a difference in RTs for the different types of sentence. Therefore, the properties of the parser must either be explained by some weakened version of these models (ranked parallel, cf. Gorrell, 1987; or partially delayed, cf. Mazuka and Itoh’s “Tentative Attachment Strategy”), or by some form of serial model.

Now let us consider the second property of the parser (i.e., top-down or bottom-up). It has been argued that the traditional type of top-down parsing system (Kimball, 1973; Woods, 1970) wrongly predicts enormous garden-path phenomena for a head-final language such as Japanese (Inoue and Fodor, 1995; Mazuka and
Itoh, 1995). Since the decisive information comes last in a head-final language, it is always dangerous to make a top-down prediction. For example, when the parser receives the sequence “Taroo-ga Hanako-o mita” (“Taroo saw Hanako”), it is not clear whether this sequence is a simple sentence or a relative clause such as “Taroo-ga [e, Hanako-o mita] otoko,-o nagutta” (Taroo hit a man who saw Hanako), or a time adverbial clause such as “Taroo-ga Hanako-o mita toki” (When Taroo saw Hanako), or a nominalized clause such as “Taroo-ga Hanako-o mita koto” (the fact that Taroo saw Hanako). There are so many possible ways of continuing this sequence that any top-down predictions that the parser makes are likely to be wrong.

On the other hand, assuming that the parser is strictly bottom-up also cannot account for the observed results. Since the bottom-up parser postulates a clause only after the head of the clause has been received, this type of parser has the same properties as a parser in a delay model. The bottom-up parser waits until it gets the head of a structure, just as the wait-and-see parser waits until it gets decisive information (often contained within the head of a particular structure). Therefore, it is reasonable to suppose that the type of parser that is most compatible with the reported results is partially bottom-up (i.e., data driven), and partially top-down (expectation making). The parser makes a top-down expectation through a bottom-up procedure (cf. Marcus, 1980). The parsing model most consistent with both of these considerations (parallel/serial/delayed and top-down/bottom-up) is the “committal” model of Inoue and Fodor (1995), which forms an expectation based on current information, and then checks this expectation as new, potentially decisive information, becomes available.

8. FINAL REMARKS

Two apparently conflicting results regarding the processing of control structures in English and Japanese were examined. The English results (Frazier et al., 1983) suggest that subject-control structures are easier to process, whereas the Japanese data (Sakamoto, 1996) suggest that the parser prefers to assume that an object is a controller in the absence of other information. To resolve this conflict, it was noted that the English data were confounded, in that the object-control sentences were always accompanied by a double-gap construction, whereas the subject-control sentences had only a single gap. Therefore, it is reasonable to conclude that the English experiments were responsive to this factor, and not to factors involved in the identification of the antecedent of PRO. Since the Japanese materials were not confounded in this way, it is reasonable to conclude that the results from these experiments are universally applicable. To account for this result using parsing theory, two proposals were made. First, it is claimed that the
parser's preference for object control stems from a grammatical preference for Goal control (cf. Nishigauchi, 1984). Because Goals are overtly marked in Japanese by Case information, we are led to the conclusion that Case information is used in parsing, and forms the basis for the parser's initial decisions about the incoming structure. The parser will make use of later information to modify these initial assumptions as necessary. The parsing model that is most consistent with these findings is the serial “committal” parser that makes top-down predictions based on available information (e.g., Case information on a noun) and makes necessary corrections in accord with incoming information (e.g., Theta-role information in a verb).

ACKNOWLEDGMENTS

This work was supported in part by Grant-in-Aid for Scientific Research (c) No. 07801073 from the Japanese Ministry of Education to the first author, and in part by a Monbusho summer fellowship awarded to the second author.

REFERENCES


NOTES
1There have been many attempts to address this question within the generative tradition, a full discussion of which is beyond the scope of this work. See, among others, Williams (1980), and Nishigauchi (1984) (discussed in detail below).
2Boland et al. (1990) argue that control information, which would in turn determine the identity of PRO, is available immediately.
3See below for an argument that strategies based on case information may be used in this interval.
4The lack of clear Case information in English may make it difficult for the parser to commit before verb information becomes available.