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PROCESSING OF MULTIPLE FILLER-GAP DEPENDENCIES
IN JAPANESE

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ABSTRACT

Numerous studies have shown that in head-initial languages such as English, French, and German, relative clauses with a gap in the subject position (subject-gap relative clauses) are easier to process than relative clauses with a gap in the object position (object-gap relative clauses). One memory-based explanation for this subject-object gap asymmetry has been linear distance: a subject gap is linearly closer to the filler than an object gap, and thus fewer words need to be processed between the gap and its filler.

This dissertation investigates the subject-object gap asymmetry in the processing of relative clauses in Japanese, a head-final language in which a relative clause precedes its head noun. In Japanese, an object gap is linearly closer than a subject gap to the filler. Therefore, the linear distance model predicts that object-gap relative clauses should be easier to process than subject-gap relative clauses. The results of two self-paced reading experiments showed that native speakers of Japanese found subject-gap relative clauses easier to process than object-gap relative clauses. At the head noun, this effect was modulated by the grammatical relation of the head noun. In following regions, however, the interaction disappeared and a consistent subject gap advantage emerged.

A gap asymmetry was also found in relative clauses with two filler-gap dependencies. This construction involves global structural ambiguity in the dependencies between gaps and fillers. When semantic/pragmatic information strongly constrained the plausible thematic roles of fillers, the results of an offline survey and two self-paced reading experiments revealed a clear subject-object asymmetry: the distant filler was preferably associated with a subject gap over an object gap. When semantic/pragmatic

information was weaker, processing became extremely difficult and showed no gap asymmetry.

These findings are inconsistent with a linear distance account. It is proposed that the asymmetry is better accounted for by the structural distance between gap and filler: a subject gap is structurally closer to the filler, and thus it is computationally easier to form a dependency with. Structural distance as an alternative to account for both Japanese findings and the role of pragmatic information during processing is discussed.

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LIST OF ABBREVIATIONS

| | |
|------|-----------------|
| ACC | accusative case |
| ADV | adverb |
| AUX | auxiliary verb |
| COMP | complementizer |
| COP | copular |
| DAT | dative case |
| GEN | genitive case |
| NOM | nominative case |
| PL | plural |
| SG | singular |
| TOP | topic |

CHAPTER 1

INTRODUCTION

Human languages in the world employ a wide range of structures with various degrees of complexity. Yet, our daily communication proceeds successfully in general, and it proceeds in an extremely rapid manner. Experimental evidence has shown that a great deal of processing occurs immediately (within approximately a few hundred milliseconds from the onset of the stimulus) often before the next word is received (e.g., Just & Carpenter 1980, Marslen-Wilson 1973, 1975, Tyler & Marslen-Wilson 1977). How such rapid and successful communication can be achieved with a complex, ambiguous input string has been a question for psycholinguists for many years. One of the goals of psycholinguistic research is to uncover the mental processes that underlie highly incremental sentence processing.

This dissertation is concerned with one of the most distinctive properties of human language, long-distance dependency. Such constructions involve two constituents that are non-adjacent in a sentence but syntactically dependent on each other. In principle, the two elements can be separated by an unlimited number of words. Sometimes, one of the elements does not have a phonetic realization (i.e., it is an empty element), and its presence must be inferred from the surrounding environment. One particular type of dependency with an empty element is commonly called a filler-gap dependency, where 'gap' refers to the empty element and 'filler' refers to the element the gap is associated with.

Numerous studies have investigated the online processing of filler-gap dependencies from various perspectives. One of the well-established findings in the literature is that a dependency involving a subject gap is easier to process than one involving an object gap. Empirical support has been obtained across different languages (e.g., English, French, Dutch, German), across various measurements (self-paced reading, eye-tracking, ERP studies, etc.), across structures (relative clauses, wh-questions, and cleft sentences) and across different population groups (L1, L2, aphasics, and normal adults).

Despite seemingly convergent evidence for a preference for a subject gap over an object gap, there is a research lacuna that waits to be filled. To date, there has been little evidence for a subject gap preference among the adult native speakers of strictly head-final languages, such as Japanese and Korean. ‘Filling a gap’ in this area of research is the main goal of this dissertation.

An investigation of filler-gap dependencies (e.g., relative clauses) has both empirical and theoretical value. Japanese is a strict head-final language, in which dependent elements precede their heads. Unlike English, where a relative clause comes after its head noun, a relative clause (containing a gap) precedes its head noun in Japanese. Japanese lacks relative pronouns (e.g., *who* and *which* in English) which serve to mark the edge of a relative clause and give a clue about the position of a gap. These typological differences between English and Japanese raise a question of whether the processing of filler-gap dependencies in Japanese is fundamentally different from the processing of the construction in English. Furthermore, a processing-based explanation that has been widely assumed to account for English findings makes the opposite

prediction for relative clauses in Japanese. In English, a subject-gap relative clause is considered to be easier to process because a subject gap is linearly closer to its head noun. In contrast, in Japanese, a SOV language with a prenominal relative clause, a subject gap is farther from the head. Therefore, this linear-based distance account predicts that a subject-gap relative clause is harder to process than an object-gap relative clause in Japanese. A contrasting view is that the processing difficulty of relative clauses is determined by the structural distance between gap and filler. According to this account, subject gap RCs are assumed to be easier crosslinguistically since a subject gap is structurally higher in the syntactic structure and thus closer to its head noun. Thus, Japanese offers an important test case to evaluate different models that cannot be teased apart if we look at only English.

With a subject-object gap asymmetry as the main theme of the study, this dissertation examines two different types of relative clauses in Japanese. The first type, which I refer to as single-gap relative clauses, involves a single filler-gap dependency. As there is little ambiguity in terms of the position of a gap in the relative clause, an asymmetry between subject-gap and object-gap relative clauses can be tested more or less straightforwardly. A related issue, the possible influence of the grammatical relation of the head noun on a gap asymmetry, is also tested in a separate experiment. The second type of relative clause, which I refer to as double-gap relative clauses, involves two filler-gap dependencies. The construction is structurally more complex and thus assumed to be more difficult to process than the first type. It also involves structural ambiguity in that there is no morphosyntactic cue that indicates the dependencies between gaps and fillers. thematic role of the head noun within the embedded clause. It is assumed that non-

structural information, such as the plausibility of the fillers as agent or theme, is the primary information source that is used to adopt a structural analysis of these ambiguous sentences. Then, it is of empirical interest whether a subject-object asymmetry appears under these circumstances, and how manipulating the strength of the pragmatic plausibility of fillers influences the magnitude of the asymmetry. Investigations of two different types of relative clauses will thus provide clues about various sorts of questions addressed in the psycholinguistic literature, such as how a filler-gap dependency is formed online, what makes the processing of a dependency more difficult, in what condition the asymmetry emerges, and so forth.

The dissertation is organized as follows. In chapter 2, I provide a brief summary of basic properties of Japanese and the syntactic structure of Japanese relative clauses that is assumed in this study. In chapter 3, I review psycholinguistic studies on filler-gap dependencies in both English and Japanese. Major issues and findings that are relevant for the processing of these structures are introduced. I also summarize evidence that shows that the processing of (strict head-final) Japanese is incremental in a similar fashion to that of English. Chapter 4 and chapter 5 report on a series of experiments in which the online processing of Japanese relative clauses was examined. Chapter 4 focuses on single-gap relative clauses, and chapter 5 reports on double-gap relative clauses. In chapter 6, possible interpretations of these experimental findings are discussed, and implications for sentence processing models are suggested.

CHAPTER 2

PROPERTIES OF JAPANESE AND RELATIVE CLAUSES

This chapter provides a brief grammatical sketch of Japanese and an outline of basic assumptions concerning the structure of Japanese relative clauses. The first section focuses on major typological characteristics of Japanese that contrast with those of English. The primary aim is to give the reader a basic overview of Japanese relevant to the more specific descriptions of sentence structures that appear in the forthcoming chapters. This is therefore not an exhaustive listing of structural notions and assumptions used in this thesis. Special terminology is presented and illustrated as it is needed in each chapter.

The second part of this chapter presents basic assumptions about the structure of Japanese relative clauses. The correct interpretation of a relative clause requires the use of complex grammatical knowledge, and how to represent such knowledge has been the focus of many linguistic theories. A number of proposals have been put forward to describe the internal structure of relative clauses, yet controversy still exists about specific details of each assumption. For the purpose of the present study and also in order to avoid unnecessary controversy, a relatively simplified structure is assumed for Japanese relative clauses.

2.1 Grammatical sketch of Japanese

2.1.1 Word order

The basic word order of a transitive sentence is Subject-Object-Verb (SOV), and this holds true both in a matrix clause (S, O, and V are underlined) and in an embedded clause (S, O, and V are italicized).¹

- (1) S *S* *O* *V* O V
John-ga [Tom-ga Mary-o nagutta] koto-o oboeteita.
John-NOM Tom-NOM Mary-ACC hit thing-ACC remembered
'John remembered that Tom hit Mary.'

As long as a strict verb-final constraint is maintained (i.e., all clauses must end with verbs), word order in Japanese is relatively free. As examples in (2) and (3) demonstrate, any order of constituents is possible before the verb.

(2) Basic word order of a ditransitive sentence

John-ga Mary-ni hon-o ageta. [S IO DO V]
John-NOM Mary-DAT book-ACC gave
'John gave a book to Mary.'

(3) Alternative ("scrambled") orders

- a. John-ga hon-o Mary-ni ageta. [S DO IO V]
- b. Mary-ni John-ga hon-o ageta. [IO S DO V]
- c. Hon-o John-ga Mary-ni ageta. [DO S IO V]
- d. Mary-ni hon-o John-ga ageta. [IO DO S V]
- e. Hon-o Mary-ni John-ga ageta. [DO IO S V]

¹ I assume that Japanese is a configurational language with a VP node. (See Saito (1985) for a detailed discussion of this issue and the references therein.)

2.1.2 Case marking

Grammatical relations of nominal entities are primarily indicated by case markers (e.g., nominative *-ga*, genitive *-no*, accusative *-o*, and dative *-ni*) that are attached to the end of each noun.

- (4) John-ga Mary-no imooto-ni hon-o ageta.
John-NOM Mary-GEN sister-DAT book-ACC gave
'John gave a book to Mary's sister.'

As shown in sentence (4), the nominative marks the subject, the accusative marks the direct object, and the dative marks the indirect object of a verb. However, the relationship between case relations and grammatical relations is not one-to-one. As exemplified by sentence (5a), the nominative *-ga* marks not only the subject of a sentence but also the direct object of a stative transitive predicate (e.g., *like*, *dislike*). In sentence (5b), the genitive *-no* marks the subject of a predicate in the relative clause.²

- (5) a. Nominative-marked direct object

John-ga nihongo-ga kiraida.
John-NOM Japanese-NOM dislike
'John doesn't like Japanese.'

- b. Genitive-marked subject within a relative clause

[John-no katta] hon
John-GEN bought book
'the book that John bought'

² See Kuno (1973) for more discussion of multiple functions of Japanese case markers.

In addition to case relations, a set of postpositions (e.g., *with*, *by*, *to* in English) is used to represent semantic/functional relations among nominals in Japanese.

- (6) John-ga Mary-to kuruma-de Kobe-ni itta.
 John-NOM Mary-with car-by Kobe-to went
 ‘John went to Kobe by car with Mary.’ [Kuno 1973:5]

2.1.3 Topic marker

In addition to *-ga*, *-o*, and *-ni*, which mark major grammatical relations in a sentence, there is another relation that is significant in the Japanese grammar, namely topic. Any of the major constituents in a sentence (e.g., subject, direct object, PPs, etc.) can become a topic by being marked with the topic marker *-wa* and preposed to sentence initial position.

- (7) a. Topicalization of subject

John-wa Mary-ni sono hon-o ageta.
 John-TOP Mary-DAT that book-ACC gave
 ‘Speaking of John, he gave that book to Mary.’

- b. Topicalization of direct object

Sono hon-wa John-ga Mary-ni ageta.
 that book-TOP John-NOM Mary-DAT gave
 ‘Speaking of that book, John gave it to Mary.’

- c. Topicalization of indirect object³

Mary-(ni)-wa John-ga sono hon-o ageta.
 Mary-(DAT)-TOP John-NOM that book-ACC gave
 ‘Speaking of Mary, John gave her that book.’

³ The dative marker can be optionally retained after topicalized. Martin (1975) proposed a hierarchy of particle deletion in Japanese (from hardest to easiest for deletion).

made ‘till’ > *kara* ‘from’ > *to* ‘with’ > *de* ‘by’ > *e* ‘to’ > *ni* (dat) > *o* (acc) > *ga* (nom)

In addition, a Japanese sentence can have a topic independent from other major grammatical relations.

- (8) Sakana-wa tai-ga oishii
fish-TOP red snapper-NOM delicious
'Speaking of fish, red snapper is the most delicious.' [Kuno 1973:62]

For the above sentence, there is no corresponding topicless sentence. This led Kuno to claim that a topic of this sort is not derived syntactically but exists as a topic in its underlying structure. For a sentence to be well-formed, the topic and the rest of the sentence is said to establish some kind of a semantic/pragmatic relationship, such that 'what follows the topic is a statement about the topic' (Kuno 1973:251).

2.1.4 Argument drop

Japanese is known as a pro-drop language. That is, pronominal arguments of a verb can be frequently dropped as long as their referents can be recovered or understood from the context or in the discourse. For instance, either the subject or the direct object, or even both arguments of the transitive verb 'bought' can be expressed as a covert element, represented as [*e*] in the following examples.

- (9) a. John-ga hon-o katta.
John-NOM book-ACC bought
'John bought a book.'
- b. [*e*] hon-o katta.
'[I/You/We/He/She/They] bought a book.'
- c. John-ga [*e*] katta.
'John bought [it/them].'

- d. [e] [e] katta.
 ‘[I/You/He/She/They] bought [it/them].’

It is also possible to have a covert argument in the subordinate clause, as in (10).

- (10) John-ga [[e] hon-o katta-to] Mary-ni itta.
 John-NOM book-ACC bought-COMP Mary-DAT said
 ‘John said to Mary that [he/she] bought a book.’

In this case, the null element is most naturally interpreted to refer to the matrix subject *John*. With the right context, however, it can also refer to other referents in the discourse.

2.1.5 Basic properties of relative clauses

Japanese is a strict head-final language, in which modifying elements precede their heads (modified elements). In the relative clause construction, a relative clause precedes its head noun.⁴ Among the positions represented in the Noun Phrase Accessibility Hierarchy (Keenan 1975, Keenan and Comrie 1977), relativization is possible on all positions except for the object of comparison.⁵ The sentences in (11) show some examples of relativization up to the indirect object position on the hierarchy. (The underline in each example indicates a position (a gap) corresponding to the relativized element in a relative clause.)

- (11) a. Relativization of the subject

[_ seito-ni hon-o ageta] sensei
 student-DAT book-ACC gave teacher
 ‘the teacher who gave a book to the student’

⁴ See Kuno (1973) for extensive discussion of some peculiar properties of Japanese relative clauses.

⁵ Noun Phrase Accessibility Hierarchy (Keenan 1975:137, Keenan and Comrie 1977:66).

Subject > Direct Object > Indirect Object > Oblique > Genitive > Object of Comparison

b. Relativization of the indirect object

[Sensei-ga _ hon-o ageta] seito
teacher-NOM book-ACC gave student
'the student to whom the teacher gave a book'

c. Relativization of the direct object

[Sensei-ga seito-ni _ ageta] hon
teacher-NOM student-DAT gave book
'the book which the teacher gave to the student'

There is no relative pronoun in Japanese that is equivalent to English *who*, *whose*, *whom* or *which*. The grammatical relation of a gap in a relative clause must be inferred based on the argument structure of the relative clause predicate and the case marking of overt nouns present in the relative clause. For instance, we infer the presence of a direct object gap in (11c) from the presence of the triadic verb *ageta* 'gave' and the presence of nominative-marked subject and dative-marked indirect object.

The morphological form of the verb in the relative clause does not differ from the verb in the matrix clause.⁶ For example, the verb form *ageta* 'gave' in the RCs above is identical to the verb form when it appears in a simple declarative sentence as in (2), (3), (4), and (7). According to Keenan (1985), this constitutes an exceptional case to a crosslinguistic generalization. He remarked that "in prenominal relative clauses, the verb

⁶ There is one exception to this. The copular has different forms – *na* in a relative clause and *da* elsewhere.

- i. Mary-ga suki-na hana
Mary-NOM favorite-COP flower
'the flower Mary likes'
- ii. Mary-ga hana-ga suki-da.
Mary-NOM flower-NOM favorite-COP
'Mary likes flowers.'

in the relative clause is almost always in some sort of non-finite form, that is different from the one it would have as the main verb of a simple declarative sentence” (p.160).

2.2 Basic assumptions of relative clauses

There are literally dozens of proposals concerning the nature of the operations and representations associated with the formation of relative clauses in human language. For the purposes of this dissertation, I will adopt the following three assumptions, each of which is widely accepted by linguists working in different theoretical frameworks.

(12) Assumptions about relative clauses

- a. Clause structure includes a subject-object asymmetry, with the subject occurring higher in syntactic structure than the direct object.
- b. Relative clauses contain a gap corresponding to the “relativized element”.
- c. The interpretation of that gap involves associating it in some manner with the head of the relative clause (hereafter, the “filler”).

This leaves us with the following representations for English and Japanese relative clauses. (I use co-indexing to indicate the relationship between a gap represented by ‘e’ and the corresponding filler.)

(13) English relative clauses

The man_i [_S Mary [_{VP} saw e_i]]....

(14) Japanese relative clauses

[_S Mary-ga [_{VP} e_i mita]] dansei_i...
Mary-NOM saw man
‘the man that Mary saw’

2.3 Conclusion

This chapter outlined basic properties of Japanese that are not shared with better-known languages, such as English and other European languages. In the processing literature, these typological characteristics of Japanese are considered to pose a special challenge to sentence processing models because they can create multiple structural analyses at a given point in a sentence. For example, as shown in (15), the appearance of an accusative marker NP at the beginning of a sentence can be analyzed as a simple sentence with a dropped subject (15b), a sentence with a scrambled accusative-marked NP in front of the subject (15c), a relative clause with a gap in the subject position (15c), and so forth.

- (15) a. Mary-o
Mary-ACC
- b. e Mary-o mita.
Mary-ACC saw.
'I/you/he/she saw Mary.'
- c. Mary-o John-ga mita.
Mary-ACC John-NOM saw
'Mary saw John.'
- d. [_i Mary-o mita] dansei_i
Mary-ACC saw man
'the man Mary saw'

This naturally raises a question of how incremental Japanese sentence processing could be. This is one of the issues that the present study is concerned with, and is reviewed extensively in the next chapter.

CHAPTER 3

PROCESSING OF FILLER-GAP DEPENDENCIES

In order to interpret a sentence, listeners/readers need to identify words, assemble them into a structure, and assign a meaning to it. Sentence comprehension is characterized as the process of creating a hierarchical mental representation out of the linearly sequenced input string. In psycholinguistics, ‘parsing’ is used to refer to the process of structure building and ‘parser’ to the processor that conducts such structural analyses.

One of the fundamental characteristics of the human parser is that sentence processing proceeds in a highly incremental manner (Frazier 1987a, Frazier & Rayner 1982, Marslen-Wilson & Tyler 1980, 1981). People do not wait till the end of a sentence but start constructing a tentative analysis on the input string immediately as they hear or read each word of a sentence. However, on considering the complexity of human language and potential ambiguities at a given point in a sentence, providing a full picture of how incremental processing proceeds online is still an incomplete endeavor.

One set of constructions that has attracted particular attention in the sentence processing literature is filler-gap dependencies (constructions such as *wh*-questions, relative clauses, and cleft sentences). A relevant example is shown in (1).

(1) [Which book]_i did the student from Germany buy t_i at the bookstore?

In Government and Binding theory (Chomsky 1981, 1982), these constructions have been analyzed as involving a constituent (e.g., *which book* in (1)) moving to a non-argument

position and leaving a trace *t* at its original position. These two elements form a syntactic dependency, through which the moved element receives a thematic role (by inheriting the thematic role assigned to the trace) and the role-assigning lexical property of the verb is satisfied. In psycholinguistics, the terms ‘filler’ and ‘gap’ are used to refer to a moved constituent and its trace. The online process of dependency formation is considered to be established when gap and filler are associated with each other (Fodor 1978).

The processing of filler-gap dependencies (e.g., *wh*-questions, relative clauses, and cleft sentences) poses a special challenge for sentence processing models. Numerous issues involving these constructions have yet to be resolved. For example, a filler and a gap do not appear next to each other and there is no limit to the number of words or clauses that separate them. An adequate theory of sentence processing needs to be able to explain how and when the parser recognizes a gap and decides to form a filler-gap dependency. Further, a gap does not have a phonetic realization in the input string.⁷ This raises the issue of whether or not the mental representation built by the parser actually involves these empty elements. There is also a question of whether the parser makes use of the grammatical constraints that restrict the formation of filler-gap dependencies.

Crosslinguistic investigation of the processing of filler-gap dependencies has also been an issue. While there has been overwhelming evidence that shows that subject-gap

⁷ Whether or not those null elements have no phonetic realizations has been an issue from an acoustic/prosodic point of view. Cooper and colleagues (cited in Nagel, Shapiro, and Naway 1994:475) reported the presence of some acoustic cues reflected in elliptical sentences. Nagel et al. (1994) also found some acoustic correlates (changes in duration and pitch contour) that are claimed to signal the presence of a *wh*-gap. However, the latter study was criticized by Straub, Wilson, McCollum, and Badecker (2001) for confounding gap position with syntactic phrase structure. They found that when phrase position was controlled, there was little difference in the measurement of acoustic cues between sentences with and without gaps.

relative clauses are easier to process than object-gap relative clauses in English (and some European languages), very few studies have investigated the issue in head-final languages such as Japanese and Korean. If we assume that the basic processing mechanism is the same across languages, a theory of sentence processing developed on English data must be tested against a variety of typologically different languages.

The purpose of this chapter is to review major findings and issues relevant for the processing of filler-gap dependencies. First, I will provide a summary of the studies that have investigated the psychological reality of empty categories. Second, I will outline major findings as well as parsing principles that have been proposed to account for those findings in the studies of filler-gap dependencies in English (and some European languages). Third, I will review three main proposals that have been put forward to account for the subject-gap advantage in the processing of English relative clauses. Fourth, a section will describe Japanese sentence processing. I will summarize evidence that indicates sentence processing in Japanese proceeds in a highly incremental fashion similar to English. A summary of the previous studies that have examined filler-gap dependencies in Japanese will conclude this chapter.

3.1 Processing of filler-gap dependencies in head-initial languages

3.1.1 Psychological reality of empty categories

The presence of phonetically null elements in the structural representation of a sentence has been postulated by a number of syntactic theories. In Government and Binding Theory (Chomsky 1981), those null elements, called empty categories (ECs),

play a central role in various syntactic phenomena. (See Chomsky 1981, 1982 for types of ECs and their characteristics.)

Although ECs are syntactically active, their phonetic emptiness poses a problem in online sentence processing. Extensive work has been conducted to investigate the psychological reality of ECs, i.e., whether or not online sentence processing computes phonetically null elements.

One of the major techniques used to investigate this issue is ‘priming’. The basic assumption underlying this technique is that a response to a word is faster when a word is presented the second time than the first time. Meyer and Schvaneveldt (1971, cited in Tanenhaus, Carlson, & Seidenberg 1985:369) demonstrated that semantically or associatively related words also facilitate recognition (e.g., doctor-nurse, rat-cheese). When this is observed, one word is said to ‘prime’ the recognition of the second word.

This method has originally been used in sentence processing studies to examine whether referentially dependent NPs, such as pronouns and anaphors, prime the recognition of their grammatically possible antecedents. For example, Nicol (1988) tested the following sentences using a cross-modal paradigm.⁸

- (2) The boxer told the skier that the doctor for the team [Nicol 1988:109-10]
a. would blame **himself** # for the recent injury.
b. would blame **him** # for the recent injury.

She found that a priming effect was observed only for the grammatically legitimate

⁸ In this task, a participant listens to a sentence auditorily presented at a normal speaking rate, and at some point during the sentence (# in above examples), s/he makes a word/nonword decision about a visually presented target word on a screen.

antecedents. That is, the response time to a semantic associate was faster only for *doctor* in (2a), while it was faster for both *boxer* and *skier* in (2b). The results were interpreted to indicate that antecedents are reactivated at the pronoun or anaphor positions. (See Bever & McElree 1988, Swinney, Ford, & Bresnan 1989 for replication of pronoun reactivation.)

Assuming parallelism between pronouns/anaphors and ECs (both of which are referentially dependent on their antecedents), the priming technique has been applied to ECs to show that ECs elicit behavioral effects analogous to those of overt anaphors. Using a cross-modal task, Swinney, Ford, Frauenfelder, and Bresnan (1988, cited in Nicol 1988 and Nicol & Swinney 1989) tested a sentence such as in (3).

- (3) The policeman saw the boy; that the crowd at the party #1 accused t_i #2 of the #3 crime.

This is a relative clause construction, in which the head noun, *the boy*, is associated with a gap located after *accused*. The results of an experiment showed that the response time to *boy* was faster than its control words, and this was observed at #2 (the presumed trace position) and #3, but not at #1.⁹ Neither *policeman* nor *crowd* elicited the effect. The authors concluded that a phonetically null element reactivates its structurally correct antecedent. Note that the absence of the priming effect at #1, a position prior to the trace, suggests that the priming effect at #2 and #3 was not merely due to the residual activation of the target word, but the ‘reactivation’ of the antecedent at the trace site. (See Balogh,

⁹ More precisely, #3 is 300msec after #2 (i.e., 1.5 syllables after #2).

Zurif, Prather, Swinney, & Finkel 1998 for English relative clauses, Bever & McElree 1988 for a review of other previous studies on wh-traces, Clahsen and Featherston 1999 for scrambled sentences in German, Miyamoto and Takahashi 2002b for Japanese scrambled sentences, Nakano, Felser, and Clahsen 2002 for long-distance scrambling in Japanese, Tanenhaus, Carlson, & Seidenberg 1985 for English relative clauses.)

In contrast to the robust facilitation effect found for wh-traces (an EC involved in relative clauses and scrambled sentences), the results for other ECs (NP-traces and PRO) seemed much weaker and less consistent. For example, McElree and Bever (1989) used visual probe recognition with phrase-by-phrase self-paced reading to test a priming effect for NP-trace (in raising, tough-movement, and passive sentences) and PRO (in control sentences).¹⁰ A probe word was presented at two different locations – the first point at which the presence of a gap is recognized (early probe) and the end of a sentence (late probe). One major finding was that neither NP-trace nor PRO elicited priming at the early probe. Priming appeared only at the late probe point. In addition, the activation level of PRO was much weaker than for NP-traces. The authors concluded that ECs are psychologically real: their antecedents were accessed during comprehension. However, their activation was not immediate, but rather delayed. In addition, pure movement traces (NP-traces) access antecedents more strongly than PRO, which is assumed to be base-generated at the subject of infinitival clause. (See Bever & McElree 1988, Bever & Sanz 1997 for the Spanish unaccusative constructions, MacDonald 1989 for passive sentences).

¹⁰ In this task, participants read a sentence on a computer one word at a time. At a position unknown to the participants, a probe word (an adjective taken from the filler NP) appears, and the participants were asked to judge as quickly as possible whether or not the probe word appeared in the sentence they had just read.

As visual probe recognition is one of the most commonly used techniques, it is important to mention some methodological problems involving this task. Balogh et al. (1998:169) argued that priming at the end of sentences may not reflect real syntactic gap-filling but rather a non-syntactic “wrap-up effect”, a type of more discourse-linked processing for the purpose of integration of all stored information. Osterhout and Swinney (1993:276) also remarked that the visual probe recognition task requires an “explicit check of memory prior to a response” and is not necessarily sensitive to antecedent activation. Due to these confounds and the possibility of tapping a different aspect of processing, the results obtained from visual recognition tasks need to be interpreted with some caution, especially when the priming effect was found only at the ends of sentences. Interestingly, however, even using a cross modal paradigm, which is considered to be less intrusive on normal comprehension, Osterhout and Swinney (1993) found a delayed reactivation of NP-traces (in passive sentences).¹¹ This suggests that NP-traces and PROs may behave somewhat differently from wh-traces during processing. (See Nicol 1988 for delayed reactivation of PRO using cross modal priming.)

To summarize, a substantial body of evidence shows some psychological validity for wh-traces in language comprehension. Wh-traces trigger immediate reactivation of their structurally correct antecedents at a presumed gap position. The finding has been obtained from various measurements – probe recognition (Miyamoto & Takahashi

¹¹ The cross-modal priming method is not free from problems, either. For example, McKoon and Ratcliff (1994) argued that participants respond faster to related probes because they are a good fit (semantically, pragmatically, and syntactically) in the sentence not necessarily because the antecedent is reactivated. (See McKoon, Ratcliff, & Ward (1994), but see also Love and Swinney (1996) and Nicol, Fodor, & Swinney (1994) for their counter-arguments and results.)

2000a), cross modal priming (Swinney et al. 1988, cited in Nicol 1988, Nicol & Swinney 1989), self-paced reading experiment (Gibson & Warren 1998, cited in Miyamoto & Takahashi 2002b), and ERP studies (Garnsey, Tanenhaus, & Chapman 1989).

There is some evidence that NP-trace and PRO access their antecedents during comprehension. However, they differ from wh-traces in terms of the timing and the magnitude of effect. Most studies observed delayed antecedent reactivation for these categories.¹² In particular, the effect of PRO (if there is any) is always delayed and weaker than that of NP-trace. Furthermore, as Nicol (1988) reported, when there are multiple antecedents for a PRO, all available antecedents seem to be reactivated, starting with the activation of the most recent filler followed by the activation of more distant fillers. She argued that an antecedent search process for PRO proceeds in a backward fashion, i.e., from right to left (p.39).¹³

These behavioral differences among ECs have been suggested to reflect linguistic differences among those categories. For example, in the case of a wh-trace, its antecedent at the clause initial, non-argument position is salient enough for the parser to recognize and initiate an explicit gap search. In contrast, the relations between NP-trace/PRO and their antecedents are more local and the recognition of an antecedent tends to be delayed, probably taking place at the gap site (Featherston 2001, cf. Nicol 1988).

¹² Featherston, Gross, Münte, & Clahsen (2000) reported that an ERP study on German PRO (in control constructions) and NP-trace (in raising constructions) elicited the P600 effect (an indicator of costly processing) at the region immediately after a gap. But NP-traces elicited stronger amplitude than PRO.

¹³ She argued that unlike wh-traces whose antecedents can be uniquely identified based on structural information, the antecedent search for PRO is to a large extent unpredictable. It relies on lexically specific information (verb control information) and in many cases requires incorporation of higher level (pragmatic) knowledge. (See her dissertation for detailed discussion.)

(See Featherston 2001, Nicol 1988, Nicol & Swinney 1989 for further discussion of differences among ECs.)

3.1.2 Constraints on filler-gap dependencies

The previous section showed that gaps (wh-traces) trigger immediate reactivation of their antecedents and the effect can be observed in various online measurements. Assuming that the parser builds a mental representation that is consistent with specifications that grammatical theories assume for human languages (Berwick & Weinberg 1984), it is of empirical and theoretical interest whether or not the parser has immediate access to grammatical constraints involving ECs. Psycholinguistic evidence on this issue seems to suggest that people do make immediate use of such grammatical knowledge in predicting the possible locations of gaps.

By using a self-paced word-by-word reading task, Stowe (1986) tested whether the parser postulates a gap in a so-called ‘subject island’ from which a movement is prohibited. Sentence (4) illustrates the island effect (Stowe 1986:239).

(4) *Wh*-word extracted from the subject NP

*Who did [_{subNP} the story about _] annoy her boy friend?

She hypothesized that if online parsing is informed by the island constraint, the parser would not attempt to postulate a gap in an island. Take the sentences in (5), for example.

(5) a. The teacher asked what_i [_{subNP} the silly story about Greg's older brother] was supposed to mean t_i.

- b. The teacher asked what_i the team [_{VP} laughed [_{PP} about Greg's older brother fumbling t_i]].

If the constraint is used immediately, there will be no processing increase when encountering the overt NP *Greg's* in (5a) since it is not a possible gap position. On the other hand, there will be a detectable increase when encountering the overt NP *Greg's* in (5b) since nothing prohibits the occurrence of a gap. In such a case, there is a preference for the parser to postulate a gap at the first possible position ('the first-resort strategy' of gap-filling, Fodor 1978:435). These predictions were supported. There was a significantly increased reading time at the overt NP in sentence (5b), while no such difficulty was detected at the equivalent region in sentence such as (5a). Stowe suggests that the syntactic constraint is used rapidly during processing. The parser makes a prediction about whether or not a gap should be posited. It appears that the development of a gap expectation is heavily dependent on syntactic constraints (Stowe 1986:244). (See Bourdages 1992, McElree and Griffith 1998 for comparable findings on relative clause islands, De Vincenzi 1996 on the Empty Category Principle.)¹⁴

Recent studies using event-related brain potentials have provided more direct evidence for the time course of unconscious signals in response to various aspects of

¹⁴ McElree and Griffith (1998) measured the time for the reader to assess the acceptability of structures with anomalous filler-gap dependencies (speed-accuracy trade-off procedures). Test sentences had three types of violations as follows (p.435):

- i. Subcategorization violation: *It was the essay that the writer knew the editor had gloated.
- ii. Thematic role violation: *It was the essay that the writer knew the editor had amazed.
- iii. Island violation: *It was the essay_i that the writer scolded the editor [who admired t_i].

Violations of configurational (island) constraints were the earliest to be detected, followed by subcategorization and thematic role violations, in that order. The authors suggest that filler-gap assignments are determined by processes that appeal first to general syntactic information and only later to specific lexical information.

syntactic processes during processing (See Osterhout and Holcomb 1995 for an overview). McKinnon and Osterhout (1996) found “a large, widely distributed positive-going wave” elicited from sentences with two types of syntactic violations involving gaps – Subjacency and Empty Category Principle violations (p.504).¹⁵ This ERP response was similar to the P600 effect, an index of the cost of syntactic integration, previously observed with various syntactic anomalies, but quite distinct from the effect observed in sentences with semantic anomalies. Furthermore, the brain response to those anomalies was remarkably rapid, lagging only 250-300 msec following the onset of the critical word that first indicates a violation (e.g., a *wh*-word introducing an island). McKinnon and Osterhout suggest that “information about movement constraints is available at very early stages of processing” (p.514). (See also Kluender and Kutas 1993a,b, Traxler & Pickering 1996, cf. Neville, Nicol, Barss, Forster, & Garrett 1991.)

In sum, psycholinguistic evidence suggests that the parser seems to recognize a gap during processing and obeys the global syntactic constraints that restrict the occurrence of gaps. Note that, however, this does not mean that there is no evidence for seemingly delayed use of gap-filling constraints. For example, Clifton and Frazier (1989) used a speeded grammaticality judgment task to investigate whether readers are garden-pathed by the possible gap within a complex NP island.¹⁶ They found that sentences with

¹⁵ Examples of syntactic violations used in the study (McKinnon and Osterhout 1996:500, 509)

- i. Subjacency violation: *I wonder which of his staff members_i the candidate was annoyed [when his son was questioned by __j].
- ii. ECP violation: *The man_i seems that it is likely __j to win.

¹⁶ In this task, the participant was asked to judge the acceptability of a sentence after reading the sentence at the rate of 350 msec per item. Sample sentences are:

- i. Doubtful gap within an island: What did John think the girl [who always won (*_)] received _?
- ii. No doubtful gap within an island: What did John think the girl [who always excelled] received _?

a doubtful gap within an island were judged 43 msec more slowly than sentences without such a gap. A similar pattern was also found for error rate: more error was found in the former condition than in the latter. However, as Clifton and Frazier admitted, the difference was marginal and the results from an end-of-sentence judgment task may not provide strong evidence, compared to other measurements such as local reading times and ERP responses. (See also Freedman & Forster 1985 for similar findings from a sentence matching task.) Given the types of evidence that we have obtained thus far, therefore, it is possible to conclude that the parser respects global syntactic constraints in the online processing of filler-gap dependencies.

These are important findings from a processing point of view. They show that grammatical knowledge not only guides the incremental association of words into the structure currently being built (e.g., linking a gap to a previously encountered filler) but also influences the parser's expectations. The parser uses it to determine where to look for a gap. Furthermore, these processes take place immediately, as evidenced by the presence/absence of the surprise effect when an overt NP is found instead of a gap.

3.1.3 Formation of filler-gap dependencies

The previous sections showed that online sentence processing involves gap postulation. It also showed that the prediction of gaps is informed by syntactic constraints. However, this does not tell us exactly how a gap is found and associated with its appropriate filler. Recall that a gap is phonetically empty and there could be an unlimited number of constituents intervening between a filler and a gap.

Frazier (1987b:548fn) proposed that the parser follows a principle – the active filler strategy – in the processing of filler-gap dependencies.

- (6) Active filler strategy (Frazier 1987b, Frazier and Flores d’Arcais 1989:332)¹⁷

Assign an identified filler as soon as possible; i.e., rank the option of a gap above the option of a lexical noun phrase within the domain of an identified filler.

That is, once a ‘moved’ phrase is identified in a non-argument position, the parser immediately assumes the presence of a filler-gap dependency. It uses the syntactic category of the filler to identify a possible gap, and the filler is assigned to “the first possible position in a syntactic phrase marker” (Frazier and Flores d’Arcais 1989:332).¹⁸ Apparently, since the subject of a clause is the first possible position for a gap to be able to appear in cases such as English *wh*-questions and relative clauses, there is always a subject-bias in those structures.

One piece of evidence for the active filler strategy has been found in Dutch, which exhibits a verb-final constituent order in embedded clauses. Relative clauses (RCs) in Dutch can be globally ambiguous as in sentence (7), taken from Frazier (1987b:545).

- (7) Ik schreef aan de vriend die mijn tante heeft bezocht
I wrote to the friend who my aunt have(sg) visited
Subject-gap RC reading: ‘I wrote to the friend who has visited my aunt.’
Object-gap RC reading: ‘I wrote to the friend who my aunt has visited.’

¹⁷ See also Clifton & Frazier 1989, Crain & Fodor 1985, Frazier & Clifton 1989, and Stowe 1986.

¹⁸ The authors imply that other type of information, such as animacy, could also be used to identify a gap (p.332).

In Dutch, the verb agrees with the subject in number. However, in sentence (7) where both the head noun ('the friend') and the NP in the RC ('my aunt') are singular, the number marking of the verb cannot help specify the grammatical role of the NPs. Even when the NPs differ in their number markings, RCs are ambiguous until the clause final auxiliary (in bold in (8)) is encountered. The same fragment can continue as a subject-gap RC as in (8a) or as an object-gap RC as in (8b).

(8) a. Subject-gap RC

[Frazier (1987b:545-6)]

De vriend die [e mijn tantes **heeft** bezocht].
the friend who my aunts have(sg) visited
'the friend who has visited my aunts'

b. Object-gap RC

De vriend die [mijn tantes e **hebben** bezocht]
the friend who my aunts have(pl) visited
'the friend who my aunts have visited'

Frazier (1987b) examined whether there is any preference in processing sentences like (7) and (8). The results of a frame-by-frame reading experiment with end-of-sentence comprehension questions showed that the subject-gap reading was chosen 74% of the time for ambiguous sentences as in (7). As for temporarily ambiguous sentences (8), response accuracy to comprehension questions showed an advantage for subject-gap RCs. Readers misinterpreted the head noun of object-gap RCs as the subject of the embedded predicate 31% of the time, while the corresponding error rate for subject-gap RCs was only 3.7%.¹⁹ Overall, a strong preference for subject-gap RCs was observed.

¹⁹ The reading times for object-gap RCs were numerically longer than those for subject-gap RCs, but the difference was not statistically significant.

These results are consistent with an active filler strategy which treats the subject as the earliest grammatically permissible position in a sentence with the parser predisposed to form a filler-gap dependency. (See also Frazier and Flores d'Arcais 1989 for the subject advantage in declarative and question sentences in Dutch.)

One implication of this heuristic principle (the active filler strategy) is that the parser does not expect to see an overt lexical phrase at the earliest possible gap position. It follows that the presence of an overt lexical phrase at that position will lead to some observable processing cost, called 'the filled-gap effect' (Crain and Fodor 1985). Stowe (1986) tested this prediction in a self-paced reading experiment. She compared the following pair of sentences (p.234).

- (9) a. My brother wanted to know if Ruth will bring **us** home to Mom at Christmas.
b. My brother wanted to know who Ruth will bring **us** home to _ at Christmas.

The reading time for *us* in sentence (9b) was significantly slower than for *us* in sentence (9a). This suggests that when a filler *who* is identified, the parser initially attempts to assign the filler to the direct object of the matrix verb (and thus expecting to see a gap there). When a lexical NP is found, the parser has to change its initial assignment and reanalyze the lexical phrase *us* as the direct object of *bring*, resulting in a processing

difficulty. (See also Crain and Fodor 1985, Frazier and Clifton 1989, Swinney et al. 1989 for similar findings.)²⁰

Frazier and Clifton (1989) tested whether the Active filler strategy remains operative across a clause boundary. They compared the following sentences in a self-paced reading experiment (p.97).

(10) a. Who did the housekeeper say [she urged **the guests** to consider _]?

b. The housekeeper said [she urged **the guests** to consider the new chef.]

The filled-gap effect (i.e., the processing increase due to the parser's initial attempt to posit a gap, which must be corrected upon the presence of an overt lexical item) was observed even when the potential gap position was not in the same clause as the identified filler. Note that the presence of the filler *who* in sentence (10a) triggers an expectation of a gap, while there is no such expectation formed in a sentence without a

²⁰ Interestingly, Stowe (1986) did not find any processing difficulty for an overt lexical phrase in subject position. The reading time of *Ruth* following a wh-filler as in (ii) did not differ from *Ruth* following *if* as in (i).

i. My brother wanted to know if **Ruth** will bring....

ii. My brother wanted to know who **Ruth** will bring....

According to the active filler hypothesis, the subject should be the first position to which a filler can be assigned (Frazier and Flores d'Arcais 1989:332). However, contrary to this prediction, the subjects in Stowe's study did not seem to expect to find a gap in the subject position. Alternatively they may have attempted to create a gap in the subject position, but upon the presence of an overt lexical phrase, they recovered from the initial analysis without difficulty. Stowe (1986:238) suggested that one possibility is that a gap-search process may be initiated after processing the subject; people start looking for a gap after the subject position is found to be filled. Another possibility is that reanalysis of the subject is much easier than of the object since a thematic role has not been assigned to the subject yet, and therefore, only a syntactic expectation needs to be corrected. In the case of object reanalysis, both the syntactic expectation and the semantic content must be corrected. Presumably, correcting the semantic interpretation is more difficult than correcting the syntactic expectation. (See also Clifton & Frazier 1989, Gibson & Hickok 1993:152, Gibson, Hickok, & Schulze 1994 for other explanations.) According to Gibson and Hickok (1993:152) and Gibson et al. (1994:392-3), a subject is fully licensed only after its role-assigning verb appears. Therefore, whether a gap or a lexical phrase is posited at the relative pronoun *who*, the processing cost associated with its unsatisfied theta-role requirement will be the same.

filler (as in (10b)). The reading time for *the guests* was longer in sentence (10a) than in sentence (10b). The results suggest that the identified filler remained active even after the clause boundary was crossed and the parser did not overlook the potential gap position.

Frazier and Clifton (1989) also found that the magnitude of the filled-gap effect was much greater when the potential gap position was in an embedded clause than in a simple matrix clause. One possible explanation was that filler-gap dependencies across clause boundaries are structurally more complex than those without a clause boundary, as illustrated in (11).

(11) a. Which book_i did the student buy t_i at the bookstore?
 └──┘

b. Which book_i did the student believe [t_i Mary bought t_i at the bookstore]?
 └──────────────────────────────────┘ └──────────────────┘

In sentence (11a), where the filler-gap dependency is formed within a single clause, there is only one ‘chain’.²¹ On the other hand, sentence (11b), with the filler associated with a gap in an embedded clause, has two chains mediated by the gap in the COMP of an embedded clause. By incorporating the notion of ‘chain’ to the active-filler strategy, De Vincenzi (1989, reported in Clifton & De Vincenzi 1990) proposed the minimal chain principle (p.277).

(12) Minimal Chain Principle

Avoid postulating unnecessary chain members at S-structure, but do not delay required chain members.

²¹ A chain is a set of co-indexed elements, bearing one and only one theta-role and one and only one case, where each element in the chain c-commands the next (Clifton and De Vincenzi 1990:276).

The principle says that the parser prefers not to posit chains. But if it is forced to posit a chain, such as when it identifies a filler, it attempts to terminate the chain as quickly as possible (p.282).²²

To sum up, the identification of a gap and the formation of a dependency with its filler proceeds in an efficient manner informed by structural considerations. The syntactic category of an identified filler is used to identify possible gap positions, and a gap is postulated at the earliest grammatically permissible position in a structure (e.g., Clifton and Frazier 1989, Crain and Fodor 1985, Frazier 1987b, Frazier and Clifton 1989, Frazier and Flores d'Arcais 1989, Stowe 1986).²³ Forming a filler-gap chain is costly since it is structurally more complex, and thus requires more processing time and effort. Therefore, there is a strong preference to end the chain as soon as possible (De Vincenzi (1989, reported in Clifton & De Vincenzi 1990). When an overt lexical phrase appears at the position where a gap is expected, the parser is surprised, resulting in a longer reading time at that position, known as the filled-gap effect (Crain and Fodor 1985, Stowe 1986, among others).

²² De Vincenzi examined Italian sentences with null subject structure and those with inverted subject structure.

- i. Null subject structure: *pro* Aux V NP ...
- ii. Inverted subject structure: *t_i* Aux V NP_i ...

A postverbal NP in Italian is temporarily ambiguous. It can be interpreted as the direct object of the verb with a null subject *pro* as in (i), or it can be interpreted as the subject which is moved to the postverbal position as in (ii). The results of a self-paced reading experiment showed that the reading time of the disambiguating region following the postverbal NP was slower in (ii) than in (i). This suggests that readers initially analyze the sentence as (i) rather than (ii), which is predicted by the minimal chain principle. The inverted subject analysis is more difficult since it involves a chain, while null subject sentence does not. (See De Vincenzi 1991 for additional evidence for the minimal chain principle in Italian.)

²³ The kind of lexical information that is used in the formation of filler-gap dependencies has been an issue. See Clifton and De Vincenzi 1990, Clifton and Frazier 1986, Crain and Fodor 1985, Frazier, Clifton, & Randall 1983, Tanenhaus, Boland, Garnsey, & Carlson 1989, and references therein.

Before closing this section, it should be noted that there is a view that the processing phenomena reported in the study of filler-gap dependencies can be accounted for without appealing to the notion of empty categories. Adopting a version of trace-free Categorical Grammars (Ades & Steedman 1982, Pickering & Barry 1993), Pickering and Barry (1991) challenged the traditional filler-gap account (e.g., Fodor 1978) by arguing that the materials used in previous studies have confounds (e.g., Crain & Fodor 1985, Stowe 1986, Swinney et al. 1988, reported in Swinney et al. 1989). In those studies, the position of a gap was adjacent to the subcategorizer (e.g., a verb), and therefore could not distinguish the filler-gap association from the filler-subcategorizer association. For example, in an eye tracking experiment in which an implausible sentence such as (13a) was compared with (13b), Traxler and Pickering (1996) found that processing difficulty occurred immediately after the verb *shot* in (13a) but not in (13b). There was no equivalent difference at the purported gap positions in both sentences.

- (13) a. That's [the garage]_i with which the heartless killer shot the hapless man t_i yesterday afternoon.
- b. That's [the garage]_i in which the heartless killer shot the hapless man t_i yesterday afternoon.

The results were taken as evidence for the direct integration of a filler at the verb, consistent with the “immediate association” model.

However, Gibson and Hickok (1993) criticized Pickering and Barry's (1991) ‘immediate association’ account. They argued that the evidence presented by Pickering and Barry can still be accounted for by a parsing model which posits gaps. According to

Gibson and Hickok, a gap can be posited as soon as an appropriate subcategorizer licenses a position (by assigning a thematic role) for that filler, whether or not the lexical items intervening between the verb and the gap are filled (p.150).²⁴ For sentence (13b), repeated as (14), for instance, the parser assumes a gap *t* as soon as it encounters the verb *shot* even before the intervening hypothesized NP [_{NP} *h*] appears.

(14) That's [the garage]_i in which the heartless killer shot [_{NP} *h*] *t*_i

As Gibson's (1991) complexity theory can fully account for the findings provided by Pickering and Barry, Gibson and Hickok (1993) concluded that the empirical data is fully compatible with accounts that assume the presence of gaps in the mental representation. (See Gorrell 1993, Miyamoto & Takahashi 2002b, Featherston 2001, for more discussion and counter-evidence to the immediate association model.)

3.1.4 Subject-object asymmetry

A finding that has been consistently reported in the processing of filler-gap dependencies in English is that relative clauses with gaps in the subject position (hereafter subject-gap RCs) are easier to process than relative clauses with gaps in the object position (object-gap RCs) (Baird & Koslick 1974, Ford 1983, Gordon, Hendrick, Johnson 2001, Hakes, Evans & Brannon 1976, Holmes 1973, King & Just 1991, King & Kutas 1995a,b, Kluender & Kutas 1993a, Kutas 1997, Traxler, Morris, & Seely 2002,

²⁴ It is assumed that a verb's argument structures are projected immediately upon encountering the verb. If the category of a filler (e.g., *wh*-word) matches category of the right most edge of the VP, a gap is postulated at that (right most) position without blocking the attachment of the element to the left of the gap to the verb.

Wanner & Maratsos 1978). Similar findings have been reported for French (Frauenfelder, Segui, & Mehler 1980, Holmes & O'Regan 1981), for Dutch (Frazier 1987b, Mak, Vonk, & Schriefers 2002), and for German (Mecklinger, Schriefers, Steinhauer, & Friederici 1995, Schriefers, Friederici, & Kühn 1995).

Different proposals have been put forward to account for these findings. One of them is a structure-based account, the active filler strategy (Clifton and Frazier 1989, Frazier and Clifton 1989, Frazier 1987b, Frazier and Flores d'Arcais 1989, Stowe 1986). As described earlier, it assumes that when the parser identifies a filler, it attempts to assign the filler to the earliest possible position in a structure.

(15) The student who

For example, when the parser reads a fragment like (15), it recognizes that a gap is needed so that the filler *who* is associated with it. Since the subject of an embedded clause is the earliest position where a gap can occur, the parser attempts to postulate a gap there as in (16a).

(16) a. Subject-gap RC: The student who e saw John

 b. Object-gap RC: The student who John saw e.....

When the fragment turns out to be a subject-gap RC as in (16a), processing proceeds without any difficulty. On the other hand, when the fragment continues like (16b), the initial attempt to insert a gap in the subject position must be corrected due to the presence of an overt lexical phrase *John*. This leads to a reanalysis, which incurs processing cost.

In short, under this analysis, the processing advantage of a subject-gap RC is a consequence of applying a structure-based heuristic strategy and its successful outcome (i.e., the absence of reanalysis). In contrast, an object-gap RC is disadvantaged because the appearance of an overt subject following the relative pronoun contradicts an initial attempt to insert a gap at that position.

In contrast to the active filler strategy, many researchers have attributed a subject-object asymmetry to the different quantity of working memory needed to process each structure (e.g., Ford 1983, Gibson 1998, 2000, King & Just 1991, Wanner & Maratsos 1978, among others). For example, within the framework of an Augmented Transition Network (ATN), Wanner and Maratsos (1978) hypothesized that the head noun of an RC whose grammatical function has not been assigned is held on a special 'HOLD' list (a memory buffer) until it is retrieved at the gap site (p.131). Take the sentences in (16) as an example. The unstructured head noun must be kept longer for the object RC (16b) than for the subject RC (16a), therefore, processing the former structure is more costly than the latter. If holding the head noun in memory incurs the processing cost, this theory predicts that the processing cost involved in object-gap RCs should appear in the region between the relative pronoun and the gap (p.138). However, this prediction turned out to be incorrect as I will show below. (See Ford 1983 for problems with this ATN account.)

It has been suggested that working memory is needed not only to store partial products of parsing but also to perform symbolic computations for each incoming word (e.g., Caplan & Waters 1999, 2001, Carpenter, Miyake, & Just 1994, Daneman & Carpenter 1980, Gibson 1998, 2000, Just & Carpenter 1992, Kaan & Stowe 2002, King

and Just 1991). Taking this perspective, King and Just (1991:581) pointed out three kinds of working memory demands that combine to make the processing of object-gap RCs more difficult. First, the matrix clause is interrupted by the embedded clause, which is true for both subject-gap and object-gap RCs.

- (17) a. Subject RC: The reporter [that e attacked the senator] admitted the error
b. Object RC: The reporter [that the senator attacked e] admitted the error

This means that while the embedded clause is being processed, the head noun of the RC needs to be stored in working memory or must be reactivated at the end of the embedded clause.²⁵ Second, a role assignment to multiple NPs requires more memory resources than a role assignment to a single NP. In the case of object-gap RCs, there is a sequence of NPs (*the reporter* and *the senator* in (17b)) that need thematic roles, but cannot be assigned until the embedded verb *attacked* appears. That is, agent and theme roles must be assigned simultaneously at the verb. In contrast, in subject-gap RCs, role assignment takes place one NP at a time. The agent role is assigned to *the reporter* at the verb *attacked*, and the theme role is assigned when *the senator* is encountered. Third, the assignment of two different roles to a single NP is assumed to be more costly. In the object RC, *the reporter* is assigned a theme role from the embedded verb but assigned an

²⁵ If we take a view that the matrix subject must be ‘reactivated’ at the matrix verb, object-gap RCs seem to have an advantage over subject-gap RCs (Amy Schafer 2003, personal communication). Assuming that the matrix subject (i.e., the filler of the following relative clause) is reactivated at the gap position, reactivation at the object of an embedded clause is more recent to the matrix verb than the reactivation at the subject of an embedded clause. If a more recently reactivated item further facilitates the re-activation of the item at a subsequent position (e.g., Gibson & Warren 1998, reported in Miyamoto & Takahashi 2002b), the priming effect should be greater at the matrix verb following an object-gap RC than following a subject-gap RC.

agent role from the matrix verb. On the other hand, in the subject RC, *the reporter* is assigned an agent role from both verbs. These extra processing demands involved in object-gap RCs, which stem from both storage and computational aspects, make these sentences harder to process.

In memory-based accounts, processing difficulties are predicted to occur at the point where substantial memory demands are required. For example, Ford (1983) reported that response times in a continuous lexical decision task at the embedded verb and matrix verb were longer for object-gap RCs than for subject-gap RCs.²⁶ Likewise, King and Just (1991) found that reading times increased in the predicted computationally demanding areas (i.e., the end of embedded clause and the matrix verb), but the increase was much greater for object relative clauses than for subject relative clauses.²⁷ A study of eye movements conducted by Holmes and O'Regan (1981) found that object-gap RCs yielded more relooking at the region prior to the head noun and the final constituent of the RC. Object gap RCs also produced more regression than subject-gap RCs at the region immediately following the relative pronoun and the region following the RC boundary.

Gibson (1998, 2000) proposed a theory of sentence processing, the Dependency Locality Theory (DLT), in which working memory demands during processing are

²⁶ In this task, the participant made a lexical decision (i.e., whether a string of letters is a word or not) for each word of a sentence. A word of a sentence is presented from left to right on a screen and all words previously read remain on the screen.

²⁷ The major goal of King and Just's study was to show that working memory capacity varies across individuals, and constrains syntactic processes. Those who have less capacity exhibit overall poorer comprehension and slower processing speed, and suffer more in sentences that require more computational operations. They proposed a parsing model, Capacity Constrained Reader (p.598). See King and Just (1991) for more details.

quantified more explicitly. The theory consists of two major claims: (1) two aspects of sentence processing consume resources – connecting a word into a partially built structure (integration) and keeping the structure in memory (storage), and (2) structural integration is constrained by locality (Gibson 2000:95). The storage cost at each point of a sentence is quantified by the number of syntactic heads that are required (i.e., predicted syntactic heads) to complete the sentence as grammatical (p.114).²⁸ For example, a noun is predicted by the appearance of a determiner, a matrix verb by the subject of a sentence, a gap by a relative pronoun, and so forth. The integration cost is calculated by the number of new discourse referents (i.e., category of nouns and verbs) between the heads of the two projections being integrated.²⁹ The longer the distance between the two elements, the more resources are required because the activation of some aspects of the first element decays over time as intervening items are processed. In sum, the DLT makes specific predictions about the time course of sentence processing by measuring the quantity of resources used for storage and integration components of sentence processing.

The subject-object asymmetry observed in the processing of RCs in English is correctly predicted by the DLT.

²⁸ In his previous work (Gibson et al 1994, Gibson 1998), storage cost was defined in terms of the number of incomplete dependencies (e.g., NPs that need thematic roles but have not been assigned yet or elements that need to assign theta roles but haven't assigned them yet). These two definitions are similar, and "there is currently no empirical evidence relevant to deciding between indexing storage cost difficulty in terms of predicted categories or incomplete dependencies: either hypothesis suffices for the data that we know of thus far (Gibson 2000:121).

²⁹ Gibson (2000:103) argues that the resources required to process an NP depend on the accessibility of the referent of the NP in the discourse. Focused entities or individuals (such as pronouns) are highly accessible requiring less resource demand, while nonfocused entities (such as proper nouns and definite/indefinite NPs) require accessing more resources. In this theory, therefore, the head noun of an NP that refers to a new discourse object and the head verb of a VP that refers to a new event are counted since they are assumed to consume substantial resources to process.

(18) a. Subject-gap RC

The reporter [who e attacked the senator] disliked the editor.
□

b. Object-gap RC

The reporter [who the senator attacked e] disliked the editor.
□

The integration distance between the relative pronoun *who* and the gap *e* is shorter in the subject-gap RC than in the object-gap RC. There are no intervening words in subject-gap RC (18a), while there are two discourse referents (*the senator* and *attacked*) intervening in (18b).

The storage cost for each sentence is shown in (19). Items that are listed below each word of the sentences are the predicted entities in order for a sentence to complete as grammatical.

(19) a. Subject-gap RC

| | | | | | | | | |
|--------|----------|------------|----------|--------|----------|----------|-----|---------|
| w1 | w2 | w3 | w4 | w5 | w6 | w7 | w8 | w9 |
| The | reporter | [who e | attacked | the | senator] | disliked | the | editor. |
| main V | main V | main V | main V | main V | main V | D.O. | N | |
| N | | relative V | D.O. | N | | | | |
| | | Gap | | | | | | |

b. Object-gap RC

| | | | | | | | | |
|--------|----------|------------|------------|------------|--------------|----------|-----|---------|
| w1 | w2 | w3 | w4 | w5 | w6 | w7 | w8 | w9 |
| The | reporter | [who | the | senator | attacked e] | disliked | the | editor. |
| main V | main V | main V | main V | main V | main V | D.O. | N | |
| N | | relative V | relative V | relative V | | | | |
| | | Gap | Gap | Gap | | | | |
| | | | N | | | | | |

The greatest difference in storage cost between subject-gap and object-gap RCs appears at w4. While there are only two elements (main verb and direct object) predicted at w4 in the subject-gap RC, there are four elements (main verb, relative verb, gap for *who*, and noun for the determiner) predicted at the corresponding region in the object-gap RC. Reading time data collected by Gibson and Ko (1998, reported in Gibson 2000) was consistent with the predictions of the integration component. Reading time increased at the embedded verb in the object-gap RC, but there was no such difficulty observed in the subject-gap RC. In both relative clauses, the reading time increased at the main verb.³⁰

In contrast to Gibson's distance metric which calculates the number of new discourse referents between gap and filler, O'Grady (1997) proposed a different distance metric assumed to be responsible for the processing difference between subject-gap and object-gap RCs (See also Collins 1994, Hawkins 1999, Pesetsky 1982 for similar approaches, but Frazier 1987b for counter-evidence from Dutch). For expository purposes, I call Gibson's integration cost theory 'the linear distance approach', and O'Grady's 'the structural distance approach'.

³⁰ The results reported in Gibson and Ko only support the predictions proposed by the integration component of the theory since there was no increased reading time observed at the region where the greatest storage cost is predicted (i.e., the determiner and the following NP in the object-gap relative clause). In another study conducted by Gibson, Desmet, Grodner, Watson, and Ko (2002), the reading time of the whole relative clause region was significantly longer in the object-gap RC than in the subject-gap RC. However, whether this difference was due to storage cost or integration cost is not clear. Gibson admitted that "it turns out that many resource complexity effects can be explained using integration cost alone" (2000:102). He also remarked that "larger quantities of either storage or integration cost cause slower integration times", but how exactly these two costs interact with each other has not been empirically defined (p.115). (See Hsiao and Gibson (2003) for a Chinese relative clause study in which only the storage component of the theory was found to correctly predict the results.) However, in her ERP study on English RCs, Kutas (1997) found much earlier divergence between subject-gap and object-gap RCs. That is, the left anterior negativity (LAN effect, an index of the increased memory load) appeared "shortly after the reader encounters the relative clause – the subject noun of an object-gap RC" (p.392), which is consistent with Gibson's storage component.

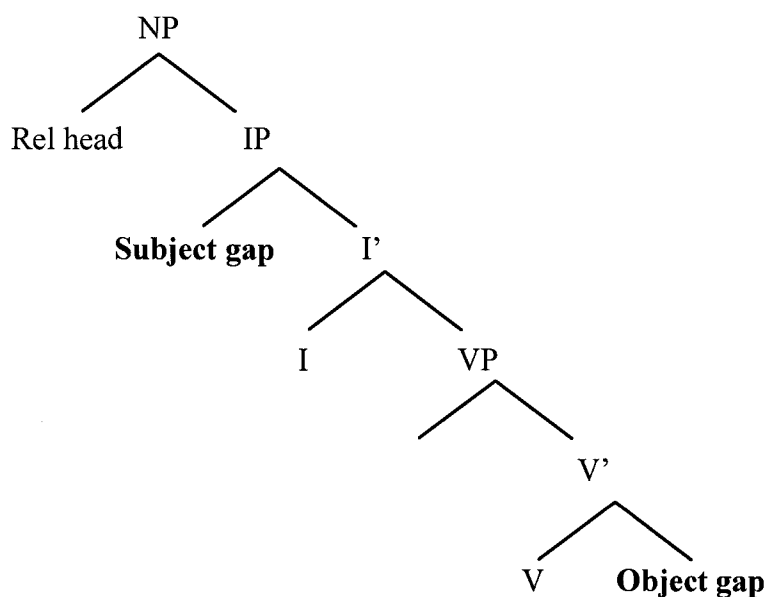
(20) The structural distance approach

[O'Grady 1997:136]

A structure's complexity increases with the number of XP categories (S, VP, etc.) between a gap and the element with which it is associated.

The structural distance approach claims that the subject-object gap asymmetry reflects the different structural positions of the subject and the direct object in the syntactic structure. Consider the following structural representation that is generally assumed for English relative clauses.

(21) Structural representation of English relative clauses



Since the object gap is more deeply embedded in the structure than the subject gap, it must traverse an additional node (VP) in order to be associated with its filler.³¹

³¹ This structural distance metric is equally applicable to a nonmovement approach to the relative clause formation in which the feature associated with a missing NP percolates up on the structure until it is matched with the relative head (O'Grady 1997:174-5).

These two approaches – the linear distance and the structural distance approaches – make the same predictions for English RCs, namely, the ease of subject-gap RCs over object-gap RCs (O’Grady, Lee, & Choo 2001:6). The subject gap is not only linearly closer but also structurally closer to the filler. However, the two hypotheses make different predictions for Korean and Japanese, SOV languages with prenominal RCs. While the structural approach predicts that subject-gap RCs are easier in Korean and Japanese since the subject is structurally higher across languages, the linear distance approach predicts the reversed pattern – ease of object-gap RCs – because the object gap is linearly closer to the filler. Although empirical data from adult sentence processing has not shown a subject-gap advantage in head final languages, both L1 and L2 acquisition data for those languages have supported the prediction proposed by the structural distance approach (Cho 1999 for L1 Korean, O’Grady, Lee & Choo 2001 for L2 Korean, O’Grady, Yamashita, Lee, Choo, & Cho 2002 for L1 Japanese, Kanno & Nakamura 2001 for L2 Japanese). I will discuss these issues in more detail in Section 3.2.2.3.

This section outlined major processing models that have been put forward to account for the well-established finding of a processing advantage for subject-gap RCs over object-gap RCs. Under the active filler hypothesis (including the Minimal Chain Principle), once a filler is identified, the parser follows a structure-based heuristic principle to find a gap. Since the subject is the earliest grammatically permissible position for a gap, the parser is predisposed to fill the subject gap with its filler. In contrast, many other theories attribute the processing asymmetry to memory

considerations. Simply, the longer a dependency is, the more difficult it is to process since the more computational resources are required. However, how the length of a dependency is defined varies. The Dependency Locality Theory (Gibson 1998, 2000) makes reference to a linear distance metric by counting the number of discourse referents between gap and filler, while the structural distance hypothesis (O’Grady 1997) counts the number of syntactic nodes between gap and filler in the syntactic structure.

With English RCs, all of these models successfully account for the empirical findings currently available (i.e., processing advantage of subject-gap RCs). Unfortunately, however, empirical evidence from other languages is very limited, especially in the area of adult sentence processing. This dissertation is an attempt to collect such empirical evidence from a language that is typologically different from English in some critical ways. In the sections that follow, I am going to summarize basic processing properties of Japanese and findings on the processing of RCs in Japanese.

3.2 Processing of filler-gap dependencies in Japanese

3.2.1 Incremental processing in Japanese

There is a general consensus among psycholinguists that sentence processing in head-initial languages proceeds in a highly incremental fashion. In English, for example, the fixed word order, early appearance of a head relative to its dependent elements, and overtly expressed constituents of a sentence give the parser relatively sufficient cues about the structure it is going to build. By contrast, in Japanese, a strict head-final language, the verb comes at the end of a clause, and all other elements (e.g., verb’s arguments and modifiers of those arguments) precede the verb. Furthermore, the flexible

constituent order and frequent argument drop make sentences inherently ambiguous, allowing more than one analysis for a given sentence.³²

Consider the following example from Inoue and Fodor (1995:9-10).

- (22) John-ni Mary-ga shookaishita tomodachi-o odorokaseta to itta.
John-DAT Mary-NOM introduced friend-ACC surprised COMP said

The sequence of two verbs at the end indicates that this sentence consists of two clauses. However, where the clause boundary falls is ambiguous because there is no formal device to signal the beginning of an embedded clause in Japanese. The sentences in (23) give three possible analyses (among many others) of this sentence (p.10).

- (23) a. [John-ni Mary_i-ga [[e_i [[e_i e_j shookaishita] tomodachi_j]-o odorokaseta] to] itta]
'To John, Mary said that she had surprised the friend she had introduced to someone.'
- b. [e John-ni [[e [[Mary-ga e_i shookaishita] tomodachi_i]-o odorokaseta] to] itta]
'Someone said to John that he had surprised the friend to whom Mary had introduced him.'
- c. [[e [[e [John-ni Mary-ga e_i shookaishita] tomodachi_i]-o odorokaseta] to] itta]
'Someone said that someone had surprised the friend that Mary introduced to John.'

In (a), the first two NPs ('John-dat' and 'Mary-nom') are analyzed as arguments of the matrix verb ('said'). In (b), only the first NP ('John-dat') is an argument of the matrix verb, while the second NP ('Mary-nom') belongs to the embedded verb ('introduced'). In (c), both initial NPs are clausemates of the most embedded clause (with 'introduced').

³² See Inoue and Fodor (1995), Hirose (1999), Mazuka (1991), Yamashita (1997, 2000) for more detailed discussion of ambiguities in Japanese.

As for the accusative marked NP ('friend-acc'), it could be interpreted as the theme of the verb 'introduced' as in (a) and (c), or it could be analyzed as the goal as in (b). Other arguments are implicit (indicated as *e* in the above sentences) and their referents are determined based on the discourse.

The inherent ambiguity of Japanese and the possibilities of misanalysis as a consequence make researchers wonder how online processing proceeds in Japanese. One proposal for responding to such massive ambiguity in Japanese is that the Japanese parser postpones structural analysis until disambiguating information (i.e., syntactic heads such as verbs) becomes available (Pritchett 1991).³³ However, a delayed parsing model such as Pritchett's is counterintuitive in the sense that it implies tremendous parsing disadvantages for Japanese.³⁴ Furthermore, recent studies on Japanese sentence processing suggest that this is not the case.

Extensive evidence (from both intuitive judgments and experimental results) has shown that the Japanese parser conducts a structural analysis incrementally based on the information available in a sentence (e.g., Hirose 1999, Inoue 1991, Inoue & Fodor 1995, Kamide & Mitchell 1999, Mazuka, Itoh, & Kondo 2002, Miyamoto & Takahashi 2002a,

³³ Pritchett (1991:252-3) proposed a head-driven parser for Japanese. According to this model, all attachment decisions are made at the head, where grammatical requirements such as case and theta role assignments are satisfied to the maximum degree possible in the local string.

³⁴ By assuming that a sentence is a projection of Infl and VP is projected when a verb appears, Inoue and Fodor (1995) argued that virtually all elements in a sentence must be left unstructured until the end of the sentence. Storing unstructured information imposes much greater demands on working memory than structured elements (Miller 1956). Furthermore, most misanalyses seem to be relatively easy or even unnoticed during normal language use. See also Miyamoto (2002) for the discussion of the problems involved in such a delay model.

2002b, Miyamoto, Gibson, Pearlmutter, Aikawa, & Miyagawa 1999, Miyamoto & Takahashi 2001, Nagai 1995, Yamashita 1997).³⁵

Yamashita (1997) showed that the Japanese parser makes use of case marking information to construct a tentative structure prior to a verb. She examined the following set of sentences using a lexical decision task.

- (24) a. Kawaii onnanoko-ga wakai sensei-ni oishii ocha-o dashita
cute girl-NOM young teacher-DAT good tea-ACC served
'The cute girl served the young teacher good tea.'
- b. Kawaii onnanoko-ga wakai sensei-ni [oishii ocha-o nonda] (to itta).
cute girl-NOM young teacher-DAT good tea-ACC drank (that said)
'The cute girl said that the young teacher drank good tea.'

The reaction time to decide whether or not a word (underlined) is a real word in Japanese was significantly faster for *dashita* ('served') in (24a) than for *nonda* ('drank') in (24b). This suggests that the parser construes the NP sequence <NP-nom NP-dat NP-acc> as co-arguments of a single clause and expects that a ditransitive verb will appear. When *dashita* ('served') appears for judgment as in (24a), the response latency should be fast since this word matches the mental representation that the parser has been building thus far. When *nonda* ('drank') appears (as in (24b)), on the other hand, processing is disrupted since this word does not meet the expectation. Furthermore, Yamashita observed that the preference for a ditransitive verb over a transitive verb was present even when the dative marked NP ('young teacher-dat') was preposed to sentence initial position. She concluded that the parser keeps track of case marking information

³⁵ See Koh 1997 for similar evidence from Korean, and Bader and Lasser 1994 for German, both of which place a verb sentence-finally in an embedded clause.

(regardless of the NP order) and uses it to make structural decisions about a sentence without waiting for the verb.

Although this study provides evidence for the active use of case marking information during processing, Yamashita's findings do not necessarily exclude Prichett's (1991) head-driven parser. Prichett's model predicts that a ditransitive verb would be responded to faster because the argument structure of the verb is 'maximally satisfied' when structural decisions are made when the verb is encountered (1991:252-3). In order to determine whether or not parsing decisions are made prior to a head (i.e., a verb), we need more direct evidence that shows that processing differences occur locally (i.e., prior to the verb).

Kamide and Mitchell (1999) tested sentences with the configuration shown in (25a). An actual sentence example is in (25b) with two possible interpretations in (25c) and (25d).

(25) a. NP-nom NP-dat NP-nom V1-ditra Adj NP-acc V2-ditra

b. Kyooju-ga gakusee-ni toshokanshisho-ga kashita mezurashii
professor-NOM student-DAT librarian-NOM lent unusual
komonjo-o miseta.
ancient-manuscript-ACC showed

c. High attachment: NP-nom **NP-dat** [NP-nom V1-ditra] Adj NP-acc V2-ditra

High attachment reading: 'the professor showed the student the unusual ancient manuscript which the librarian had lent'

d. Low attachment: NP-nom [**NP-dat** NP-nom V1-ditra] Adj NP-acc V2-ditra

Low attachment reading: 'the professor showed the unusual ancient manuscript which the librarian had lent the student'

The sentence is globally ambiguous in that the grammar itself does not specify either interpretation. The underlined dative NP, which is always optional for Japanese ditransitive verbs (Kamide & Mitchell 1999:640), can be attached to either an embedded ditransitive verb ('lent') (giving a low attachment reading) or a matrix ditransitive verb ('showed') (giving a high attachment reading). An incremental pre-head parsing model predicts that high attachment is preferred throughout the sentence. This is because as soon as the first NP appears, the parser projects the highest possible level sentence node and attaches both nominative NP and dative NP to the forthcoming predicate of that node (p.635). Since this initial analysis remains unchanged, the preference for high attachment is obtained. On the other hand, a head-driven delayed model predicts that an attachment preference will split. According to this model, the first attachment decision is made at the embedded verb. Since this verb's argument structure must be maximally satisfied, the dative NP is attached to the embedded ditransitive verb. At the sentence-final verb, which is also ditransitive, the same principle (satisfying argument structure maximally) applies. Then, both high and low attachments compete with each other, resulting in 50/50 split attachment decisions. The results of a self-paced reading experiment supported the prediction of the incremental pre-head model. The sentence final verb was read faster when it was ditransitive than when it was transitive, while at the embedded verb, the reading times of ditransitive and transitive verbs did not differ. This study suggests that an attachment decision of a dative NP to the matrix verb is made prior to the matrix verb. When the matrix verb is unexpectedly transitive, processing load increases.

Another piece of evidence for incremental parsing (i.e., parsing decisions made prior to a verb) comes from Miyamoto (2002). In one experiment, he compared sentences with configurations shown in (26a) and (26b). Actual sentences are given in (26c) and (26d) respectively.

(26) a. Ambiguous relative clause (ARC)

| | | | | | | | |
|-----|--------|--------|--------|----|--------|-----|-------------------|
| w1 | w2 | w3 | w4 | w5 | w6 | w7 | w8 |
| Adv | NP-NOM | NP-DAT | NP-ACC | V | NP-ACC | Adv | V _{main} |

b. Double accusative sentence (DA)

| | | | | | | | |
|-----|--------|--------|--------|----|--------|-----|-------------------|
| w1 | w2 | w3 | w4 | w5 | w6 | w7 | w8 |
| Adv | NP-NOM | NP-ACC | NP-ACC | V | NP-DAT | Adv | V _{main} |

- c. Ofisu-de shokuin-ga kakarichoo-ni ocha-o dashita josei-o teineini
office-at employee-NOM manager-DAT tea-ACC served woman-ACC politely
shoukaishita.
introduced
‘At the office, the employee politely introduced the woman who served the tea to the manager.’
- d. Ofisu-de shokuin-ga kakarichoo-o ocha-o dashita josei-ni teineini
office-at employee-NOM manager-ACC tea-ACC served woman-DAT politely
shoukaishita.
introduced
‘At the office, the employee politely introduced the manager to the woman who served the tea.’

Assuming that Japanese readers build a structure incrementally based on case marking information, Miyamoto made the following predictions. In sentence (a), the first three NPs (w2-w4) are initially construed as arguments of a single clause. At w6, the appearance of another NP indicates that the initial single-clause analysis is incorrect and a relative clause has to be built. This results in longer reading times at this position. For

sentence (b), as soon as readers reach w4 (the second accusative NP in the fragment), the parser will insert a clause boundary between w3 and w4 since no verbs in Japanese take two accusative marked arguments (known as double-*o* constraint). Inserting a clause boundary requires an extra processing cost, and thus longer reading times will be expected at w4.³⁶ Since this clause boundary insertion gives the parser an earlier clue that the sentence contains more than one clause, there will be no detectable surprise when the relative clause head (another signal for an embedded clause) is encountered at w6. Word-by-word reading times supported these predictions. Miyamoto concluded that case marking information is used not only to assemble words into a structure prior to the verb but also to generate predictions about the incoming string. (See Miyamoto et al 1999 for more evidence for a pre-head attachment decision observed in RCs with multiple attachment sites.)

In summary, empirical evidence has shown that the Japanese parser does not wait for a clause final verb to appear, but makes active use of case marking information to develop predictions about upcoming words. For example, a sentence-initial sequence of case marked NPs (NP-nom NP-dat NP-acc) is initially analyzed as clausemates and the appearance of a ditransitive verb is predicted (e.g., Inoue & Fodor 1995, Mazuka 1991, Miyamoto 2002). Case marking also signals the presence of a clause boundary (Miyamoto 2002). For instance, when a sequence of two accusative marked NPs is

³⁶ Longer reading times at w4 in sentence (b) were not due to the sequence of NPs with identical case marking, but due to the insertion of a clause boundary. In order to tease apart the two possibilities, this experiment included another condition (c) which had the configuration [Adv NP-acc NP-nom NP-acc V ...]. Note that this condition no longer has a sequence of accusative marked NPs. Longer reading times were observed at word 4 in both (b) and (c) conditions, which indicates that the increased reading times were due to the insertion of a clause boundary.

detected, the parser immediately inserts a clause boundary without waiting for confirmation from the verb.

3.2.2 Filler-gap dependencies in Japanese

The previous section showed that despite strict head finality, Japanese sentence processing is very similar to that of English. Sentences are processed in a highly incremental fashion. People assign a tentative structure to an incoming word based on case marking information and develop certain expectation about the incoming words.³⁷

A question arises as to whether filler-gap dependencies in Japanese are processed in a similar manner to English. As noted by many researchers (e.g., Hawkins 1999, Hirose 1999, Yamashita, Stowe, & Nakayama 1993), there are typological and grammatical characteristics of Japanese that make the processing of this construction very difficult (as compared to English). In English, a filler precedes a gap. In particular, fillers in structurally salient positions (e.g., *wh*-phrases and relative pronouns in non-argument positions) signal to the parser that a gap is needed, and the occurrence of a gap is therefore anticipated. The position of a gap can also be signaled by certain syntactic cues, such as the form of a relative pronoun (e.g., *whom* indicates that a gap will be found in an object position). By contrast, in Japanese, a gap precedes its filler. If the gap comes first, it should be harder to recognize and there may be considerable backtracking when the filler is encountered (Hawkins 1999:273). Furthermore, there is no morphosyntactic cue that signals the exact position and the role of a relative clause gap

³⁷ For the use of information other than case marking, see Hirose (1999) and Nagai (1995).

(Hirose and Inoue 1998:73). Frequent occurrence of pro-drop (implicit arguments) also makes the detection of an appropriate gap more difficult. These differences seem to suggest that very different strategies may be involved in the processing of gaps in Japanese.

The sections that follow provide an overview of the processing of filler-gap dependencies. Three major issues are of particular concern here: (1) whether or not there is any observable effect associated with the postulation of a gap in Japanese, (2) at which point in a sentence a gap is recognized and a filler-gap dependency is formed, and (3) whether or not there is a subject-gap advantage in the processing of Japanese relative clauses.

3.2.2.1 Postulation of gaps

Early studies on the processing of gaps failed to provide consistent evidence for processing difficulty in postulating a gap. For example, Mazuka et al. (1989, reported in Mazuka 1991) found no evidence for processing cost involved in reanalysis with gaps. They examined different types of garden-path complex sentences in which the parser fails to detect a gap initially and inserts it later after reanalysis. For example, they compared the following sentences.

(27) a. Subject-gap center-embedded RC [Mazuka 1991:223-225]

Roojin-ga [e_i kodomo-o yonda] josee_i to hanashi-o shita.
old man-NOM child-ACC called woman with talk-ACC did
'An old man talked with a woman who called the child.'

b. Object-gap center-embedded RC

Hiroshi-ga [Masao-ga e_i katta] pan_i-o tabeta.
Hiroshi-NOM Masao-NOM bought bread-ACC ate
'Hiroshi ate the bread Masao bought.'

In sentence (27a), the sequence <NP-nom NP-acc V> is initially understood as a simple transitive clause without a gap. When the following NP ('woman') is encountered, Japanese readers recognize that this NP is the head noun of a relative clause, and insert a gap in the subject position of the relative clause. According to Mazuka et al., this is a typical case of 'failing to detect a gap and inserting it later with reanalysis'. Sentence (27b), on the other hand, does not require reanalysis. The first verb ('bought') indicates that the two nominative NPs cannot be the co-arguments of the verb and thus must belong to different clauses. Since the direct object is missing in a sequence <Masao-nom bought>, a gap is inserted in the object position of the embedded clause. Mazuka et al. found no total reading time differences between these two sentences. Taken together with other results of this sort, they concluded that failing to detect a gap initially and inserting it later with reanalysis of the embedded subject is not associated with processing cost. It was suggested that postulating gaps in Japanese is 'post-initial-stage processing', that is, gaps are not recognized during the initial stage of processing (p.230).

However, other explanations are possible for the absence of reading time differences between (27a) and (27b). First, lexical items were not matched between the two sentences. Therefore, the absence of predicted difference could be simply due to different lexical items and/or plausibility difference between the sentences. Second, even if center-embedded object-gap RCs (e.g., sentence (27b)) may not involve reanalysis, a

sequence of two nominative-marked NPs has been found to increase processing load, possibly due to insertion of a clause boundary (Miyamoto 2002), a similarity interference effect (Uehara 1997), the marked nature of the nominative case (Kuno 1973), and so forth. In fact, Nakamura (1999/2000) tested relative clauses equivalent to those in (27) and found that the local reading time increased at the second nominative-marked NP in (27b), while the increased reading time was observed at the head noun of (27a), suggesting the strong garden-path effect. Therefore, when only the overall reading time of a sentence is measured, it is possible that different types of processing difficulties in each sentence cancel out the overall difference between the sentences.

In Yamashita, Stowe, and Nakayama (1993), the processing of two different types of RCs as in (28) was investigated using a word-by-word self-paced reading task.

(28) a. Gapless relative clause³⁸ [Yamashita et al. 1993: 256]

Yokohama-de [kodomu-ga neshshinni shishuu-o utta] okane-ga
 Yokohama-at children-NOM ardently anthology-ACC sold money-NOM
 ‘In Yokohama, the money from the children’s selling of anthologies...’

b. Regular relative clause

Yokohama-de [kodomu-ga neshshinni machi-de e_i utta] shishuu_i-ga
 Yokohama-at children-NOM ardently town-at sold anthology-NOM
 ‘In Yokohama, the anthologies that the children sold in town...’

They found that the embedded verb of the regular RC (i.e., ‘sold’ in (28b)) was read more

³⁸ Gapless relative clauses are quite common in both spoken and written Japanese. In this construction, the head refers to the result of the action or event denoted by the relative clause (Yamashita et al. 1993:255).

i. [[kodomu-ga okashi-o katta] oturi
 child-NOM candy-ACC bought change
 ‘the money left after the child bought candy’

slowly than that of the gapless RC in (28a). The authors interpreted the results to mean that the parser makes use of the verb's argument information and immediately postulates a gap at this position. This produces an additional processing cost. For gapless RCs, on the other hand, significantly increased reading times were observed at the head noun.³⁹ This suggests that the parser initially analyzed the gapless RC as a simple clause (because there is no missing argument) and was surprised at the appearance of the head noun. The absence of a surprise effect at the head noun of the regular RC, on the other hand, suggests that a missing argument makes the reader expect a relative clause structure prior to the head noun. Yamashita et al. concluded that postulating a gap requires extra processing effort, and that verb argument information is utilized online in order to make a tentative decision about the syntactic structure that is currently being built.

Their study suggests an important fact about the processing of filler-gap dependencies in Japanese. A gap is posited relatively rapidly at the position where the parser recognizes that a gap is needed. In the case of regular RCs, this is the embedded verb position. As I summarized earlier, the Japanese parser conducts a structural analysis incrementally by making use of case marking information. It keeps track of both the number and the type of case marked NPs. At the embedded verb, the parser evaluates the verb's argument structure, and postulates a gap if there is any missing argument. Since postulating a gap entails a processing cost, an increased reading time is observed at the verb.

³⁹ In Yamashita et al. (1993), these effects were originally reported as appearing one word later. However, it was confirmed that there was in fact no delayed effect (Hiroko Yamashita 2003, personal communication).

Yamashita (1995) examined a similar set of sentences (gapless and regular RCs, plus adjunct RCs) and replicated the garden path effect, i.e., the increased reading time at the head noun of gapless and adjunct RCs. However, she found no processing cost associated with postulating a gap at the embedded verb of a regular RC. That is, there was no statistical difference in reading times between the embedded verb of the regular RC on the one hand and the embedded verb of the gapless and adjunct RCs on the other. Therefore, the evidence for a processing cost associated with postulating a gap has not been established yet.

One possible reason for these inconsistent findings may be the fact that unlike English in which the presence of a filler triggers an explicit gap-search process for the purpose of dependency formation, in Japanese positing a gap itself is not necessarily motivated by the formation of a filler-gap dependency. Since Japanese is a pro-drop language, a gap (an empty pronoun in GB terms) is posited whenever an argument is missing (Inoue 1991). Considering the high frequency of argument drop in everyday Japanese, it is less likely that the mere postulation of a gap incurs considerable and measurable processing cost. However, further investigation is needed to test how the expectation of a relative clause is formed prior to the appearance of the relative head and how the processing cost of postulating a gap is different from that of forming a dependency.

3.2.2.2 Processing of scrambled sentences

Recent studies on gap processing in Japanese have primarily focused on scrambled sentences. In Government and Binding Theory, scrambling is analyzed as

involving the movement of a constituent, creating a trace at its canonical position (e.g., Saito 1985). While earlier studies on scrambling failed to provide psycholinguistic support for processing difficulty (Nakayama 1995, Yamashita 1997), recent findings have suggested that scrambled sentences are associated with some processing cost. Furthermore, like English, factors such as a distance effect have also been shown to affect the processing of scrambled sentences in Japanese (e.g., Garnsey, Yamashita, Itoh, & McClure 2001, Mazuka, Itoh, Kondo 2002, Miyamoto and Takahashi 2001, 2002a,b, Ueno and Kluender 2003).

A piece of evidence that shows that scrambling involves creating a gap at the original position was obtained by a probe reactivation study conducted by Miyamoto and Takahashi (2002a). They conducted an end-of-sentence probe recognition task following a scrambled sentence with $\langle \text{NP}_i\text{-acc NP-nom } t_i \text{ V} \rangle$ order. Example sentences are shown in (29).

(29) a. Canonical condition

probe
↓

[Gakko-de mondai-o dashita] kooshi-**ga** mukuchina gakusei-o mita.
 school-at question-ACC asked lecturer-NOM quiet student-ACC saw
 ‘The lecturer who asked the question at school saw the quiet student.’

b. Scrambled condition

probe
↓

[Gakko-de mondai-o dashita] kooshi-**o** mukuchina gakusei-ga **e_i** mita.
 school-at question-ACC asked lecturer-ACC quiet student-NOM saw
 ‘The quiet student saw the lecturer who asked the question at school.’

In this task, the participants read a sentence in a word-by-word manner. At the end of each sentence, a probe word (e.g., *mondai* ‘question’) taken from an RC modifying a subject NP or a preposed object NP was presented for recognition. The underlying logic for this task is that the recognition to a word is faster when the word itself or its associate has been presented more recently. If the filler (i.e., the scrambled element) is assumed to be reactivated at the gap site, the recognition to the probe word should be faster following the scrambled sentence than following the canonical sentence. The prediction was borne out. The probe following scrambled sentence (29b) was recognized faster than the probe following canonical sentence (29a), which suggests that the antecedent is reactivated at the gap in scrambled sentences.

Miyamoto and Takahashi (2002b) also examined the processing of VP-internal scrambling, in which the accusative argument of a ditransitive verb is preposed in front of the dative argument.⁴⁰ The sample test sentences are schematically shown below (p.170).⁴¹

(30) a. Canonical

[_{CP} NP-nom [_{RC} NP-dat **NP-acc** ditransitive-V] NP-acc V-comp] NP-nom
report-V.

b. Scrambled

[_{CP} NP-nom [_{RC} NP_i-acc **NP-dat t_i** ditransitive-V] NP-acc V-comp] NP-nom
report-V.

⁴⁰ Miyamoto and Takahashi (2002b:169-170) discussed some advantages of VP-internal scrambling over the scrambling of a constituent (accusative or dative NP) over the nominative marked NP. First, the nominative marked NP may signal a clause boundary (Miyamoto 2002). Hence, any processing cost observed at the nominative NP position may not reflect scrambling, but insertion of a clause boundary. Second, both dative-accusative and accusative-dative orders are common in Japanese, thus frequency will be of less concern.

⁴¹ In the above schematic representations, I removed the gaps associated with the relative head nouns for simplicity.

The critical region of comparison is the NP in bold immediately preceding the ditransitive verb. The results of a self-paced reading experiment showed that the scrambled condition (30b) took significantly longer to read than the canonical condition (30a), suggesting the processing cost associated with postulating a gap and relating it with the moved NP-acc. No significant differences were found in any of the other regions, including at the ditransitive verb.

There are several implications that can be drawn from this study. First, if this syntactic analysis of scrambling is correct, the processing cost associated with scrambled sentences may provide crosslinguistic support that a sentence formed by a movement operation is structurally more complex and thus produces some processing difficulty (De Vincenzi 1996, Fodor 1978, Hawkins 1999, among others). Second, this study constitutes additional evidence for the incremental parsing of Japanese. Miyamoto and Takahashi explained that in VP-internal scrambling in Japanese (see (30b) above), the parser may not be able to detect a scrambled structure until the dative marked NP is reached. This is because without verb information, the sequence <NP-nom NP-acc> is more likely to be analyzed as a simple transitive clause (Inoue 1991, Inoue and Fodor 1995, Miyamoto 2002).⁴² At the dative NP, the parser constructs a tentative analysis that the sentence must be a ditransitive clause. By looking at the <NP-acc NP-dat> order, it also recognizes that it involves scrambling and inserts a gap at the position following the dative-marked NP. A gap is inserted at the first point at which the parser recognizes that

⁴² However, if this is the case, there is a possibility that the parser generates an expectation that a transitive verb should appear following the <NP-nom NP-acc> sequence. Then, the increased reading time at the NP-dat can be due to encountering an unexpected NP-dat instead of a transitive verb (Kazue Kanno 2003, personal communication).

a gap is necessary, and the processing consequence of this process shows up immediately (Miyamoto & Takahashi 2002b:175). The recognition of the need for a gap and the insertion of a gap take place simultaneously before the information from the verb becomes available (p.176).

In the same study, Miyamoto and Takahashi (2002b) further found that the distance effect between gap and filler is manifested in Japanese scrambled sentences. Recall that it has been shown in English that the longer the filler-gap dependency, the more difficult it is to process (e.g., Gibson 1998, 2000, Just & Carpenter 1992, King & Just 1991). (See section 3.1.4 in this chapter for a review.). In order to manipulate the distance factor, Miyamoto and Takahashi used the following sentence types.

(31) a. Canonical

[_{CP} NP-nom [_{RC} <1> NP-dat <2> **NP-acc** ditrans-V] NP-acc V-comp]
NP-nom...

b. Scrambled

[_{CP} NP-nom [_{RC} <1> NP_i-acc <2> **NP-dat** t_i ditrans-V] NP-acc V-comp]
NP-nom...

In order to make a long and short filler-gap distance condition for each sentence, a long phrase was inserted at either <1> or <2>. When inserted at <1>, it created short canonical and short scrambled conditions because the insertion of the phrase does not affect the filler-gap distance. When inserted at <2>, it created long canonical and long scrambled conditions because the distance between gap and filler becomes longer. The critical region of comparison is the NP in bold. Preliminary results showed that the long scrambling condition was read significantly more slowly than the short scrambling

condition in scrambled sentences, whereas there was no comparable difference between the long and short canonical conditions. This suggests that like English, the processing of filler-gap dependencies is influenced by the linear distance between gap and filler: the longer the distance between gap and filler, the more difficult it is to process.

Miyamoto and Takahashi (2001) argued that the processing phenomenon observed in filler-gap dependencies is best treated under a more general parsing principle, namely the locality constraint on the length of dependency, assumed by a memory-based account (Gibson 1998, 2000) outlined earlier. Unlike heuristic strategies such as the Active Filler Hypothesis (Frazier and Clifton 1989) and the Minimal Chain Principle (De Vincenzi 1991) that are specific to constructions with fillers preceding gaps (e.g., *wh*-phrases in English), the memory-based locality constraint can account for a wider range of dependency constructions with and without gaps. (See Gibson 1998, 2000 for a review.)

For example, Japanese *wh*-phrases appear in-situ and thus leave no traces. However, a *wh*-phrase requires a question particle (attached to the predicate) at the end of a clause. Miyamoto and Takahashi (2001) predicted that the dependency between *wh*-phrase and question particle (QP) should obey the locality requirement. That is, there should be a preference for a sentence in which the QP appears closer to the *wh*-word over a sentence in which the QP appears farther from the *wh*-word. The prediction was borne out in a self-paced reading experiment using materials shown below.

- (32) w1 w2 w3 w4 w5
 a. [NP-nom **WH**-acc V-comp] NP-nom V-**QP**?
 b. [NP-nom NP-acc V-comp] NP-nom V.
 c. [NP-nom **WH**-acc V-**QP**] NP-nom V-QP?
 d. [NP-nom NP-acc V-**QP**] NP-nom V.

Sentence (32c) is the short *wh*-word-QP distance condition and sentence (32a) is the long *wh*-word-QP distance condition. The third region (V-comp) of (a) was read more slowly than the same region of (b). This suggests that after reading a *wh*-word in (a), the parser built an expectation that a QP could appear at the first predicate position. Since this position was filled with a complementizer and not with a QP, the parser was surprised, resulting in increased reading time. On the other hand, the third region (V-QP) of (c) was read faster than that of (d). In (c), the expectation for the QP was met at the earliest position, thus the region was read without any difficulty. In (d), in contrast, since there was no *wh*-word in the preceding region, the QP was not expected. This also led to an increased reading time. Miyamoto and Takahashi suggested that forming a dependency (even without a gap) is constrained by the locality requirement, which further supports a view that dependency formation consumes working memory and thus is preferred to be completed as soon as possible whenever the opportunity arises.⁴³

⁴³ A processing similarity between English *wh*-questions (i.e., a filler-gap dependency) and Japanese *wh*-questions (i.e., *wh*-word and question particle dependency) was also observed in an ERP study conducted by Ueno and Kluender (2003).

3.2.2.3 Subject-object asymmetry

There is overwhelming evidence that suggests that subject-gap RCs are easier to process than object-gap RCs in English. However, very few studies have examined this issue in Japanese sentence processing. One of the earliest studies was the one conducted by Hakuta (1981) with Japanese-speaking children (from 3;3 to 6;2) using a traditional act-out task. In one of his experiments, the effect of gap was examined in left-branching RCs with an intransitive predicate in the matrix clause, as shown in (33).

- (33) a. Subject-gap RC: [e NP-acc V] NP-nom V.
 b. Object-gap RC: [NP-nom e V] NP-nom V.

Superior performance was obtained for object-gap RCs like (b) over subject-gap RCs like (a). The detailed analysis of responses revealed that children had problems comprehending an action expressed in the embedded clause of a subject-gap RC. The initial <NP-acc V> sequence was interpreted as agent-verb. Taken together with the results from his other experiments, he concluded that case marking plays a secondary role in the processing of complex clauses by children. It is the configuration factor that determines the relative difficulty of those sentences processed by Japanese children.

The results of Hakuta's study may imply a fundamental difference between children and adults in terms of the type of information used in sentence comprehension. Recall that Japanese adults make use of detailed knowledge about case marking in order to assign a structure to the input string. However, more recent acquisition studies with Japanese children (and Korean children as well) have shown that children in both languages prefer subject-gap RCs over object-gap RCs. (Cho 1999 for L1 Korean,

O'Grady, Yamashita, Lee, Choo, & Cho 2002 for L1 Japanese, cf. Clancy, Lee, & Zoh 1986)

To my knowledge, Sheldon's (1976) offline study was the first to examine the processing of Japanese RCs with an adult population. She asked 32 native speakers of Japanese to rank the relative difficulty of comprehending four types of RCs on a 4-point scale. The RCs differed from each other in terms of two factors – gap position and modifying position as shown below.

(34) a. SS (Subject-gap RC modifying the matrix subject)

[e_i Shojo-o tsukitobashita] otoko_i-wa shonen-o nagutta.
girl-ACC pushed away man-TOP boy-ACC hit
'The man that pushed away the girl hit the boy.'

b. SO (Object-gap RC modifying the matrix subject)

[Shojo-ga e_i tsukitobashita] otoko_i-wa shonen-o nagutta.
girl-NOM pushed away man-TOP boy-ACC hit
'The man that the girl pushed away hit the boy.'

c. OS (Subject-gap RC modifying the matrix object)

Otoko-wa [e_i shojo-o tsukitobashita] shonen_i-o nagutta.
man-TOP girl-ACC pushed away boy-ACC hit
'The man hit the boy that pushed away the girl.'

d. OO (Object-gap RC modifying the matrix object)

Otoko-wa [shojo-ga e_i tsukitobashita] shonen_i-o nagutta.
man-TOP girl-NOM pushed away boy-ACC hit
'The man hit the boy that the girl pushed away.'

The results showed the following difficulty ranking: SO > OO = SS > OS (from hardest to easiest). One major finding was that object-gap RCs (SO and OO) were judged to be

significantly more difficult than subject-gap RCs (SS and OS). This tendency was true, but even stronger, for English-speaking participants tested in the same study. The relative ranking judged by English speakers was SO=OO > SS > OS (from hardest to easiest), in which both object-gap RCs (SO and OO) were judged to be equally difficult. Another finding that was true for both Japanese- and English-speaking participants was that center-embedded RCs are not necessarily more difficult than non-center-embedded RCs. In Japanese, OS is center-embedded, but it was found to be the easiest. Likewise, in English, SS is center-embedded, but it was judged to be easier than OO, which is right-branching. Sheldon concluded that the NP accessibility hierarchy proposed by Keenan and Comrie (1977) seems to have some psychological reality. According to this hierarchy, subject is the position that is the most accessible to relativization. With respect to the stronger effect of object-gap disadvantage in English than in Japanese, Sheldon (1976) argued that the linear distance between gap and filler increases the memory load in English. That is, an object gap is farther from the filler than a subject gap in English.

Although offline judgments provide useful information about the relative difficulty of a structure, there are a few problems with Sheldon's study. First, the difficulty ranking of RCs may reflect a pragmatic, rather than structural, difference among the four sentences. For example, a fragment of the SO type had the meaning of 'the girl pushed away the man'. Similarly, a fragment of the OO type meant 'the girl pushed away the boy'. Both meanings are less plausible in my world knowledge, and in fact they were judged as the most and the second most difficult among Sheldon's participants. A plausibility pretest would be necessary in order to ensure that the

difficulty judgment was not due to plausibility difference but due to structural considerations. Second, Sheldon implied that the linear distance between gap and filler has a sort of additive effect in English. That is, the subject of a sentence is the least marked NP for relativization across languages. In the case of English, object-gap RCs are even more disadvantaged because of their linearity effect. However, she was not clear about how the NP accessibility and the filler-gap distance effect interact with each other when these two effects conflict such as in Japanese. In Japanese, linearity favors object-gap RCs, but the accessibility hierarchy favors subject-gap RCs. Overall, subject-gap RCs were easier than object-gap RCs, but the SS type (subject-gap RC) were not distinguishable from the OO type (object-gap RC). How and why the relative order (OS > OO = SS > SO) came out needs further investigation.

Abe, Hatasa, and Cowan (1988) also compared four types of RCs equivalent to those of Sheldon's study shown in (34).⁴⁴ In their first experiment, the overall reading time of each sentence and the response accuracy to end-of-sentence comprehension questions were examined.⁴⁵ The overall reading times did not differ across conditions. Comprehension accuracy, however, revealed a difference among the four conditions: OO > OS > SO > SS (from hardest to easiest). Both OS and OO are center-embedded RCs. The OS type contained a prototypical garden-path configuration (i.e., a sequence of NP-

⁴⁴ Although the authors used these labels (SS, SO, OS, and OO) to distinguish relative clauses, they did not conduct a 2×2 factorial analysis. They treated them as four conditions of a single factor (i.e. sentence type).

⁴⁵ In this study, the overall reading times are defined as the duration between the onset of the presentation of a sentence and the point at which the participants touched a box located on the lower left hand portion of the touch sensitive computer screen when they finish reading. Prior to the end-of-sentence comprehension question, there was another task in order to control a possible ceiling effect. In this task, the participants view three four-digit numbers and touch the one divisible by four (p.82).

nom NP-acc V), while OO involved a sequence of stacked NPs. The authors argued that garden path sentences and sentences with stacked constituents are a source of complexity, and that the latter is harder to resolve than the former. In terms of the gap difference, they did not provide any explanation as to why SS (subject-gap RC) was easier to comprehend than SO (object-gap RC).⁴⁶

Overall, findings of some acquisition studies and studies with an adult population (Abe et al. 1988, Sheldon 1976) point to a possible subject-gap advantage in left-branching RCs (where no extraneous factors are involved) in head final languages. However, all of these previous studies on Japanese RCs were based on offline measurements. In order to test whether a subject-object gap asymmetry is in fact a result of online processes of gap detection and filler-gap dependency resolution, it is necessary to examine the time course of processing those sentences. If so, the difference should appear at the position where the parser recognizes an RC structure and resolves a filler-gap dependency.

In order to obtain more direct evidence for the online processing of gaps, Nakamura (1999/2000) examined Japanese relative clauses in a word-by-word self-paced reading experiment. The test sentences used in this study were comparable to those in

⁴⁶ In their second experiment, both matrix and embedded verbs were changed to ditransitive verbs. Therefore, the test sentences had nine conditions – three gap positions (subject, direct object and indirect object) crossed with three modifying positions (matrix subject, matrix direct object, and matrix indirect object). However, since the authors did not treat gap as a single factor, the relative difficulty in terms of gap positions is unknown. The authors also manipulated case marking on the head noun (nominative *-ga* vs. topic *-wa*) in both experiments. They did not find any effect in the first experiment, whereas there was a main effect of case marking in the second experiment. Relative clauses whose head nouns had a topic marker were read faster than the sentences whose head nouns had a nominative marker. The authors argued that *-wa* is easier since it only marks the matrix subject, while *-ga* can mark both the matrix and the embedded subject.

Abe et al. (1988) and Sheldon (1976) as in (34). Each sentence consisted of five words and differed in terms of two factors – gap position and modifying position. As reported in Abe et al. (1988), the OS type (NP-nom [NP-acc V] NP-nom) showed a strong garden-path effect. Reading time of the head noun was much longer in the OS type (center-embedded subject gap, mean = 1739ms) than in OO type (center-embedded object gap, mean = 1336ms). This suggests that the Japanese readers initially interpreted the sequence <NP-nom NP-acc V> as a simple clause, and was surprised at the appearance of an unexpected noun. With regard to the gap effect, reading time of the head noun was numerically longer in an object-gap RC (SO type, mean = 1336ms) than in a subject-gap RC (SS type, mean = 1260ms), suggestive of a potential gap difference, but the difference did not reach significance.⁴⁷ No gap difference was found in any other regions. Aside from the gap difference, one interesting observation was that people spent more time at the head noun of RCs of both SS and SO types. Given that the parser recognizes an RC and forms a dependency at the head, the increased reading time at the head position seems to reflect the processing cost associated with these two processes, consistent with the scrambling results in Miyamoto and Takahashi (2002b).

Some methodological problems in Nakamura's study need to be mentioned. First, each sentence had a different set of lexical items. Without controlling lexical items, it is difficult to determine whether the absence of a gap effect could truly reflect the nature of the position of a gap or something else (e.g., lexical frequency and/or plausibility of a

⁴⁷ In Kanno and Nakamura (2001), a similar pattern was obtained. There was no gap asymmetry for adult native speakers of Japanese, although the subject-gap advantage was found for English native speakers learning Japanese as a second language.

sentence). Second, as Nakamura pointed out, the test sentences may have been too easy for any subtle gap effect (if one exists) to manifest itself in online processing by adult native speakers. It was suggested that processing demands needed to be increased, such as by inserting additional words or introducing an additional task.

To summarize, in contrast to overwhelming evidence for a preference for subject-gap RCs over object-gap RCs in English, evidence for the subject-object asymmetry in head-final languages is weak and less consistent. Subject gap RCs were found to be easier than object-gap RCs in end-of-sentence comprehension questions (Abe et al. 1988) and an offline sentence difficulty rating study (Sheldon 1976), while reading time results did not reveal a reliable difference, as measured by total reading times (Abe et al. 1988) or by word-by-word reading times (Nakamura 1999/2000). However, it seems too early to conclude that there is no gap asymmetry in head-final languages. First, the offline studies gave some evidence for the native speaker's intuitive preference for subject-gap RCs over object-gap RCs. Second, the reading studies outlined above may not constitute strong evidence for the absence of asymmetry because of methodological problems (e.g., a confound of case marking on the head noun, no plausibility and lexical control, a possible ceiling effect due to too easy experimental materials, etc.). A final conclusion about this issue needs to wait for further studies that refine the methodology and overcome the confounds of previous studies.

3.3 Conclusion

This chapter reviewed major findings and issues involved in studies of filler-gap dependencies in English and Japanese. Despite the apparent typological differences

between these two languages, empirical findings have shown that parsing proceeds incrementally and filler-gap dependencies are processed in an efficient fashion guided by the grammar of the language. For example, when the parser recognizes that a filler-gap dependency must be formed, a gap is inserted at the earliest possible position in the structure. In English, the presence of a *wh*-word in sentence initial position triggers an expectation that a gap must be found in order to form a dependency. Then, a gap is inserted as soon as a grammatically licensed gap position is reached (e.g., the subject or direct object of a sentence). When an overt lexical item is found at that position, processing speed slows down, reflecting the parser's attempted reanalysis. In Japanese, the parser actively uses the case marking information to build a structure and to form an expectation about the upcoming words. Processing difficulty is observed at the earliest point in a sentence at which the parser recognizes that a clause boundary is necessary, a gap needs to be postulated, and/or a filler-gap dependency has to be formed.

Among the issues involved in the processing of filler-gap dependencies, there is one issue for which Japanese lacks empirical evidence comparable to that of English. Extensive research has shown that subject-gap RCs are easier to process than object-gap RCs in English. However, the results of previous studies on this topic are far from conclusive for Japanese, especially in the field of adult sentence processing. Although it is possible that the lack of equivalent findings is attributed to syntactic differences in the RC constructions between the two languages, the problem may lie in the methodologies and the designs of the previous studies. The next two chapters will report on the studies

in which subject-object gap asymmetry and some related issues are investigated in the processing of Japanese RCs.

CHAPTER 4

PROCESSING OF SINGLE-GAP RELATIVE CLAUSES

This chapter will report on two self-paced reading experiments that investigated the processing of Japanese single-gap relative clauses (SGRCs).⁴⁸ The primary goal of the study was to collect empirical data on the issue of a subject-object gap asymmetry. In particular, this study tested in Japanese the predictions of two distance metrics that have been put forward to account for findings on English RCs.

The two distance metrics differ in terms of the way they define the length of a dependency between gap and filler as shown in (1) and (2).

- (1) The Linear Distance Hypothesis (Gibson 1998, 2000)

Count the number of words/new discourse referents intervening between gap and filler. The more words intervening, the more difficult the processing.

- (2) The Structural Distance Hypothesis (O'Grady 1997:136)

A structure's complexity increases with the number of XP categories (S, VP, etc.) between a gap and the element with which it is associated.

In the case of English RCs, the subject gap is closer to the filler both linearly and structurally. Therefore, these two metrics make the same prediction for English RCs, namely, the ease of subject-gap RCs. However, the two metrics diverge in their

⁴⁸ SGRCs are those in which one of the argument positions (subject or direct object) of a transitive clause is relativized. Throughout this dissertation, the terms subject-gap RC and object-gap RC are used to refer to each type of RCs respectively.

predictions for Japanese, a head-final language with a prenominal RC. Consider the following Japanese RCs.⁴⁹

(3) a. Subject-gap RC

[_{IP} e_i [_{VP} Taro-o mita]] dansei_i-ga basu-ni notta.
Taro-ACC saw man-NOM bus-to got on
'The man who saw Taro got on the bus.'

b. Object-gap RC

[_{IP} Taro-ga [_{VP} e_i mita]] dansei_i-ga basu-ni notta.
Taro-NOM saw man-NOM bus-to got on
'The man who Taro saw got on the bus.'

When the number of words is counted, there are two words (*Taro-o* and *mita*) intervening between the subject gap and its filler, while only one word (*mita*) intervenes between the object gap and its filler. Therefore, the Linear Distance Hypothesis predicts that object-gap RCs are easier to process than subject-gap RCs in Japanese. On the other hand, when structural distance is considered, the subject gap is closer to the filler than the object gap since there is an extra VP node intervening between the object gap and filler. Therefore, the Structural Distance Hypothesis predicts that subject-gap RCs are easier to process than object-gap RCs not only in English but also in Japanese.

For both distance metrics, the predicted difference between subject-gap and object-gap RCs is assumed to appear at the filler position. Recall that the filler is the position at which the parser recognizes an RC structure and resolves the filler-gap

⁴⁹ As Japanese is very ambiguous, a sentence could be analyzed in more than one way. However, I assume that the RC analysis given in (3a) and (3b) is the simplest analysis and the most plausible interpretation without specific contexts.

dependency. If there is a difference in processing cost associated with the type of RC, the effect should appear at the head noun.

Since it is possible that the test sentences used in Experiment 1 are relatively easy for adult native speakers of Japanese to process, a secondary task was administered during half of the session for each participant.⁵⁰ In one condition – the single task condition – the participant read the sentences silently. In another condition – the dual task condition – the participant read the sentences while articulating a nonsense syllable (*ru* or *ne*) loudly. Assuming that there is only a single resource pool available for conducting various cognitive tasks (Just & Carpenter 1992), any additional task concurrent with the primary processing task is assumed to compete for the limited set of resources. Tasks such as remembering a string of digits or articulating nonsense syllables have been found to impose an additional demand on working memory (Baddeley 1986). Therefore, the dual task condition should tax the participants' effective working memory during processing, so that a possible ceiling effect due to relatively easy test sentences will be avoided. In order to see whether the main effect of gap type (i.e., a subject-object gap asymmetry) would be modulated by the reading task, Experiment 1 included both single-task and dual-task conditions. If there was a subject-object gap difference, the effect would appear in a more demanding task such as the dual task condition than under less demanding conditions, or that the magnitude of the difference would become greater in the dual task condition than in the single task condition.

⁵⁰ Recall that no asymmetry was found in Nakamura's (1999/2000) processing study on Japanese relative clauses. It was pointed out that the test sentences used may have been too easy for adult native speakers.

Experiment 2 tested the effect of grammatical relation of the head noun on the subject-object gap asymmetry. Previous studies on the processing of RCs have shown that a match/mismatch of grammatical/case relations of gap and filler influences the processing of RCs (MacWhinney 1977, MacWhinney 1982, MacWhinney & Pléh 1988, Sheldon 1974, 1977, Sauerland & Gibson 1998). For example, Sheldon (1974) found that young English-speaking children comprehended RCs better when the grammatical function of gap and filler coincided (the parallel function strategy). MacWhinney's (1977) perspective shift argued that people make use of perspective when constructing an interpretation of the clause in sentence. The starting point is the subject of the clause, and shifting the perspective from the subject to another entity requires computational resources. Therefore, a subject-gap RC modifying the matrix subject is the easiest to process since there is no perspective shift required in the processing of this structure. Sauerland and Gibson (1998) proposed the case-matching hypothesis which states that RCs are preferably attached to NPs whose case matches that of the relative pronoun (cf. Hemforth, Konieczny, Seelig, & Walter 2000).

In order to test this possibility, Experiment 2 manipulated the grammatical relation of the head noun. The head noun of an RC had an either topic, nominative, or accusative marker. If the gap asymmetry is independent of the grammatical relation of the head noun within the matrix clause, the difference between a subject gap and an object gap should appear consistently across the conditions. On the other hand, if the gap asymmetry is modulated by the role of the head noun, there should be an interaction of gap and grammatical relation. For example, the magnitude of the gap asymmetry could

differ across conditions. A word-by-word self-paced reading task allowed us examination of the time course of this match/mismatch effect and the strength of the effect relative to that of a gap asymmetry.

4.1 Experiment 1

This experiment tested the predictions of two filler-gap distance metrics in the processing of Japanese RCs. The Linear Distance Hypothesis (Gibson 1998, 2000) predicts that object-gap RCs are easier to process than subject-gap RCs. The Structural Distance Hypothesis (O'Grady 1997) predicts that subject-gap RCs are easier than object-gap RCs. The critical region of comparison is the head noun of the RC, at which the parser is assumed to recognize that an RC structure is involved and to resolve the filler-gap dependency.

If there is a subject-object gap asymmetry, the effect is predicted to appear in the more demanding condition (i.e., the dual-task condition) but not in the less demanding condition (i.e., the single-task condition). Alternatively, it is predicted that the effect might appear in both conditions, but that the magnitude would be greater in the dual task condition than in the single task condition.

4.1.1 Method

4.1.1.1 Participants

Twenty-four native speakers of Japanese were paid for their participation in the experiment. They were graduate students at the Nara Institute of Science and

Technology (NAIST) in Japan and people from the surrounding community. All participants had normal vision and were naïve to the purpose of the experiment.

4.1.1.2 Materials

Thirty-two sets of test sentences were constructed for the experiment. Each set contained two RCs that differed in gap position. An example is given in (4).

(4) a. Subject-gap relative clause

[_{RC} e_i toshiyori-no obaasan-o basutei-made miokutta] onnanoko_i-wa
 elderly-GEN old-woman-ACC bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

b. Object-gap relative clause

[_{RC} toshiyori-no obaasan-ga e_i basutei-made miokutta] onnanoko_i-wa
 elderly-GEN old-woman-NOM bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who the old woman walked to the bus stop was holding a stuffed animal.'

In the subject gap condition, the filler *onnanoko* ‘the girl’ is associated with a gap in the subject position of an RC, while in the object gap condition, the filler is associated with a gap in the direct object position. The two sentences were identical except for the case marking on the NP (‘elderly woman’) within the RC: the NP in a subject-gap RC has an accusative marker (-o) and the NP in an object-gap RC has a nominative marker (-ga). In both conditions, the RC modified the topicalized subject of the matrix clause, as indicated by the topic marker -wa. The rest of the sentence consisted of the matrix object NP and

the transitive predicate. The complete list of test sentences used in this experiment is provided in Appendix D.

These thirty-two sets of test sentences were distributed into two lists (List A and List B) using a Latin square method. In this way, each participant, who was assigned to either one of the lists, read only one of the two conditions for each set, and overall read the same number of sentences from each condition (i.e., 16 subject-gap RCs and 16 object-gap RCs per participant).

Each list was further divided into two blocks. Each participant read one of the blocks under the single task condition and the other block under the dual task condition. The assignment to a list and a block and the order of the tasks were counterbalanced across participants. The following shows a summary of the lists prepared for the experiment.

Table 4.1. Presentation Lists for Experiment 1.

| List | First session | Second session |
|------|------------------------------------|------------------------------------|
| 1 | Dual task, List A (first block) | Single task, List A (second block) |
| 2 | Dual task, List A (second block) | Single task, List A (first block) |
| 3 | Single task, List A (first block) | Dual task, List A (second block) |
| 4 | Single task List A (second block) | Dual task, List A (first block) |
| 5 | Dual task, List B (first block) | Single task, List B (second block) |
| 6 | Dual task, List B (second block) | Single task, List B (first block) |
| 7 | Single task, List B (first block) | Dual task, List B (second block) |
| 8 | Single task, List B (second block) | Dual task, List B (first block) |

Thirty-eight non-experimental sentences were added to each presentation list in a pseudo-random order, so that at least one non-experimental sentence intervened between any two test sentences. These non-experimental sentences were test sentences for other

unrelated experiments and varied in terms of their structures, which included passive sentences, sentences with scrambling, and RCs with attachment ambiguity.

4.1.1.3 Design

Experiment 1 was designed for a two-way ANOVA with repeated measures on the two independent variables – the Task type and the RC type. The Task type had two levels (single task and dual task) and the RC type had two levels (subject gap and object gap), creating a total of four conditions for this experiment. Note that the order of a task and the assignment to a list and a block were counterbalancing factors for the purpose of controlling the potential ordering effect. Therefore, these factors were collapsed in statistical analyses, maintaining only the two experimental factors (Task type and RC type). The dependent variables in this experiment were response accuracy (%) to comprehension questions and mean reading times at each region of a sentence (msec.). See Section 4.1.1.6 for more detailed description of how to calculate each dependent measure.

4.1.1.4 Pretest norming study 1

An offline survey was conducted in order to ensure that head nouns are equally plausible as a subject or a direct object of the embedded clause. First, each RC was transformed into a simple transitive sentence by placing the filler at its gap position within the RC. Such a transformation was necessary in order to remove any effect specific to the RC structure while preserving the propositional content and lexical items of the RC. Second, because the subject of a sentence in Japanese is commonly marked

not only with nominative *-ga* but also topic *-wa*, two versions were created with a different marker on the subject. The following sentences illustrate the four conditions crossing Marking on the subject NP (nominative vs. topic) and RC type prior to transformation (subject-gap vs. object-gap).

- (5) a. Simple sentence with nominative subject, transformed from a subject-gap RC

Onnanoko-**ga** toshiyori-no obaasan-o basutei-made miokutta.
 girl-NOM old-GEN old-woman-ACC bus-stop-to walked
 'The girl walked the old woman to the bus stop.'

- b. Simple sentence with nominative subject, transformed from an object-gap RC

Toshiyori-no obaasan-**ga** onnanoko-o basutei-made miokutta.
 old-GEN old-woman-NOM girl-ACC bus-stop-to walked
 'The old woman walked the girl to the bus stop.'

- c. Simple sentence with topic subject, transformed from a subject-gap RC

Onnanoko-**wa** toshiyori-no obaasan-o basutei-made miokutta.
 girl-TOP old-GEN old-woman-ACC bus-stop-to walked
 'The girl walked the old woman to the bus stop.'

- d. Simple sentence with topic subject, transformed from an object-gap RC

Toshiyori-no obaasan-**wa** onnanoko-o basutei-made miokutta.
 old-GEN old-woman-TOP girl-ACC bus-stop-to walked
 'The old woman walked the girl to the bus stop.'

Thirty-two sets of simple sentences were distributed to four presentation lists using a Latin square procedure.

Thirty-two graduate students at NAIST, who were participants in an unrelated online experiment, served as the participants for the survey. The survey involved a pencil-and-paper questionnaire, consisting of one page of instructions and three pages of

test items (10-11 sentences per page). The participants were asked to give each sentence an intuitive judgment on a 5-point scale from 1 (very natural) to 5 (very unnatural) according to how natural the meaning of each sentence was. All participants' data were used for data analysis.⁵¹

Table 4.2 shows the mean naturalness score for each condition.

Table 4.2. Pretest 1: Mean naturalness scores (1: very natural ~ 5: very unnatural).

| | Nominative marked subject | Topic marked subject |
|-------------|------------------------------|-------------------------|
| Subject gap | (a) 1.89 | (c) 1.59 |
| Object gap | (b) 1.77 | (d) 1.66 |

A two-way ANOVA with repeated measures was performed, treating Marking on the subject and RC type as within-participant (F_1) variables. A separate two-way ANOVA was also carried out, treating the two factors as within-item (F_2) variables. There was a significant main effect of Marking in both participant ($F_1(1,31)=7.519$, $p=.01$) and item ($F_2(1,31)=14.154$, $p=.001$) analyses. That is, sentences with a nominative-marked subject were consistently judged as less natural than those with a topic-marked subject. Neither the RC type nor the interaction of Marking and RC type reached significance (RC type: $F_1(1,31)=.222$, $p=.641$; $F_2(1,31)=.079$, $p=.781$; Interaction: $F_1(1,31)=3.149$, $p=.086$; $F_2(1,31)=2.304$, $p=.139$).

It is not entirely clear why sentences with a nominative-marked subject were rated as less natural than sentences with a topic-marked subject. It has been suggested that

⁵¹ The lists distributed to the first three participants contained only thirty test items (instead of 32 items). The additional two test items were added to the lists starting with the fourth participant.

nominative *-ga* is inherently more marked than topic *-wa* due to its multiple functionality (e.g., Inoue 1991, Miyamoto 2002, Yamashita 1997). However, crucially, the absence of a main effect of RC type confirmed that there was no plausibility difference between sentences in the subject-gap condition and sentences in the object-gap condition. That is, the head noun (e.g., *onnanoko* ‘girl’) was equally plausible as the subject and as the direct object of the types of clauses tested.

4.1.1.5 Procedure

Experiment 1 used a word-by-word self-paced reading task with a non-cumulative moving-window presentation (Just, Carpenter, & Woolley, 1982). It was controlled by the software PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) run on a Power Macintosh computer. A button-box, connected to the computer, was used as an input and timing device for the experiment.

Sentences were written in Japanese (kana and kanji) characters using 12-point Osaka Toohaba font. Each sentence was segmented in such a way that the entire relative clause was shown as a whole, followed by a word-by-word presentation of the rest of the sentence. A ‘word’ in this experiment refers to a *bunsetsu* unit which consists of a content word and a postposition or a case marker that is attached to the content word. The presentation of the whole RC region was intended to reduce the processing difficulty that was expected under the dual task condition. It was also intended to prevent participants from pressing buttons in accordance with their articulation of a nonsense syllable. The slashes in sentence (6) indicate the actual segmentation.

(6) Subject-gap relative clause (repeated from (4a))

/ Toshiyori-no obaasan-o basutei-made miokutta / onnanoko-wa /
elderly-GEN old-woman-ACC bus-stop-to walked girl-TOP
nuigurumi-o / daiteita. /
stuffed-animal-ACC holding
'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

The segmentation of non-experimental sentences was similar to that of test sentences.

Region 1 consisted of three to five *bunsetsu* units, which were presented as a whole, and the rest of the sentence was presented in a word-by-word fashion. Note that the end of Region 1 corresponded to the RC boundary in the test sentences but not in the non-experimental sentences.

Each participant was tested individually in a quiet room. The reading task began with the presentation of an entire sentence masked with dots. A group of dots corresponded to each region of a sentence, and the boundary between regions was indicated with a space. The participant's first pressing one of the three buttons (i.e., the leftmost button) on the button box replaced the dots of the first region with actual words, while the rest of the sentence remained dot-masked. The subsequent button press revealed the words of the second region, turning the words of the first region back into dots. The participant continued this process until the end of a sentence, which was marked by a period. When the participant finished reading the last word of a sentence, s/he pressed the button again, and this triggered the presentation of a comprehension question. The comprehension question asked about the content of either the relative clause or the matrix clause of the sentence just read. The participant answered questions by pressing either the middle button (if 'yes') or the rightmost button (if 'no'). The

number of correct ‘yes’ and ‘no’ answers was equal across experimental conditions, and no feedback was given to the participant’s answer. The pressing of a button in response to a comprehension question triggered the presentation of the next sentence.

In the single-task condition, the participant read sentences silently at a natural speed and answered comprehension questions silently as well. In the dual-task condition, the participant was asked to read sentences while articulating a syllable (*ru* or *ne*) loudly altered for each sentence. It was emphasized that the articulation of a syllable should start as soon as an entire dot-masked sentence appeared on the screen (before pressing any button) and continue till the end of the sentence except for a short stop for the purpose of breathing. When a comprehension question appeared, the participant was instructed to stop articulating the syllable so that s/he could read and answer the question silently.

All participants read sentences in both reading conditions. The order of reading tasks was counterbalanced across lists, and the two reading sessions were separated by a short break during which the participant was asked to fill out a demographic form. Each reading session was preceded by a written instruction presented on the computer screen and eight practice sentences.

4.1.1.6 Data analysis

The data from all twenty-four participants were used for the subsequent analysis. This was justified based on the response accuracy to the end-of-sentence comprehension questions, including both experimental and non-experimental sentences. The mean response accuracy of all participants was 82.5% (ranging from 59.7% to 98.7%) under

the dual-task condition, and was 89.0% (ranging from 69.1% to 98.7%) under the single-task condition. Although response accuracy of some individuals was relatively low, especially in the dual-task condition (e.g., 59.7% for one participant for the dual-task condition), none of the participants' mean accuracy (for both dual-task and single-task conditions) went below 69.8%. The overall response accuracy of all participants for both reading conditions was 85.7%.

Experiment 1 had two independent variables (Task type and RC type) and two dependent variables (response accuracy to the end-of-sentence comprehension questions and reading times). For response accuracy to the end-of-sentence comprehension questions, each condition's mean response accuracy (%) was calculated for each of the 24 participants. Then, these scores were thrown into a 2×2 ANOVA with repeated measures, treating both Task type and RC type as within-participant variables (F_1 , participant analysis). This was to examine how consistent the effects of the experimental factors were across participants. Each condition's mean response accuracy (%) was also calculated for each of the 32 items. Then, a separate 2×2 ANOVA with repeated measures was conducted, treating both Task type and RC type as within-item variables (F_2 , item analysis). This was aimed at examining the consistency of the effects across items.

A similar procedure was conducted for reading times. The computer recorded the interval of a participant's button presses, which was defined as the reading time of each region of a sentence. Each region-by-condition mean reading time was first calculated for each participant (participant analysis). Then, a 2×2 ANOVA with repeated measures

was conducted for each region, treating Task type and RC type as within-participant variables. Each region-by-condition mean reading time was also calculated for each item (item analysis), and then thrown into a 2x2 ANOVA with repeated measures, treating Task type and RC type as within-item variables. The critical region for comparison was the head noun of the relative clause, at which point the parser was assumed to recognize an RC structure and resolve the filler-gap dependency. No scores were eliminated from the analysis. Thus, the reading times presented below are untrimmed, raw reading times for each region.

For all two-way ANOVAs, when the interaction of two factors reached significance, subsequent analyses were conducted in order to examine the nature of the interaction.

4.1.2 Results

4.1.2.1 Comprehension questions

Table 4.3 and Figure 4.1 show the mean response accuracy to the end-of-sentence comprehension questions.

Table 4.3. Experiment 1: Mean response accuracy for comprehension questions.

| | Dual task | Single task |
|-------------|-----------|-------------|
| Subject gap | 88.2% | 93.9% |
| Object gap | 80.4% | 88.8% |

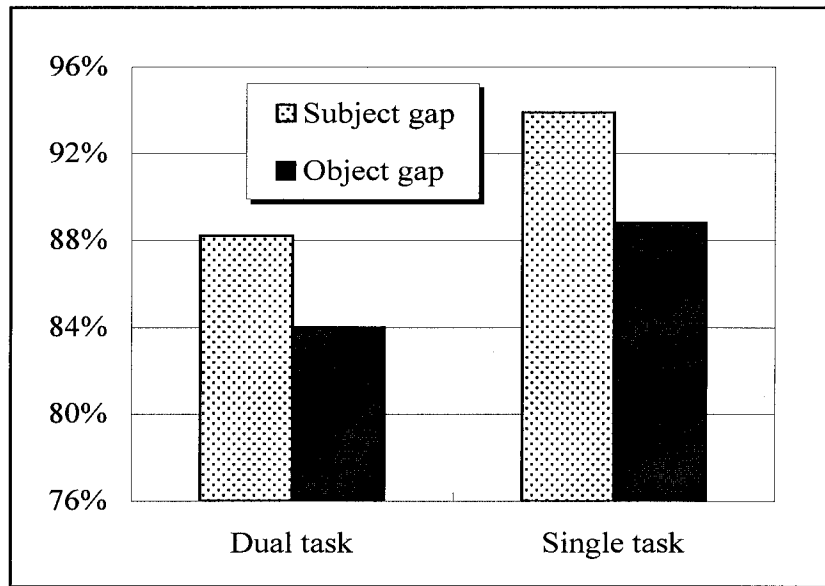


Figure 4.1. Experiment 1: Mean response accuracy for comprehension questions.

The mean response accuracy was higher in the single task condition (mean 91.3%) than in the dual task condition (mean is 84.3%), and the difference was significant for both the participant ($F_1(1,23)=7.183, p=.013$) and item ($F_2(1,31)=11.382, p=.002$) analyses. The correct response rate was also higher in the subject-gap condition (91.0%) than the object-gap condition (84.6%), and the difference was reliable for the participant analysis ($F_1(1,23)=18.543, p<.001$) but only marginally significant for the item analysis ($F_2(1,31)=3.845, p=.059$). The interaction of the Task type and the RC type did not reach significance ($F_1(1,23)=.300, p=.589; F_2(1,31)=.474, p=.486$). In sum, the results of comprehension questions found an advantage of subject-gap RCs over object-gap RCs, in both task types.

4.1.2.2 Reading times

Table 4.4 shows the untrimmed mean reading times in milliseconds for each region of the sentence.

Table 4.4. Experiment 1: Mean reading times (msec.).

| Task | RC type | Region 1 (RC) | Region 2 (head) | Region 3 (NP-acc) | Region 4 (verb) |
|-------------|-------------|------------------|--------------------|----------------------|--------------------|
| Dual task | Subject gap | 3884 | 1135 | 947 | 918 |
| | Object gap | 3687 | 1228 | 922 | 898 |
| Single task | Subject gap | 4034 | 1119 | 760 | 704 |
| | Object gap | 4028 | 1452 | 746 | 772 |

The reading time for the RC region (region 1) was numerically faster for the dual task condition than for the single task condition. The reading time was also numerically faster for the object gap condition than for the subject gap condition. However, neither of the main effects nor the interaction of Task type and RC type reached significance (Task type: $F_1(1,23)=.747$, $p=.397$; $F_2(1,31)=1.023$, $p=.320$; RC type: $F_1(1,23)=.449$, $p=.509$; $F_2(1,31)=.285$, $p=.597$; Interaction: ($F_1(1,23)=.198$, $p=.660$; $F_2(1,31)=.218$, $p=.644$). Therefore, only the reading times of the main clause region will be reported below.

Figure 4.2 shows the reading times of the main clause region (from region 2 to region 4).

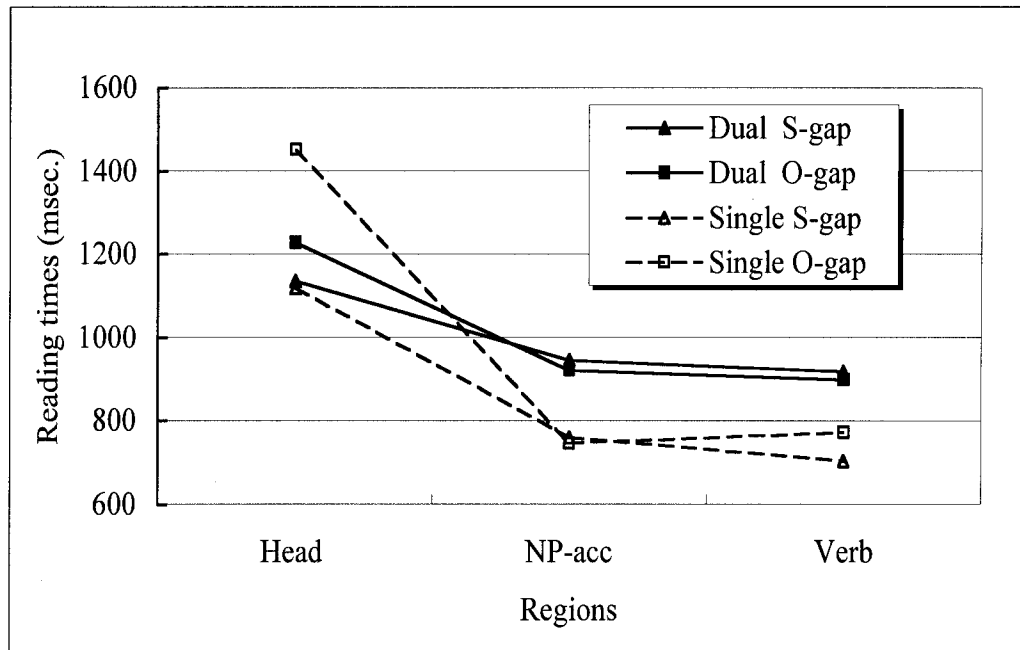


Figure 4.2. Experiment 1: Mean reading times of the main clause region (msec.).

For the head noun (region 2), the reading time was shorter for subject-gap RCs than for object-gap RCs, and the difference was statistically significant in both the participant analysis ($F_1(1,23)=6.165, p=.021$) and the item analysis ($F_2(1,31)=5.190, p=.030$). The main effect of Task type and the interaction of Task type and RC type did not reach significance (Task: $F_1(1,23)=.678, p=.419$; $F_2(1,31)=2.153, p=.152$; Interaction: $F_1(1,23)=3.241, p=.085$; $F_2(1,31)=2.398, p=.132$). The results suggest that subject-gap RCs were consistently easier to process than object-gap RCs regardless of task conditions.

For the following two regions (regions 3 and 4), only the main effect of Task type was found to be significant, as demonstrated by the longer reading times for the dual task condition than for the single task condition (Region 3: $F_1(1,23)=6.496, p=.018$; $F_2(1,31)=32.753, p<.001$); Region 4: $F_1(1,23)=5.863, p=.024$; $F_2(1,31)=22.202, p<.001$).

Neither the RC type nor the interaction of Task type and RC type showed reliable differences (Region 3, RC type: $F_1(1,23)=.420$, $p=.524$; $F_2(1,31)=.490$, $p=.489$; Interaction: $F_1(1,23)=.034$, $p=.856$; $F_2(1,31)=.015$, $p=.902$; Region 4, RC type: $F_1(1,23)=.559$, $p=.462$; $F_2(1,31)=.593$, $p=.447$; Interaction: $F_1(1,23)=2.340$, $p=.140$; $F_2(1,31)=1.011$, $p=.322$).

In summary, Experiment 1 showed superior performance for subject-gap RCs over object-gap RCs in both response accuracy to comprehension questions and reading times. This pattern was consistent regardless of the task condition (single task or dual task). Furthermore, as predicted, the gap difference appeared at the head noun of the RC. The results were consistent with the prediction proposed by the Structural Distance Hypothesis (O'Grady 1997).

4.1.3 Discussion

Experiment 1 investigated a subject-object gap asymmetry in the processing of Japanese RCs with special focus on testing two distance metrics. The Linear Distance Hypothesis predicted that object-gap RCs would be easier to process than subject-gap RCs since the object gap is linearly closer to the filler in Japanese. On the other hand, the Structural Distance Hypothesis predicted that subject-gap RCs would be easier since the subject position is higher than the direct object position in the tree structure and thus structurally closer to the filler. The results of Experiment 1 support the Structural Distance Hypothesis. In both response accuracy to comprehension questions and reading time data, the performance on the subject-gap RC was superior to the performance on the object-gap RC, whether participants read sentences with or without a concurrent task.

Furthermore, the time course of reading suggested that the effect associated with resolving a filler-gap dependency is immediate. The difference appeared at the head noun of an RC, at which the parser is assumed to recognize the RC structure and resolve the filler-gap dependency.

Experiment 1 also manipulated reading conditions by adding a concurrent task so that the comprehension of a sentence becomes more demanding. In the single task condition, participants read sentences silently, while in the dual task condition, they read sentences while concurrently articulating a nonsense syllable. In general, the addition of a secondary task led to weaker performance in reading. Response accuracy to the end-of-sentence comprehension question was lower for the dual task than for the single task. Reading times in the regions immediately following the head noun of an RC were longer in the dual task condition than in the single task condition.

However, there were several findings that are not very clear. First, although the difference was not statistically significant, the whole RC region (i.e., region 1) was read faster in the dual task condition than in the single task condition. Given that performing a secondary task is expected to increase the overall working memory demand during processing, this result was counterintuitive. Second, there was no interaction of RC type and Task type at the head noun. In other words, object-gap RCs were more difficult than subject-gap RCs at the head, and the magnitude of the asymmetry was not statistically different between the two reading conditions.

For the first finding (faster reading times in the RC region in the dual task condition than in the single task condition), it is possible that because of the increased

processing demand and less attentional resources, participants moved rather quickly through the beginning of a sentence and started to conduct major structural analyses toward the end of the sentence when sufficient information had accumulated. However, by the time they reached the end, the information from earlier regions had begun to decay and as a result the interpretation may not have been completed in all trials. Taken together with the weaker comprehension accuracy in the dual task condition, the results seem to indicate speed-accuracy trade-offs for the RC region – fast in performance and as a result low in accuracy.

The second finding (the absence of Task type×RC type interaction at the head noun) suggests that the effect of introducing an additional task and the effect of processing gaps may be more or less independent from each other. One possibility is that these effects tap different aspects of sentence comprehension. As reviewed in the previous chapter, there is a general consensus among psycholinguists that sentence comprehension involves two major tasks that consume working memory resources (e.g., Gibson 1998, Just & Carpenter 1992) – performing symbolic computations (‘integration’) and storing the partial products generated by computation (‘storage’). It may be the case that introducing an extraneous task, such as articulating a nonsense syllable, has a greater effect on the storage component than on the integration component of working memory, making remembering and retrieving information more difficult during processing. In contrast, processing gaps, which involves the identification of a gap and the resolution of a filler-gap dependency, is primarily a computational operation, and thus less sensitive to storage requirements.

A relatively intact effect of a concurrent task on the processing of gaps in Japanese may also be related to the fact that an RC structure is initially analyzed as a simple clause and thus no prediction needs to be held in working memory. Therefore, the integration process (i.e., the filler-gap dependency formation) that takes place at the head noun does not need to be modulated by a storage demand that may have been significantly affected by an additional task. Interestingly, it has been reported in English that an external memory load factor, such as recalling final words of sentences presented prior to the target sentence, modulates the processing of gaps (e.g., King & Just 1991). Since the early appearance of a filler triggers the prediction for a gap and the prediction is held in memory until a gap is found, it is reasonable to assume that the processing of gaps is affected by both the integration cost and the storage cost. However, further investigation is needed in order to test exactly what component of sentence comprehension is affected by different extraneous tasks.

To summarize, the results of Experiment 1 supported the Structural Distance Hypothesis. However, there is an alternative explanation for a subject-gap preference over an object gap. It has been reported that matching case/grammatical relations between gap and filler facilitates the processing of RCs (e.g., Sauerland & Gibson 1998, Sheldon 1974, 1977). In Experiment 1, the head noun of the RC had a topic marker. Since the topic marker most commonly marks the subject of a sentence, this parallelism may make the processing of subject-gap RCs easier. Experiment 2 examined in more detail whether or not the subject gap advantage found in Experiment 1 was simply due to the parallel function of gap and filler.

4.2 Experiment 2

Experiment 2 was an extension of Experiment 1, designed to replicate the gap asymmetry in a standard self-paced reading task. It was different from Experiment 1 in the following respects. Experiment 1 found that the effect of introducing a concurrent task is more or less independent from the effect of gap processing. Therefore, the task factor (single vs. dual task conditions) was not used in Experiment 2. All sentences were read silently. In addition, the RC portion of a sentence was presented one word at a time in Experiment 2. This allowed us to examine in more detail the time course of processing in the RC region.

In addition to the subject-object gap asymmetry, Experiment 2 examined the effect of grammatical relations of the head noun by manipulating the markers on the head noun – topic, nominative, and accusative.⁵² This was to test whether or not the subject gap advantage found in Experiment 1 was due to the parallel function between a gap and its filler. If a parallel relation between gap and filler is the key factor that determines the processing difficulty of RCs, this predicts that RCs with parallel relations between gap and filler will be easier to process than those with nonparallel relations between gap and filler. Specifically, subject-gap RCs should be easier to process than object gap RCs when the head noun has a nominative or topic marker. This would replicate Experiment

⁵² Note that the relationship between case relations and grammatical relations are not one-to-one. However, I assume that case marking is the primary information source that indicates grammatical relations in Japanese, and for most of the prototypical transitive verbs (such as those used in Experiment 2), the nominative *-ga* marks the subject and the accusative *-o* marks the direct object of a sentence. It should also be noted that topic is a discourse-related notion and that the topic marker itself does not specify any grammatical relation of a sentence. Therefore the correlation between a topic-marked NP and its grammatical function in a sentence needs to be investigated independently. Here, without any empirically supported justification, I assume that a human animate, topic-marked NP that appears sentence initially would be most naturally interpreted as the grammatical subject of a sentence.

1. More crucially, parallel function also predicts that object-gap RCs should be easier than subject-gap RCs when the head noun is accusative-marked. A crossover pattern across the head marking conditions, as indicated by an interaction of RC type and Marking on the head noun, should be observed.

On the other hand, if the RC type (subject gap or object gap) is the only significant factor that determines the processing difficulty of RCs, an asymmetry should be observed regardless of the marking of the head noun. A main effect of RC type with no interaction of RC type and Marking on the head noun would support this prediction. In terms of relative difficulty of RCs, Experiment 2 provides another test of the predictions of the two distance metrics – the Linear Distance Hypothesis and the Structural Distance Hypothesis. Since neither of these hypotheses makes predictions about the effect of grammatical relations of the head noun on RC processing, the same set of predictions applied to Experiment 2 as described in Experiment 1.

4.2.1 Method

4.2.1.1 Participants

Twenty-eight native speakers of Japanese participated in the experiment. They were graduate students at NAIST or people from the surrounding community. None of them participated in Experiment 1 or knew the purpose of the experiment.

4.2.1.2 Materials

Test sentences were constructed based on the thirty-two sets of subject-gap and object-gap RCs used for Experiment 1. For each of these RCs with the topic-marked

head, two additional versions were created – a sentence involving a nominative-marked head noun and a sentence involving an accusative-marked head noun. Crossing two main factors, Marking on the head noun (topic, nominative, and accusative) and RC type (subject-gap and object-gap), each set had the following six sentences types.

(7) a. Subject-gap RC with topic-marked head

[_{RC} _ toshiyori-no obaasan-o basutei-made miokutta] onnanoko-**wa**
 old-GEN old-woman-ACC bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

b. Object-gap RC with topic-marked head

[_{RC} Toshiyori-no obaasan-ga _ basutei-made miokutta] onnanoko-**wa**
 old-GEN old-woman-NOM bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who the old woman walked to the bus stop was holding a stuffed animal.'

c. Subject-gap RC with nominative-marked head

[_{RC} _ toshiyori-no obaasan-o basutei-made miokutta] onnanoko-**ga**
 old-GEN old-woman-ACC bus-stop-to walked girl-NOM
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

d. Object-gap RC with nominative-marked head

[_{RC} Toshiyori-no obaasan-ga _ basutei-made miokutta] onnanoko-**ga**
 old-GEN old-woman-NOM bus-stop-to walked girl-NOM
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who the old woman walked to the bus stop was holding a stuffed animal.'

e. Subject-gap RC with accusative-marked head

[_{RC} _ toshiyori-no obaasan-o _ basutei-made miokutta] onnanoko-o
old-GEN old-woman-ACC bus-stop-to walked girl-ACC
omawarisan-ga yobitomete.
policeman-NOM called-and-stopped
'A policeman stopped the girl who walked the old woman to the bus stop.'

f. Object-gap RC with accusative-marked head

[_{RC} Toshiyori-no obaasan-ga _ basutei-made miokutta] onnanoko-o
old-GEN old-woman-NOM bus-stop-to walked girl-ACC
omawarisan-ga yobitomete.
policeman-NOM called-and-stopped
'A policeman stopped the girl who the old woman walked to the bus stop.'

Sentences (a), (c), and (e) were subject-gap RCs, and sentences (b), (d), and (f) were object-gap RCs. Sentences (a) and (b) contained topic-marked head nouns. Sentences (c) and (d) contained nominative-marked head nouns. Sentences (e) and (f) contained accusative-marked head nouns. Up to the head noun, all six sentences involved identical lexical items except for the case marking (*-o* vs. *-ga*) on the NPs within the RC.

Lexical items following the head noun were identical between sentences with a topic-marked (*-wa*) head and sentences with a nominative-marked (*-ga*) head. In both types, the RC modified the subject of the matrix clause, and the rest of the sentence consisted of the direct object and the predicate of the matrix clause. In the accusative-marked condition, where the RC modified the fronted direct object of the matrix clause, the rest of the sentence consisted of the subject and the predicate of the matrix clause. Previous studies on scrambling in Japanese have shown that sentences with scrambled constituents are associated with processing cost, presumably due to the resolution of a

filler-gap dependency between the moved element and its gap (Mazuka, Itoh, Kondo 2002, Miyamoto & Takahashi 2002a,b). Therefore, it is possible that we would observe some processing difficulty at the matrix subject in the accusative condition (e.g., (7e) and (7f)), assuming that the parser recognizes the scrambling structure and resolves a dependency at that position.

Of the 32 sets of test sentences used for Experiment 1, two sets were removed in order to make six presentation lists. Those were the items whose scores in the pretest norming survey in Experiment 1 showed the largest difference between the subject-gap and the object-gap RC conditions within the nominative condition. This made the plausibility scores between the subject-gap and object-gap conditions more similar for Experiment 2 than for Experiment 1.

These 30 test sentences were distributed into six lists for presentation to participants. Sixty non-experimental sentences were added to each list in a pseudorandom manner, so that at least one filler sentence intervened between any two test sentences. A complete list of test sentences used for Experiment 2 is provided in Appendix E.

4.2.1.3 Design

Experiment 2 was designed for a two-way ANOVA with repeated measures on both of the two independent variables – Marking on the head noun and RC type. The first variable had three levels (topic vs. nominative vs. accusative) and the second independent variable had two levels (subject gap vs. object gap), creating a total of six conditions for the experiment. The dependent variables in this experiment were response

accuracy (%) to the end-of-sentence comprehension questions and reading times for each region of a sentence (msec.).

4.2.1.4 Procedure

Experiment 2 used a word-by-word self-paced reading task with non-cumulative moving window presentation. The procedure was identical to that of Experiment 1 except that in Experiment 2 the RC region was read in a word-by-word fashion and there was no secondary task concurrent with reading a sentence. All sentences were read silently. The following shows the segmentation of a test sentence.

(8) Subject-gap relative clause with topic marked head noun

/ Toshiyori-no / obaasan-o / basutei-made / miokutta / onnanoko-wa /
old-GEN old-woman-ACC bus-stop-to walked girl-TOP
nuigurumi-o / daiteita. /
stuffed-animal-ACC holding
'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

A comprehension question followed each sentence. The question asked about the content of either the relative clause or the matrix clause of a sentence. The participant answered the question by pressing the 'yes' or 'no' button on the button box. No feedback was provided for participant responses.

4.2.1.5 Data analysis

Data from four participants were discarded because of their low response accuracy (lower than 80%) on the end-of-sentence comprehension questions including both test and non-experimental sentences. Thus, the results reported in the following

section were based on the data from 24 participants. The overall mean response accuracy was 90.2% (ranging from 81.5% to 96.9%) after the removal of the four participants' data.

Experiment 2 had two independent variables – RC type (subject-gap vs. object-gap) and Marking on the head noun (topic vs. nominative vs. accusative). The dependent variables were the same as in Experiment 1 – mean response accuracy to end-of-sentence comprehension questions and the reading time of each region of a sentence. For each dependent measurement, two separate ANOVAs with repeated measures were performed – one with the participant analysis (F_1) where the two independent factors were treated as within-participant variables, and one with the item analysis (F_2) where the two independent factors were treated as within-item variables. When the interaction of Marking on the head noun and RC type was found to be significant, subsequent analyses were conducted in order to examine the nature of the interaction.

For reading times, the critical region of comparison was the head noun (i.e., the filler) of the relative clause, at which point the parser is assumed to recognize the RC structure and resolve a filler-gap dependency. No scores were eliminated from the analysis. The reading time results shown below represent raw mean reading times for each region.

4.2.2 Results

4.2.2.1 Comprehension questions

The mean percentage of correct responses to the end-of-sentence comprehension questions is provided in Table 4.5 and Figure 4.3.

Table 4.5. Experiment 2: Mean response accuracy for comprehension questions (%).

| Case marking | RC type | Correct response (%) |
|--------------|-------------|----------------------|
| Topic | Subject gap | 91.7 |
| | Object gap | 92.5 |
| Nominative | Subject gap | 89.2 |
| | Object gap | 86.7 |
| Accusative | Subject gap | 82.5 |
| | Object gap | 80.0 |

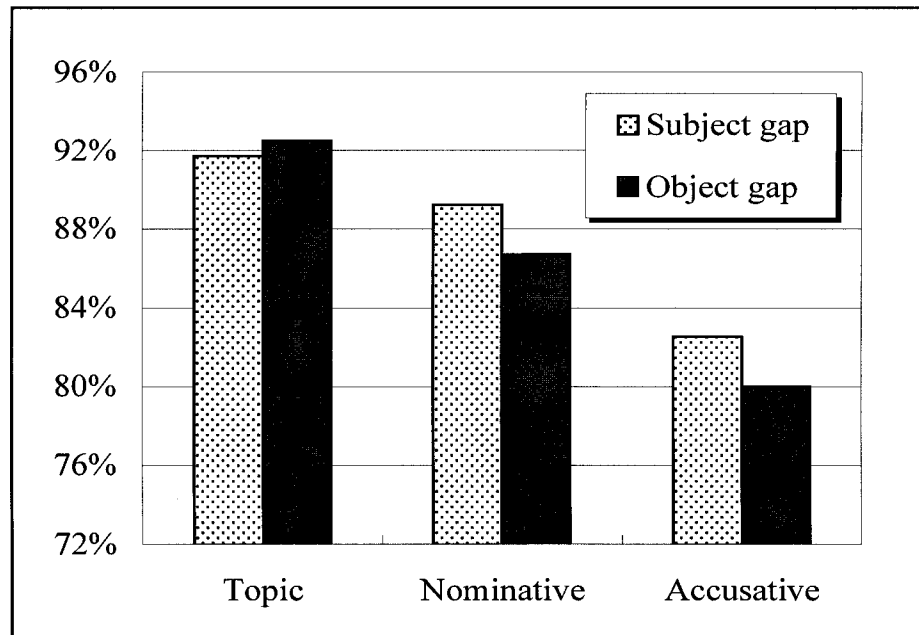


Figure 4.3. Experiment 2: Mean response accuracy for comprehension questions (%).

There was a significant main effect of Marking on the head ($F_1(2,46)=6.916$, $p=.002$; $F_2(2,58)=5.207$, $p=.008$). Bonferroni pairwise comparisons found that the topic condition was comprehended significantly better than the accusative condition ($p_1=.011$, $p_2=.011$), but none of the other pairs (the topic vs. the nominative, the nominative vs. accusative) differed from each other. There was no main effect of RC type ($F_1(1,23)=.235$, $p=.632$; $F_2(1,29)=.205$, $p=.654$) nor an interaction of RC type and Case marking ($F_1(2,46)=.182$, $p=.834$; $F_2(2,58)=.202$, $p=.817$).

In sum, unlike Experiment 1 in which subject-gap RCs were comprehended better than object-gap RCs, the results of response accuracy in Experiment 2 did not show a gap difference. Considering the similarity of the test sentences, these inconsistent results between the two experiments are puzzling. However, comprehension accuracy can be influenced by not only the processing difficulty manifested at a particular region of a sentence, but also some other factors, such as overall reading speed, segmentation of a sentence, other experimental factors manipulated in an experiment, and so forth. Therefore, it is necessary to look at the local reading times of a sentence.

4.2.2.2 Reading times

Table 4.6 and Figure 4.4 present the mean reading time in milliseconds by region and condition.

Table 4.6. Experiment 2: Mean reading times (msec.).

| Case marking | RC type | W1 [NP-gen] | W2 NP | W3 Loc | W4 V] | W5 Head | W6 NP | W7 V |
|--------------|-------------|----------------|----------|-----------|----------|------------|----------|---------|
| Topic | Subject gap | 776 | 811 | 855 | 905 | 913 | 640 | 907 |
| | Object gap | 933 | 876 | 1061 | 926 | 1265 | 793 | 944 |
| Nominative | Subject gap | 831 | 859 | 881 | 973 | 1032 | 706 | 1099 |
| | Object gap | 798 | 938 | 851 | 984 | 1582 | 807 | 1334 |
| Accusative | Subject gap | 821 | 929 | 888 | 845 | 1103 | 892 | 1210 |
| | Object gap | 780 | 874 | 815 | 870 | 1191 | 988 | 1586 |

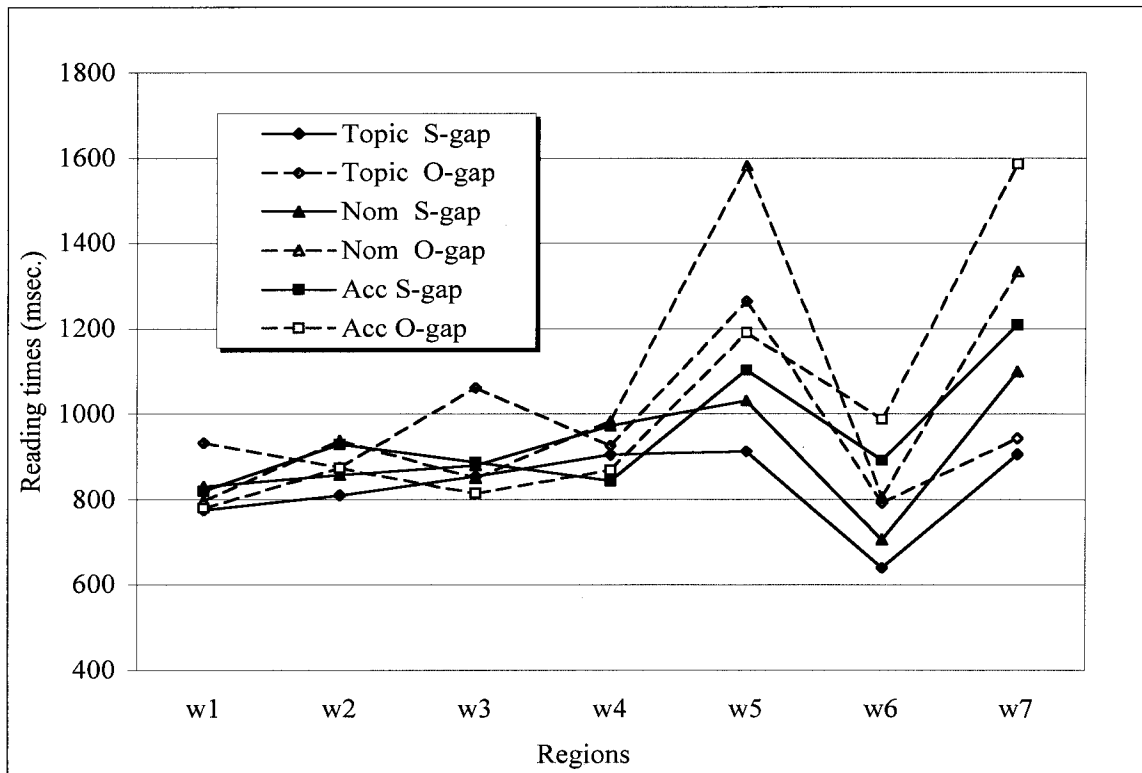


Figure 4.4. Experiment 2: Mean reading times (msec.).

Within the RC region (from region 1 to region 4), there was an interaction of Marking on the head and RC type in region 1 (a modifier ‘elderly’) and region 3 (a locative phrase ‘to the bus stop’). In both regions, the interaction was significant only with the item analysis (Region 1: $F_1(2,46)=2.001$, $p=.147$; $F_2(2,58)=3.611$, $p=.033$; Region 3: $F_1(2,46)=2.668$, $p=.080$; $F_2(2,58)=3.356$, $p=.042$). A close examination of reading times showed that in both regions, an object-gap RC with a topic-marked head noun yielded longer reading times than other conditions. However, these seemed to be chance differences. In region 1, the lexical item was identical across all six conditions. Therefore, there was no way for the reader to distinguish the object-gap topic condition from the other conditions. Similarly, at region 3, all three object-gap conditions shared

the same lexical items from the beginning of the sentence through this region (elderly/woman-nom/to-bus-stop). Therefore, it is unlikely that only the topic condition was read in some consistently different manner from the other two conditions. Other than these interactions, there was no significant effect ($p > .1$) in the RC region (region 1 through region 4).

Figure 4.5 below presents the reading times at the head noun (region 5).

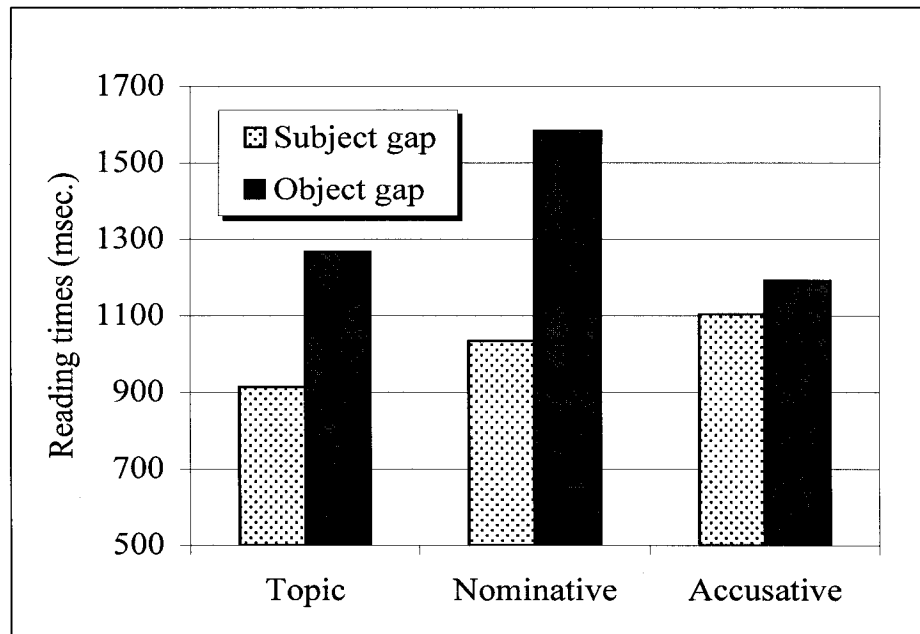


Figure 4.5. Experiment 2: Mean reading times at region 5 (msec.)

There was a robust main effect of RC type ($F_1(1,23)=25.023$, $p < .001$; $F_2(1,29)=13.348$, $p = .001$), a main effect of Marking on the head ($F_1(2,46)=3.496$, $p = .039$; $F_2(2,58)=5.021$, $p = .01$), and an interaction of RC type and Marking on the head ($F_1(2,46)=6.246$, $p = .004$;

$F_2(2,58)=5.709, p = .005$).⁵³ In terms of the RC type, object-gap RCs were read more slowly than subject-gap RCs. As for head marking, the nominative condition took longer than the topic condition. Most of all, the presence of an interaction suggests that the effect of RC type is not uniform across the three case-marking conditions.

The interaction seems to be due to the processing difficulty of an object-gap RC when the head noun had a nominative marker. This observation was confirmed by the results of one-way ANOVAs with repeated measures on Marking on the head noun. There was no difference across the subject-gap conditions ($F_1(2,46)=2.198, p = .123$; $F_2(2,58)=2.583, p = .084$), whereas there was a significant difference across the object-gap conditions ($F_1(2, 46)=5.839, p = .005$; $F_2(2, 58)=6.948, p = .002$). Bonferroni pairwise comparisons found that in the object-gap condition, the nominative-marked head was read significantly more slowly than the topic-marked head ($p_1 = .02, p_2 = .02$) and the accusative-marked head ($p_1=.016, p_2 = .004$). There was no difference between the topic-marked head and the accusative-marked head ($p = 1$).

To summarize the reading time results at the head noun, some sort of a mismatch effect between the grammatical relations of gap and filler seems to play a role in the processing of Japanese RCs. However, the significant main effect of RC type and the overall reading time differences across conditions (as shown in the above figure) suggest

⁵³ A statistical note: When the analysis included List as a between-subject variable in addition to the two within-participant variables (RC type and Marking on the head noun), the three-way interaction was found to be significant. There is no explanation for this interaction, although this seems to be due to a difference among participants who were randomly assigned to each list rather than differences among items. A larger number of participants in each list, trimming the reading time data, and controlling the frequency of the lexical items in the critical region may be able to avoid this sort of problem in future studies.

that there is a subject gap advantage over an object gap beyond relational matches and mismatches.

In the following two regions, at the NP following the head noun and the sentence-final predicate, the interaction of RC type and Marking on the head noun disappeared (region 6: $F_1(2,46)=.187$, $p=.830$; $F_2(2,58)=.202$, $p=.818$; region 7: $F_1(2,46)=2.586$, $p=.086$; $F_2(2,58)=1.694$, $p=.193$). In region 6, both RC type and Case marking were significant (RC type: $F_1(1,23)=5.619$, $p=.027$; $F_2(1,29)=7.032$, $p=.013$; Case: $F_1(2,46)=7.106$, $p=.002$; $F_2(2,58)=10.865$, $p<.001$). The same held true for region 7 (RC type: $F_1(1,23)=9.522$, $p=.005$; $F_2(1,29)=5.058$, $p<.032$; Case: $F_1(2,46)=10.877$, $p<.001$; $F_2(2,58)=11.064$, $p<.001$).

Figure 4.6 shows the reading times for region 6.

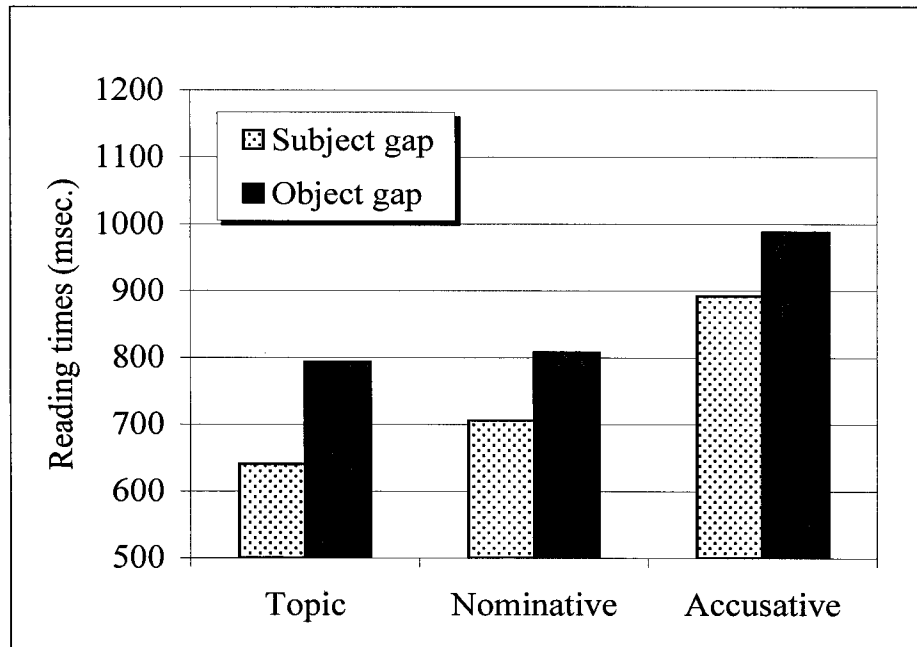


Figure 4.6. Experiment 2: Mean reading times at region 6 (msec.).

Subject-gap RCs were read consistently faster than object-gap RCs. With regard to Marking on the head noun, Bonferroni pairwise comparisons found that the accusative condition was significantly longer than the topic condition ($p_1 = .004$; $p_2 = .002$) and the nominative condition ($p_1 = .019$; $p_2 = .007$). There was no difference between the topic and nominative conditions ($p_1 = 1$; $p_2 = .935$). One possible explanation for the difficulty involved in the accusative condition may be the cost associated with scrambling as described earlier. A sample sentence in this condition (sentence (7e)) is repeated here as (9).

(9) Subject-gap RC with accusative-marked head

[_{RC} _ toshiyori-no obaasan-o basutei-made miokutta] onnanoko-o
 old-GEN old-woman-ACC bus-stop-to walked girl-ACC
 omawarisan-ga yobitomete.
 policeman-NOM called-and-stopped
 'A policeman stopped the girl who walked the old woman to the bus stop.'

In this sentence, the direct object of the matrix clause *onnanoko-o* ('girl-ACC') has been preposed in front of the matrix subject *omawarisan-ga* ('policeman-NOM'). As reviewed in chapter 3, scrambled sentences have shown to be more difficult to process than their corresponding non-scrambled sentences (Mazuka, Itoh, & Kondo 2002, Miyamoto & Takahashi 2002a,b). Assuming that scrambled sentences involve a gap created by movement of the direct object, the longer reading time at the nominative-marked NP 'policeman' in this sentence is likely due to the extra processing cost associated with the filler-gap dependency created by scrambling. See also the discussion section of

Experiment 2 for another possibility, an inherent difficulty of nominative case in Japanese (e.g., Inoue 1991, Miyamoto 2002, Uehara 1997).

Figure 4.7 presents the reading times at region 7, the sentence-final predicate.

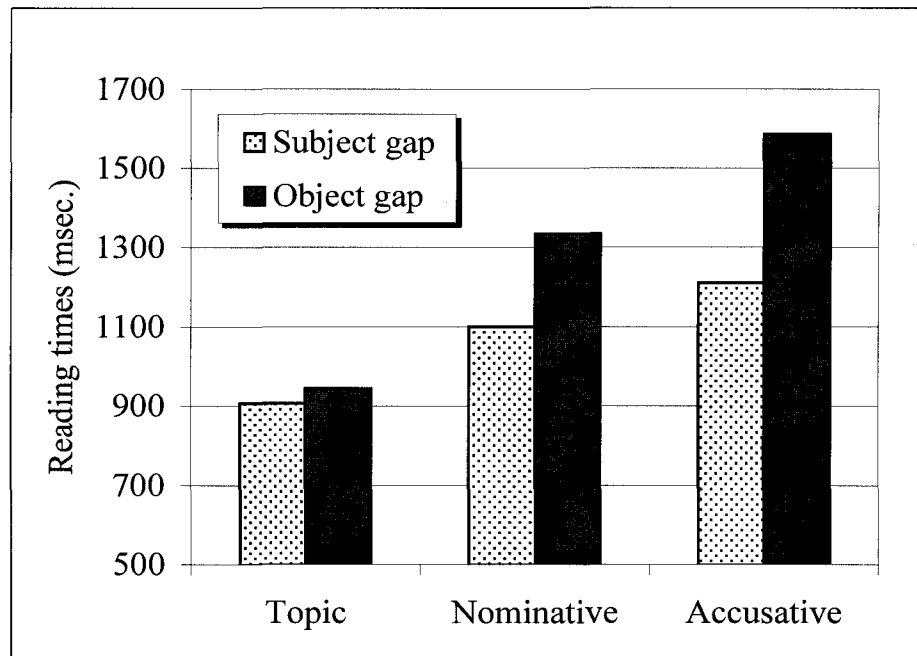


Figure 4.7. Experiment 2: Mean reading times at region 7 (msec.).

Similar to region 6, subject-gap RCs were read significantly faster than object-gap RCs regardless of the marking on the head. Bonferroni pairwise comparisons of three marking conditions found that the topic condition was significantly faster than the nominative condition ($p_1 < .001$; $p_2 = .018$) and the accusative condition ($p_1 = .002$; $p_2 < .001$). There was no difference between the nominative and accusative conditions ($p_1 = .395$; $p_2 = .238$).

The superior performance of the topic condition was very similar to the pattern found for end-of-sentence comprehension questions (shown in Table 4.5 and Figure 4.3).

The sentence-final region is known to be the place where sentence wrap-up takes place. That is, the parser integrates all information and completes the analysis of a sentence to reach its final interpretation. Therefore, it makes sense to find parallelism between the time the parser spent wrapping up a sentence and the overall comprehension accuracy of a sentence. Although it is not clear exactly what made the topic construction so easy to process, the superiority of the topic case condition is consistent with a general view that topic marker is less marked than other case markers. (See the discussion below.)

4.2.3 Discussion

The aim of Experiment 2 was to test the possibility that the subject gap advantage found in Experiment 1 may be due to the parallel relation between a gap and its filler. The results of Experiment 2 did not fully support this hypothesis. Object-gap RCs were almost as easy as subject-gap RCs when the head noun had an accusative marker. Crucially, however, they never became ‘easier’ than subject-gap RCs in this condition as well as in any other conditions, suggesting that there is an inherent difficulty in object-gap RCs compared to subject-gap RCs. Furthermore, when the head region was passed, a consistent subject gap advantage emerged and remained until the end of a sentence.

The overall results are consistent with the Structural Distance Hypothesis (O’Grady 1997). According to this hypothesis, subject-gap RCs are computationally advantaged because a subject gap is structurally higher and thus closer to the filler. Experiment 2 demonstrated that although the reading time of the head noun region was temporarily affected by the marking on the head, subject-gap RCs were overall easier than object-gap RCs.

In addition to these major findings, Experiment 2 had two interesting observations with regard to the marking of the head noun. First, among the three markers on the head noun, the topic condition produced superior performance to other conditions, in particular compared to the accusative condition. Its advantage (in relation to the accusative marker) was found in the response accuracy to the end-of-sentence comprehension question and in the reading time of both the sentence-penultimate NP (region 6) and the sentence-final predicate (region 7). Second, the nominative-marked head noun seemed to make the processing of object-gap RCs particularly difficult, as demonstrated by a significant interaction of Marking on the head noun and RC type at the head noun region. This could be partially explained by the relation mismatch between a gap and its filler, but a question still remains as to why the effect of relation mismatch is much more prominent in object-gap RCs than in subject-gap RCs.

Numerous studies have reported that there are some inherent differences among postpositions (case markers and topic marker). For example, in self-paced reading experiments, a second nominative marked NP was read more slowly than a corresponding non-nominative marked second NP (Mazuka, Ito, & Kondo 2000, Miyamoto 2002, Yamashita 1997). When the overall reading time was compared, sentences with a topic-marked subject were read faster than sentences with a nominative-marked subject (Abe, Hatasa, & Cowan 1988). M. Inoue (1991, cited in Miyamoto 2002) found that reanalysis was easier when involving a topic-marked subject over a nominative-marked subject. The pretest norming study reported in Experiment 1 of the

present study also found that simple sentences with a topic-marked subject were rated as more natural than sentences with a nominative-marked subject.

The marked behavior of *-ga* is said to be due to its inherently complex discourse, syntactic, and semantic properties. First, in addition to its neutral descriptive interpretation, the nominative marker *-ga* has an “exhaustive-listing” sense (‘X, and only X’) which selects a specific entity out of the current discourse (Kuno 1973:38). Second, the nominative case *-ga* can mark not only the subject of a matrix clause but also the subject of an embedded clause. In this sense, *-ga* is more ambiguous than the topic case *-wa*, which only appears in matrix clauses. Third, the nominative-marked NP often introduces a clause boundary (Inoue 1991, Miyamoto 2002, Yamashita 1997). It is the first case-marked element in a canonical sentence in Japanese. It cannot be scrambled, and the absence of a morphosyntactic device that explicitly marks the beginning of an embedded clause will make it a potentially strong processing cue that indicates the presence of a clause boundary (Miyamoto 2002).⁵⁴ Finally, the processing difficulty associated with a nominative-marked head noun in an object-gap RC may simply be due to the occurrence of several NP with identical case. Consider the following object-gap RC (7d), repeated as (10) for convenience.

⁵⁴ There may be prosodic cues that indicate a clause boundary in spoken language.

(10) Object-gap RC with nominative-marked head

[_{RC} Toshiyori-no obaasan-**ga** _ basutei-made miokutta] onnanoko-**ga**
old-GEN old-woman-NOM bus-stop-to walked girl-NOM
nuigurumi-o daiteita.
stuffed-animal-ACC holding
'The girl that the old woman walked to the bus stop was holding a stuffed-
animal.'

It has been suggested that repetition of categories causes some similarity-based interference and incurs some processing cost (Gordon, Hendrick, Johnson 2001, Lewis & Nakayama 2002, Uehara 1997). Thus, it is possible that the second nominative-marked 'girl' receives interference from the previous nominative-marked NP 'old woman'.

However, a mere repetition of similarly marked NPs cannot be the sole explanation for the difficulty of sentence (10). The repetition of an accusative-marked NP in the subject-gap RC with an accusative-marked filler did not produce a similar degree of difficulty.

In summary, the multi-functional nature of a nominative case marker seems to make a sentence more ambiguous and make the processing more difficult. However, this does not explain the whole interaction pattern that we observed at the head noun. In the remainder of this section, I will discuss a possible explanation for this problem.

At the head noun of an RC, the parser is assumed to carry out two major integrations – associating the filler with a gap within the RC for the purpose of licensing an RC and identifying the grammatical relation of the head noun within the matrix clause. It seems that when the grammatical relation of the head noun is identical or similar to the grammatical relation of the gap, the role identification of the head noun is facilitated and thus requires no additional cost. Therefore, what is manifested in the relation matched

conditions (i.e., a subject-gap RC with the nominative-marked head and an object-gap RC with the accusative-marked head) is the inherent processing cost associated with different gaps. That is, resolving a filler-gap dependency with a subject gap is computationally easier than resolving a dependency with an object gap.

When the grammatical relation of the head noun differs from that of the gap, on the other hand, the role identification process of the head noun seems to become more costly, requiring additional computational resources. This could be due to the interference from the role of the gap or due to the difficulty involved in the different role assignments (e.g., King & Just 1991). Accordingly, the resolution of a filler-gap dependency will be more difficult because the amount of resources available for this computation decreases. Furthermore, it seems that the effect of relation mismatch may have a greater impact on the processing of object-gap RCs than on the processing of subject-gap RCs. Assuming that there is a single pool of computational resources (Just & Carpenter 1992), the amount of resources available for a computational task depends on the amount of resources that other tasks consume. Computing two difficult tasks simultaneously (e.g., processing object-gap RC and assigning the non-object role to the head noun) taxes the memory system most, and therefore, the greatest processing difficulty should be observed. When computing only one difficult task while the other tasks do not add to the cost, such as in the case of an object-gap RC with an accusative-marked filler, processing may not be impeded as long as a sufficient amount of resources is available. When processing subject-gap RCs, which is computationally less demanding, the influence from other computational tasks should be minimal.

In conclusion, Experiment 2 examined the effect of relation match/mismatch between gap and filler on the processing of subject-gap and object-gap RCs. The overall results replicated a processing advantage of subject-gap RCs over object-gap RCs. The grammatical relation of the head noun was found to temporarily modulate the processing of gaps. However, the inherent processing difficulty involved in object-gap RCs was still observed, and a consistent subject gap advantage emerged as soon as the head noun region was passed. Overall, Experiment 2 provided additional evidence that supports the prediction of the Structural Distance Hypothesis for head-final languages.

4.3 General discussion

4.3.1 Summary of findings

This chapter reported the results of two self-paced experiments that examined the online processing of filler-gap dependencies in Japanese. The goal of the study was to collect empirical evidence on the issue of a subject-object asymmetry in a head-final language. In particular, the study tested two different hypotheses (the Linear Distance Hypothesis and the Structural Distance Hypothesis) that have been put forward to account for the ease of subject-gap RCs in English and other SVO languages.

The rationale for investigating Japanese RCs comes from their apparent typological and processing differences from those of English RCs. Typologically, Japanese is a head final language, thus an RC precedes its head noun. It lacks relative pronouns (e.g., *who*, *whom*, *whose* in English), and there is no formal distinction between predicates in a matrix clause and those in an embedded clause. It is also a pro drop

language in which any argument of a predicate can be freely dropped without violating grammaticality.

These typological properties of Japanese RCs create a very different processing profile from that of English RCs. In English, the detection of an RC construction is made relatively early in a sentence, for example, through the presence of a relative pronoun or a complementizer (*that*). As soon as an RC is recognized, the parser predicts a gap because a filler-gap dependency must be resolved for the RC to be properly interpreted. The prediction is held in working memory until a gap is found. The farther the gap is from the filler, the greater the processing cost, since keeping the prediction longer and reactivating the filler at the gap site consumes more cognitive resources (e.g., Gibson 1998, 2000). In Japanese, on the other hand, an RC is initially analyzed as a simple clause with a missing argument.⁵⁵ Since the missing element is not yet recognized as an RC gap, no prediction is made for the filler. It is only when a noun appears at the position following the verb that the parser recognizes an RC structure and looks for a gap for the filler. That is, the detection of an RC, the identification of an RC gap, and the resolution of a filler-gap dependency take place simultaneously at the head noun in Japanese.

These typological and processing differences between the two languages make the investigation of Japanese filler-gap dependencies very interesting. First, a commonly

⁵⁵ Whether or not a sentence with a gap is always analyzed as a simple clause with a missing argument needs to be investigated independently. For example, as Mazuka, Itoh, and Kondo (2002) mention, the occurrence of an NP-acc at the beginning of a sentence has more than one structural possibility – a simple clause with a missing argument, scrambling, an RC construction, etc. However, it is commonly assumed that a simple clause analysis is preferred over the others because argument drop is more frequent and it is the simplest structure.

assumed distance metric for English RCs (i.e., linear distance) makes the opposite prediction for Japanese RCs. It predicts that object-gap RCs should be easier to process than subject-gap RCs since an object gap is closer to the filler in linear terms. Second, this prediction is not consistent with previous findings on Japanese RCs. Although the amount of evidence is much smaller than for English and although there are some methodological problems in some of the previous studies, evidence suggests that Japanese-speaking children and adults find subject-gap RCs easier to comprehend than object-gap RCs (Abe et al. 1988, O’Grady, Yamashita, Lee, Choo, & Cho 2002, Sheldon 1976). Third, in English RCs, the two distance metrics – linear distance and structural distance – are confounded. However, these two metrics make distinct predictions for Japanese RCs: the former predicts an object gap advantage, while the latter predicts a subject gap advantage. All these facts about Japanese RCs suggest that evidence from Japanese, if collected in a carefully controlled manner, will make a meaningful contribution to the study of human sentence processing.

This chapter reported two self-paced reading experiments. In Experiment 1, the processing of subject-gap and object-gap RCs was tested in two different reading conditions – reading with and without a concurrent task. The concurrent task (articulating a nonsense syllable) was intended to reduce effective working memory during processing so that a ceiling effect due to the relative ease of the test sentences would be avoided. The experiment found a significant processing advantage for subject-gap RCs in both reading conditions. Furthermore, the gap difference appeared at the

head noun of the RC. There was no equivalent difference within the RC region and the regions following the head noun.

Experiment 2 provided additional support for the subject gap advantage found in Experiment 1. Varying the marker on the head noun (topic, nominative, and accusative) did change the size of the gap asymmetry such that the nominative-marked head noun made the processing of object-gap RCs even more difficult. However, the marking on the head noun never reversed the gap asymmetry, and a consistent subject-gap advantage emerged when the head noun region was passed and remained till the end of a sentence.

In sum, the following conclusions can be drawn from the present study. First, despite apparent typological differences, adult native speakers of Japanese were similar to the speakers of other languages. They found subject-gap RCs easier to process than object-gap RCs. As expected for an incremental parser for Japanese, a filler-gap dependency is resolved at the earliest point in the parse where it is certain that an RC structure is being processed. Recall that prior to the head noun, an RC is analyzed as a simple clause with a missing argument. In Japanese, the head noun of the RC is the first point that the parser becomes sure about an RC structure. In single-gap RCs, the position of a gap can be identified prior to encountering the head noun on the basis of the case marking on the NP within the RC and the argument structure of the embedded verb. Since there is only one gap in the RC and there is little ambiguity in terms of the position of the gap, the dependency can be resolved immediately at the head noun. As a result, a computational effect – a subject-object gap asymmetry – emerges. (See chapter 5 for cases where there is ambiguity in dependency resolution between gap and filler.)

Second, a subject gap advantage in Japanese is consistent with the prediction proposed by the Structural Distance Hypothesis (O'Grady 1997). Under this hypothesis, the resolution of a filler-gap dependency is assumed to involve a computational operation on syntactic structure. Since a subject gap is structurally higher and thus closer to the filler, the resolution of a dependency with a subject gap is computationally less costly than with an object gap, which is more deeply embedded in the structure.

Empirical support obtained from Japanese for the Structural Distance Hypothesis has important implications. The hypothesis can account not only for findings from Japanese but also for findings from English and other European languages. Note that a hierarchical structure in which the subject is higher than the direct object is assumed by most contemporary syntactic theories. Therefore, regardless of the position of a head element relative to its dependent, a crosslinguistic advantage for subject-gap RCs is predicted. Although a subject-object gap asymmetry needs to be tested in more typologically diverse languages, the Structural Distance Hypothesis can be considered as an alternative that can account for a widely attested subject-gap advantage across languages.⁵⁶

⁵⁶ Chinese (a SVO head-initial language with prenominal RCs) is another good test case to tease apart the linear and structural distance metrics. Self-paced reading studies conducted by Hsiao and Gibson (2003) found a processing advantage for object-gap RCs. It was also reported that Mandarin/Cantonese aphasic patients preferred object-gap RCs (Grodzinsky 2000, Law & Leung 2000). These findings may constitute counter-evidence to the prediction of the Structural Distance Hypothesis. However, a close examination of the reading profile in Hsiao and Gibson's study shows that the difficulty associated with subject-gap RCs appeared within the RC region. There was no gap difference found at the head noun. This suggests that the difficulty is not due to a computational demand associated with the resolution of a filler-gap dependency, but due to a storage-related demand (i.e., holding predictions in working memory). At this point, I have no explanation as to why the resolution of a dependency does not incur integration cost in Chinese. It may be the case that the storage-related advantage favoring the object-gap RC is so large that the effect of the integration cost cannot be detected at the head noun.

4.3.2 Thematic constraints

There is yet another issue that deserves special attention in the discussion of a subject-object asymmetry in Japanese RCs. It has been pointed out that Japanese RCs have a number of peculiar properties that English RCs do not share (e.g., Kuno 1973).⁵⁷ Observing a strong parallelism between the topic construction and the RC construction, Kuno argued that Japanese RCs are licensed by the same semantic principle that licenses the topic construction.

(11) Aboutness relation [Kuno, 1973: 253fn, Kuno, 1976: 420]⁵⁸

A relative clause must be a statement about its head noun.

According to this principle, the degree of sentence acceptability depends on how easily a head noun is interpreted as the topic of an RC (Kuno, 1976: 425). For example, the subject of a sentence is, in general, easier to relativize than the object of a sentence, since the subject is more topical than the direct object.⁵⁹ Hence, this constraint would imply that the subject gap advantage found in Experiment 1 and 2 is simply due to semantic reasons, i.e., the thematic interpretability of NPs.

The aboutness relation as a licensing condition for Japanese RCs is compatible with a number of structural analyses that assume that Japanese RCs involve a base-

⁵⁷ For example, a pronoun can appear in the position that corresponds to a gap in an RC. Japanese also permits relativizations whose equivalent English relativization is not grammatical. Furthermore, there are cases where the head noun of an RC finds no corresponding position in an RC, known as gapless RCs.

⁵⁸ Kuno (1976) used the term 'the thematic constraint' for this condition. However, in this dissertation, it is referred to as 'aboutness relation' or 'aboutness condition' as commonly used by most linguists.

⁵⁹ Kuno argues that the NP accessibility hierarchy for relativization proposed by Keenan and Comrie (1977) is in fact a hierarchy for accessibility to thematic interpretation of NPs (Kuno, 1976:427).

generated null pronominal (i.e., *pro* in Government and Binding theory, Chomsky 1981, 1982).⁶⁰ If a gap in Japanese RCs is a *pro*, which is not created by a movement operation, the association of a gap with its filler does not need to be constrained by a structural factor. It is simply an anaphoric process such as for a pronoun and its antecedent.⁶¹ Then, the filler-gap association is a matter of finding a prominent or salient entity in a sentence or discourse (Keenan & Comrie 1977, Kuno 1973).

4.3.2.1 Offline survey on thematic constraint

A preliminary offline survey was conducted in order to examine thematic constraints on the RCs that were used in the self-paced experiments of the present study. Assuming a parallelism between RCs and their corresponding topic sentences as proposed by Kuno, it tested whether topic sentences corresponding to subject-gap RCs are rated as more natural than topic sentences corresponding to object-gap RCs.

Twenty-nine undergraduate students at Kyoto Sangyo University in Japan participated in the survey for non-monetary compensation. Test materials were the thirty-two sets of RCs that were used in Experiment 1. They were transformed into corresponding topic sentences. Sentences (4a) and (4b), repeated here as (12a) and (12b),

⁶⁰ Such analyses are assumed by a number of scholars, such as Haig (1979, 1996, 2000), Hoji (1985), Kuno (1973, 1976), Mihara (1994), Murasugi (2000a,b), Nakamura (1986-7), Perlmutter (1972), Rizzi (1986), Saito (1985), Takano (1989). Note that a *pro* analysis sharply contrasts with the movement analysis of RCs that is commonly assumed for English RCs.

⁶¹ There is a view that the interpretation of plain pronouns is resolved on pragmatic basis (O'Grady 2001:9, and references therein). A pronoun can have a broader range of antecedents, which are not constrained by locality. It can also be used deictically. The fact that reflexive pronouns are used in the very restrictive case of anaphoric expressions is informative enough for the parser to resolve plain pronouns pragmatically.

are original RCs, and sentences (13a) and (13b) are equivalent topic sentences respectively.

(12) a. Subject-gap RC

[_{RC} e_i toshiyori-no obaasan-o basutei-made miokutta] onnanoko_i-wa
 elderly-GEN old-woman-ACC bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who walked the old woman to the bus stop was holding a stuffed animal.'

b. Object-gap RC

[_{RC} Toshiyori-no obaasan-ga e_i basutei-made miokutta] onnanoko_i-wa
 elderly-GEN old-woman-NOM bus-stop-to walked girl-TOP
 nuigurumi-o daiteita.
 stuffed-animal-ACC holding
 'The girl who the old woman walked to the bus stop was holding a stuffed animal.'

(13) a. Topic sentence corresponding to a subject-gap RC (subject topic)

Onnanoko_i-wa [_S e_i toshiyori-no obaasan-o basutei-made miokutta]
 girl-TOP old-GEN old-woman-ACC bus-stop-to walked
 'As for the girl, she walked the old woman to the bus stop.'

b. Topic sentence corresponding to an object-gap RC (object topic)

Onnanoko_i-wa [_S toshiyori-no obaasan-ga e_i basutei-made miokutta]
 girl-TOP old-GEN old-woman-NOM bus-stop-to walked
 'As for the girl, the old woman walked her to the bus stop.'

These topic sentences were assigned to one of two presentation lists by using a Latin Square design.⁶² The survey was conducted in a university classroom using a pencil-and-paper questionnaire. Participants were asked to rate the naturalness of each

⁶² This offline survey was combined with another survey which examined the topic versions of double-gap relative clauses. With thirty-two sets of single-gap sentences and twenty-four sets of double-gap sentences, each list thus contained 56 sentences.

sentence on a 5-point scale from 1 (natural) to 5 (unnatural). They were encouraged to give their intuitive judgment by using all five points as much as possible without taking too long for each sentence. Written instructions and sample sentences were given on the first page of the questionnaire. Data from one participant was discarded because of his/her incomplete questionnaire. Thus, the analysis was conducted on the data from twenty-eight participants with fifteen of them rating one list and thirteen rating the other list.

Table 4.7 presents the within-participant and within-item mean naturalness scores.

Table 4.7. Survey on thematic constraint:
Mean naturalness scores (1 natural – 5 unnatural).

| | Participant means | Item means |
|---------------|-------------------|------------|
| Subject topic | 1.5558 | 1.5595 |
| Object topic | 4.2634 | 4.2542 |

Topic sentences corresponding to subject-gap RCs were rated as significantly more natural than those corresponding to object-gap RCs, and the difference was robust for both the participant analysis ($F_1(1,27)=822.93, p <.001$) and the item analysis ($F_2(1,31)=1061.439, p <.001$). The results supported the predictions of the thematic constraint. That is, the head noun of a subject gap RC was much more easily interpreted as the topic of a decontextualized sentence than the head noun corresponding to an object gap.⁶³

⁶³ Alternatively, a preference for encoding the topic with subject may be due to a general perceptual processing strategy of sentences, which treats the first noun as the agent of an action (Bever 1970:298-299).

In summary, with respect to a relative processing difficulty of RCs, both the thematic constraint and the Structural Distance Hypothesis make the same prediction for both Japanese and English, namely easier relativization of the subject than the direct object. At this point, no empirical evidence seems to exclusively choose one over the other. However, several points should be mentioned. First, in order for the thematic constraint to be empirically testable, it needs to be more explicit about how processing difficulty is determined and where the difficulty occurs. For example, there has been overwhelming evidence at least in English that shows that an increased working memory load is observed at certain regions in a sentence, such as at the embedded verb and the matrix verb. Unless the thematic constraint has some very good semantic-based reasons to predict these memory costs at these particular points, distance-based explanations that make reference to the use of working memory cannot be discarded. Second, the Structural Distance Hypothesis and the thematic constraint are not necessarily mutually exclusive. A relative clause is a construction that is used to fulfill specific discourse-related, communicative functions, such as narrowing down a potential set of referents. Therefore, any RC needs to conform to a basic functional requirement so that the two clauses are related in a meaningful way. However, this does not necessarily exclude the possibility that the association of a gap and a filler requires some processing cost and that some sort of distance effect plays a role in this association.

One related question that can be asked on this issue is whether the thematic constraint is the sole licensing condition for RCs in Japanese. In other words, can RCs in different languages be explained by different sets of principles? This largely depends on

the syntactic analysis that one assumes for Japanese RCs. In order to form a conclusion on this issue, further studies are necessary in which each account (e.g., thematic constraint and distance metrics) can be tested independently.

4.3.3 Further studies

The present study provided empirical evidence for the ease of processing subject gap RCs in Japanese. However, in order to obtain a more detailed picture of RC processing, further studies are needed. The following are some of the possibilities as an extension of the present study. First, it is necessary to investigate exactly what the parser assumes when encountering a missing argument and where in the sentence a gap is postulated. Since Japanese allows more than one possible analysis at a given point in a sentence, information that points to which analysis is more likely to be assumed will be useful in order to predict the parsing decisions at each point in a sentence (e.g., in determining the position of a gap in a sentence). Second, the second experiment of the present study varied the marking on the head noun – topic, nominative, and accusative. However, a wide range of postpositions needs to be tested in order to determine whether the size of the gap asymmetry differs depending on the postpositions, and whether the parallel/nonparallel relation between gap and filler is manifested in all cases. Third, previous studies have shown that an animacy contrast mitigates the difficulty the parser experiences in processing object-gap RCs (Kutas 1997, Mak, Vonk, & Schriefers 2002, Traxler, Morris, & Seely 2002). It is of empirical interest how the animacy of head nouns influences the processing of single-gap RCs in Japanese. Fourth, the effect of grammatical relations, case relations, and thematic roles on RC processing could be

explored in more detail. Most previous studies, as well as the present one, have some confounds in terms of grammatical relations and thematic roles. That is, the grammatical subject is the agent of an action denoted by the embedded predicate, and the grammatical object is the theme of the action. In order to tease apart these factors and see how salient each type of information is in processing, it is necessary to test other combinations, such as experiencer subjects.

4.3.4 Conclusion

The present chapter reported on two experiments that investigated the processing of single-gap RCs. Like English, native speakers of Japanese found subject-gap RCs easier to process than object-gap RCs. This subject-object asymmetry was interpreted as reflecting a different structural position of the gap with which the filler must be associated. Because a subject gap is higher in the structure and thus closer to the filler, it is computationally easier to resolve a dependency. The appearance of a gap effect at the filler indicates that the parser conducts a structural analysis rapidly and resolves a filler-gap dependency as soon as it recognizes an RC structure. In a single-gap RC, such a rapid analysis is possible because there is little ambiguity in terms of the number of gaps and the position of the gap. There is only one gap in the RC, and its structural position is uniquely identified by the case marking of the NP in the RC together with the argument structure of the embedded verb. Therefore, as soon as the filler is found, a dependency can be formed with the gap in the RC. However, a question arises as to whether other types of information can be used to identify the position of a gap when there is more than one gap in an embedded clause with which the filler can be associated. Another question

is whether a subject-object asymmetry appears in sentence types where the primary information source of structure building is non-syntactic. These questions are addressed in more detail in the next chapter and tested in a different type of RCs that involve structural ambiguity.

CHAPTER 5

PROCESSING OF DOUBLE-GAP RELATIVE CLAUSES

The previous chapter presented evidence for a gap asymmetry in the processing of single-gap RCs in Japanese. The online resolution of a filler-gap dependency was found to be easier when the head noun (i.e., filler) corresponded to a subject gap than to an object gap. The results supported the prediction proposed by the Structural Distance Hypothesis. According to this hypothesis, subject-gap RCs are computationally less costly since a subject gap is higher in the structure, and thus closer to the filler.

The primary goal of the present chapter is to collect additional evidence in favor of a subject gap advantage. The structure examined in this chapter is a double-gap RC. Unlike a single-gap RC in which only one of the arguments (i.e., subject or direct object) of a transitive predicate is relativized, a double-gap RC involves relativization of two arguments. The following illustrates an example for each type of RC.

- (1) a. Single-gap RC: subject is relativized

[e_i sono seki-o yoyakushita] kyaku_i-wa okotteita.
that seat-ACC reserved customer-TOP angry-was
'The customer who reserved that seat was angry.'

- b. Single-gap RC: direct object is relativized

[Sono kyaku-ga e_i yoyakushita] seki_i-wa kitanakatta.
that customer-NOM reserved seat-TOP dirty-was
'The seat that the customer reserved was dirty.'

- c. Double-gap RC: both subject and direct object are relativized

[[e_i e_j yoyakushita] seki_j-ga totemo kitanakatta] kyaku_i-wa okotteita.
 reserved seat-NOM very dirty-was customer-TOP angry-was
 ‘(Lit)The customer_i [that the seat_j [that e_i reserved e_j] was very dirty] was angry.’

- d. Double-gap RC: both subject and direct object are relativized

[[e_i e_j yoyakushita] kyaku_i-ga jikan-ni okureta] seki_j-wa katadukerareteita.
 reserved customer-NOM time-to late-was seat-TOP put-away-was
 ‘(Lit)The seat [that the customer [that e_i reserved e_j] was late] was put away.’

Sentence (1a) involves relativization of the subject, where the head noun *kyaku* ‘customer’ corresponds to a subject gap. Sentence (1b) is an instance of relativization of the direct object where the head noun *seki* ‘seat’ corresponds to an object gap. In double-gap RCs (1c) and (1d), both *kyaku* ‘customer’ and *seki* ‘seat’ are relativized. Hence, there is a sequence of gaps (subject gap and object gap) in the most embedded clause, and these gaps must be related to fillers in higher positions. In sentence (1c), the filler in the intermediate clause (*seki* ‘seat’) is associated with the object gap and the filler in the higher clause (*kyaku* ‘customer’) is associated with the subject gap. In sentence (1d), the filler-gap association is reversed. The filler in the intermediate clause (*kyaku* ‘customer’) corresponds to a subject gap and the filler in the higher clause (*seki* ‘seat’) corresponds to an object gap. Throughout this thesis, the filler in the intermediate clause is referred to as ‘close filler’ and the filler in the higher clause is referred to as ‘distant filler’, reflecting the distance between filler and gap.

Previous syntactic analyses of double-gap RCs have shown that a sentence in which the distant filler is linked to a subject gap (e.g., (1c)) is preferred over one in which

the distant filler is linked to an object gap (e.g., (1d)).⁶⁴ It is therefore of empirical interest whether this asymmetry is manifested in the online processing of double-gap RCs and where the asymmetry appears.

Properties of double-gap RCs involve another interesting issue in the study of sentence processing, namely the role of semantic/pragmatic information during processing. Double-gap RCs are structurally ambiguous in that there is no morphosyntactic information that specifies the dependencies between gap and filler. Compare single-gap RC (1a) and double-gap RC (1c), repeated here as (2a) and (2b) respectively.

(2) a. Single-gap RC: subject is relativized

[e_i sono seki-o yoyakushita] kyaku_i-wa okotteita.
 that seat-ACC reserved customer-TOP angry-was
 ‘The customer who reserved that seat was angry.’

b. Double-gap RC: both subject and direct object are relativized

[[e_i e_j yoyakushita] seki_j-ga totemo kitanakatta] kyaku_i-wa okotteita.
 reserved seat-NOM very dirty-was customer-TOP angry-was
 ‘(Lit)The customer_i [that the seat_j [that e_i reserved e_j] was very dirty] was angry.’

In sentence (2a), the RC is analyzed as involving a subject gap since the embedded predicate ‘reserved’ is transitive (requiring both subject NP and direct object NP), and the NP within the embedded clause (*seki-o* ‘seat-acc’) has an accusative marker. In double-

⁶⁴ Double-gap RCs have been the focus of numerous studies since they challenge the notion of Subjacency, constraints on syntactic movement assumed in the framework of Government and Binding theory (Chomsky 1981, 1982). For various syntactic analyses of these structures including some asymmetries in judgments, see Hasegawa 1984-5, Huang 1984, Haig 1979, 1996, 2000, Imai 1986, Izutani 1995, Kuno 1973, Ue 1982, among others.

gap RCs, in contrast, both arguments of the embedded predicate are relativized and thus there is no overt case-marked NP in the most embedded clause. The parser will recognize that there are two gaps (subject gap and object gap), but there is no formal cue that indicates the dependencies between gaps and fillers. Note that the case markers on the fillers (*-ga* on ‘seat’ and *-wa* on ‘customer’) indicate the grammatical relation of those NPs in the matrix clause, but they do not indicate the roles with respect to the embedded predicate. In this sense, the association of a gap and its filler must be determined based on other, non-structural information.

One useful source of information comes from semantics/pragmatics. Consider sentence (2b) again. Despite a global structural ambiguity, Japanese speakers may find the roles of fillers unambiguous. This is presumably because semantic/pragmatic information from the embedded verb *reserved* and the two fillers *seat* and *customer* makes obvious the thematic roles of the fillers – *customer* as an agent and *seat* as a theme. This suggests that the parser makes active use of semantic/pragmatic information in order to carry out a structural analysis of double-gap RCs. A question then arises as to how the relative strength of semantic/pragmatic information modulates the processing of double-gap RCs, in particular, the subject-object asymmetry involving the distant filler.

This chapter consists of three main studies – one offline survey and two online self-paced reading experiments. The offline survey was aimed at obtaining baseline data that is relevant for the online experiments. It examined Japanese native speakers’ judgments about the overall naturalness of the constructions, the argument relationship of

the fillers to the embedded predicate, and the possibility of misanalysis involved in these structures.

The first self-paced reading experiment investigated a subject-object asymmetry in the processing of double-gap RCs. Sentences whose distant filler corresponds to a subject gap were compared with sentences whose distant filler corresponds to an object gap. Note that the distant filler is the position where the parser recognizes a double-gap RC structure and resolves a filler-gap dependency. Also, it has been shown that the resolution of a filler-gap dependency is less costly when involving a subject gap than when involving an object gap. Then, a reasonable prediction would be that a distant filler corresponding to a subject gap should be read faster than a distant filler corresponding to an object gap.

The second self-paced reading experiment explored the role of semantic/pragmatic information in the processing of double-gap RCs, and its effect on the subject-object asymmetry. Questions that are addressed are: (1) how the parsing of ambiguous structure is influenced by varying the relative strength of the pragmatic bias that constrains the thematic roles of filler, and (2) whether the magnitude of the gap asymmetry changes depending on the strength of the pragmatic information.

There is one issue that needs clarification before investigating the online processing of double-gap RCs in Japanese in detail. With respect to the difficulty involved in the long-distance dependency with an object gap, an issue exists as to whether the difficulty reflects a mere computational cost associated with different structural positions of the gap or whether it reflects an unparsable configuration for the

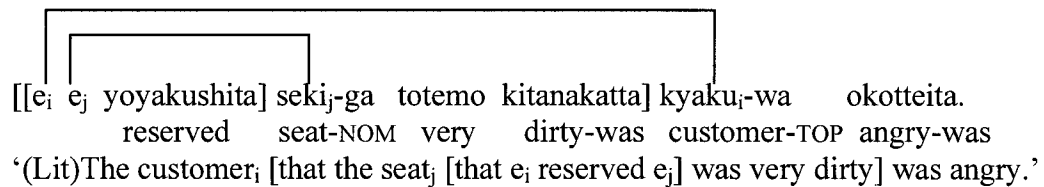
sentences with multiple filler-gap dependencies. For example, Fodor (1978) proposed a constraint that prohibits certain types of filler-gap dependencies.⁶⁵

(3) The Nested Dependency Constraint (NDC) [Fodor 1978:448]

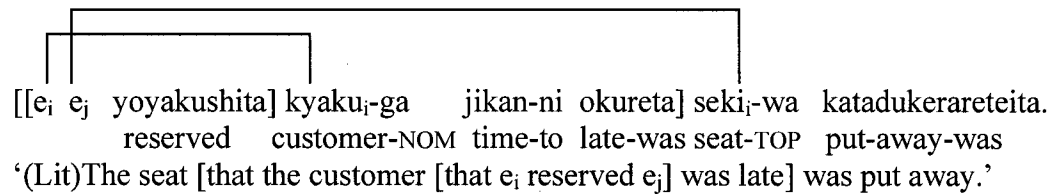
If there are two or more filler-gap dependencies in the same sentence, their scopes may not intersect if either disjoint or nested dependencies are compatible with the well-formedness conditions of the language.

Sentences (1c) and (1d) are repeated below as (4a) and (4b) to illustrate this constraint to Japanese double-gap RCs.

(4) a. Double-gap RC: distant filler involving a subject gap



b. Double-gap RC: distant filler involving an object gap



In (4a), the two dependency lines are nested, while in (4b), those lines are crossed.

Therefore, (4b) is unacceptable.

The asymmetry has also been explained on syntactic grounds. For instance, Hasegawa (1984-5) and Huang (1984) argued that the asymmetry stems from a

⁶⁵ For related arguments, see Pesetsky (1982), Ue (1982), cf. also Bach, Brown, Marslen-Wilson (1986).

distribution of different empty categories at different syntactic positions. The empty category at the subject position is a null pronominal, which can be freely coindexed with its non-local antecedent. In contrast, the empty category in the object position cannot be a null pronominal, but must be a variable created by movement. Since there are constraints on a movement operation, long-distance extraction of an object gap is prohibited.

However, as I mentioned briefly in the previous chapter, there has been an argument that the well-formedness of Japanese RCs is best explained by semantic/pragmatic considerations rather than structural ones (Haig 1979, 1996, Izutani 1995, Kornfilt, Kuno, & Sezer 1980, Kuno 1973, 1976). These researchers have presented numerous examples that would violate the NDC but are still acceptable. The presence of counterexamples suggests that it may be difficult to maintain the position that double-gap RCs with crossed dependencies (or with long-distance object extraction) are ungrammatical across-the-board in Japanese. At the same time, this shows that the role of semantic/pragmatic information in the interpretation of Japanese RCs needs to receive more attention from the processing point of view.

To summarize the discussion, the subject-object asymmetry in double-gap RCs is an unresolved issue. The present study pursues the hypothesis that double-gap RCs with object-linked distant filler are parsable, and explores the possibility that the asymmetry may reflect a difference in computational cost associated with different structural positions of gaps.

5.1 Experiment 3

This offline survey was conducted in order to obtain Japanese native speakers' intuitive judgments about double-gap RCs.⁶⁶ Offline judgment data is a useful way of obtaining information about the overall complexity of a structure and the processing difficulty the parser could experience in processing those structures (Bach, Brown, & Marslen-Wilson, 1986, Babyonyshev & Gibson, 1999, Mazuka, Itoh, Kondo 2002:143). It is also considered to be informative when the construction is so complex that online data alone may not be able to provide straightforward answers to research questions. The predictions in the subsequent online experiments were formulated based on this offline data.

5.1.1 Method

5.1.1.1 Participants

Twenty-five graduate students at the NAIST and people from the surrounding community participated in the survey. All were native speakers of Japanese. They were also participants in some unrelated online experiments and were paid for their participation.

5.1.1.2 Materials

Twenty-four sets of double-gap RCs were prepared for the survey. Each set consisted of six sentences which varied in terms of two factors – Pragmatic bias (strong vs. mild vs. null) and Gap type (subject-gap vs. object-gap). The pragmatic bias was

⁶⁶ I owe gratitude to Dr. Edson Miyamoto who suggested the importance of conducting an offline survey.

pretested, as described in Appendix A. The sentences in (5) illustrate these six conditions.⁶⁷ The specific predictions for these materials are given below in Section 5.1.1.6.

(5) a. Strong bias, distant filler involving a subject-gap

[[e_i e_j yoyakushita] seki_j-ga totemo kitanakatta] kyaku_i-wa ueitoresu-o yonda.
reserved seat-NOM very dirty-was customer-TOP waitress-ACC called
Plausible interpretation: ‘The customer that the seat that (he) reserved was dirty called a waitress.’
Implausible interpretation: ‘The customer that the seat that reserved (him) was dirty called a waitress.’

b. Strong bias, distant filler involving an object-gap

[[e_i e_j yoyakushita] kyaku_i-ga totemo kitanakatta] seki_j-wa ueitoresu-ga soojishita.
reserved customer-NOM very dirty-was seat-TOP waitress-NOM cleaned
Plausible interpretation: ‘As for the seat that the customer that reserved (it) was dirty, a waitress cleaned (it).’
Implausible interpretation: ‘As for the seat that the customer that (it) reserved was dirty, a waitress cleaned (it).’

c. Mild bias, distant filler involving a subject-gap

[[e_i e_j yonda] tenin_j-ga totemo shitsureidatta] kyaku_i-wa tenchoo-ni koogishita.
called clerk-NOM very rude-was customer-TOP manager-to complained
More plausible interpretation: ‘The customer that the clerk that (he) called was very rude complained to the manager.’
Less plausible interpretation: ‘The customer that the clerk that called (him) was very rude complained to the manager.’

d. Mild bias, distant filler involving an object-gap

[[e_i e_j yonda] kyaku_i-ga totemo shitsureidatta] tenin_j-wa tenchoo-ni soodanshita.
called customer-NOM very rude-was clerk-TOP manager-to consulted
More plausible interpretation: ‘The clerk that the customer that called (him) was very rude consulted with the manager.’
Less plausible interpretation: ‘The clerk that the customer that (he) called was very rude consulted with the manager.’

⁶⁷ The coindexation in the sample sentences represents the one for the plausible interpretation.

e. Null bias, distant filler involving a subject-gap

[[e_i e_j yonda] tsuma_j-ga terebi-o miteita] otto_i-wa niwa-ni deta.
called wife-NOM TV-ACC watching-was husband-TOP yard-to went

Assigned interpretation: ‘The husband that the wife that (he) called was watching TV went out to the yard.’

Equally possible interpretation: ‘The husband that the wife that called (him) was watching TV went out to the yard.’

f. Null bias, distant filler involving an object-gap

[[e_i e_j yonda] otto_i-ga terebi-o miteita] tsuma_j-wa niwa-ni deta.
called husband-NOM TV-ACC watching-was wife-TOP yard-to went

Assigned interpretation: ‘The wife that the husband that called (her) was watching TV went out to the yard.’

Equally possible interpretation: ‘The wife that the husband that (she) called was watching TV went out to the yard.’

The first factor, Pragmatic bias, refers to the strength of pragmatic information (i.e., people’s world knowledge or common sense) that constrain the plausible thematic roles of fillers. It had three levels – strong bias, mild bias, and null bias. (In the above examples, fillers are underlined and the most embedded predicate is the first word of each sentence.) In the strong bias condition (e.g., sentence (a) and (b)), the thematic role of each filler is uniquely identifiable based on general pragmatic knowledge. For example, ‘customer’ is the only plausible agent and ‘seat’ is the only plausible theme for the transitive verb ‘reserve’. The reverse pattern is implausible. In the mild bias condition (sentences (c) and (d)), one filler is more plausible as the agent than the other, although the reverse pattern is not impossible. For example, for the fillers ‘customer’ and ‘clerk’, the former is more plausible as agent than the latter in an action denoted by the verb ‘call’. In the null bias condition (sentence (e) and (f)), ‘wife’ and ‘husband’ are equally good as agent or theme.

The second factor, Gap type, involves the type of gap with which a distant filler is associated. (In the above examples, distant fillers are indicated with double underlines and closer fillers with single underlines.) In the subject gap condition (sentences (a) and (c)), the distant filler is the only or more plausible agent, thus more likely to be associated with a subject gap in the embedded clause. In the object gap condition (sentences (b) and (d)), the distant filler is the only or more plausible theme, thus more likely to correspond to an object gap in the embedded clause. For the fillers in the null bias condition (sentences (e) and (f)), both the distant and the close filler are equally good as either agent or theme. Therefore, the assignment of sentences to the subject gap or the object gap condition was made arbitrarily in order to maintain a factorial design. In the experiments reported here, a main effect of Gap type is not expected to appear in the null bias condition.

Each sentence consisted of three clauses – the most embedded clause (RC1), the intermediate clause (RC2), and the matrix clause. Sentence (5a), repeated here as (6), illustrates the structure.

(6) Double-gap RC

| | | | | | | |
|--|-----------------------|----------|--------------|------------------------|--------------|--------------|
| w1 | w2 | w3 | w4 | w5 | w6 | w7 |
| [RC2 [RC1 e _i e _j yoyakushita] | seki _j -ga | totemo | kitanakatta] | kyaku _i -wa | ueitoresu-o | yonda. |
| | reserved | seat-NOM | very | dirty-was | customer-TOP | waitress-ACC |

‘The customer that the seat that (he) reserved was dirty called a waitress.’

Word 1 is the predicate of the most embedded clause (RC1). Since both arguments of this clause are relativized, this is the only overt element in the clause. RC1 modifies the subject (word 2) of an intermediate clause (RC2), and words 3 and 4 constitute the

predicate associated with this subject. RC2 modifies the subject of the matrix clause (word 5). Words 6 and 7 are the remaining elements of the matrix clause.

For each sentence, the predicate of the intermediate clause (words 3 and 4) was designed to be semantically compatible with the immediately following NP (word 5). For example, in the above sentence, the correct reading of the intermediate clause is ‘the seat was very dirty’ where ‘very dirty’ is the predicate of the preceding subject NP ‘the seat’. However, ‘very dirty’ could be semantically compatible with the following NP ‘customer’, although it is not syntactically correct. This manipulation was made in order to see whether people might be led to an incorrect structural analysis when reading a sentence with a highly complex structure (e.g., Christianson, Hollingworth, Halliwell, & Ferreira 2001, Frazier 1985, Gibson & Thomas 1999, Traxler, Morris, & Seely 2002).⁶⁸

These twenty-four sets of test items were distributed into six presentation lists using a Latin Square design. In this way, each participant, who was assigned to one of the lists, read only one of the six conditions in each set, and sentences in each condition were read by the same number of participants. Fifty-five non-experimental sentences with various sentence structures were inserted into each list in a pseudorandom order, so that at least one non-experimental sentence intervened between any two test sentences. A complete list of test materials is given in Appendix F.

⁶⁸ I owe thanks to Edson Miyamoto and Fumiko Yamada who pointed out such possibilities in double-gap RCs.

5.1.1.3 Design

Experiment 5 was designed for a two-way ANOVA with repeated measures on both Pragmatic bias and Gap type. The first independent variable, Pragmatic bias, had three levels – strong, mild, and null. The second independent variable, Gap type, had two levels – subject gap and object gap. Crossing these two factors, the experiment had a total of six conditions.

The dependent variables in this experiment were responses to three different questions asked for each condition. See Section 5.1.1.7 for how to calculate dependent variables.

5.1.1.4 Pretest norming study 2

A paper-and-pencil questionnaire was conducted in order to check the test sentences in terms of two points – (1) whether the pragmatic factors manipulated in the experiment had the intended bias, and (2) whether the intermediate predicate was semantically compatible not only with the preceding NP but also with the immediately following noun. A complete description of the questionnaire and the results are provided in Appendix A.

5.1.1.5 Procedure

The main offline survey was conducted using paper-and-pencil questionnaires, with each survey containing seventy-nine (24 test and 55 non-experimental) sentences. Each sentence had three questions, and the participant was instructed to answer on a 5-point scale. The first question asked about the overall naturalness of each sentence. The

second question examined a preference in interpreting the two fillers in relation to the embedded predicate. The third question tested the likelihood of an incorrect association between an intermediate predicate and its immediately following NP. The following are sample questions for sentences (5a) and (5b). In the actual survey, instructions and sentences were all written in Japanese.

(7) a. Strong bias, distant filler involving a subject-gap (repeated from (3a))

予約した席がとても汚かった客はウェイトレスを呼んだ。

- Q1: この文全体は、意味が 自然 1 2 3 4 5 不自然
 Q2: 上の文から「客が席を予約した。」という解釈ができますか。
 はい 1 2 3 4 5 いいえ
 Q2: 上の文から「客がとても汚かった。」という解釈ができますか。
 はい 1 2 3 4 5 いいえ

[[e_i e_j yoyakushita] seki_j-ga totemo kitanakatta] kyaku_i-wa ueitoresu-o yonda.
 reserved seat-NOM very dirty-was customer-TOP waitress-ACC called
 ‘The customer that the seat that (he) reserved was dirty called a waitress.’

- Q1: The meaning of this sentence is:
 Very natural 1 2 3 4 5 Very unnatural
 Q2: For this sentence, is it possible to interpret as ‘the customer reserved the seat?’
 Yes 1 2 3 4 5 No
 Q3: For this sentence, is it possible to interpret as ‘the customer was dirty’?
 Yes 1 2 3 4 5 No

b. Strong bias, distant filler involving an object-gap (repeated from (3b))

予約した客がとても汚かった席はウェイトレスが掃除した。

- Q1: この文全体は、意味が 自然 1 2 3 4 5 不自然
 Q2: 上の文から「客が席を予約した。」という解釈ができますか。
 はい 1 2 3 4 5 いいえ
 Q2: 上の文から「席がとても汚かった。」という解釈ができますか。
 はい 1 2 3 4 5 いいえ

[[e_i e_j yoyakushita] kyaku_i-ga totemo kitanakatta] seki_j-wa ueitoresu-ga soojishita.
 reserved customer-NOM very dirty-was seat-TOP waitress-NOM cleaned
 ‘The seat that the customer that reserved (it) was dirty, a waitress cleaned (it).’

Q1: The meaning of this sentence is:

Very natural 1 2 3 4 5 Very unnatural

Q2: For this sentence, is it possible to say ‘the customer reserved the seat’?

Yes 1 2 3 4 5 No

Q3: For this sentence, is it possible to say ‘the seat was dirty’?

Yes 1 2 3 4 5 No

The sentence presented for judgment in Q2 was identical in subject-gap and object-gap conditions for each pragmatic bias pair. This was to examine whether there is a preference for associating the distant filler with a subject gap of an embedded predicate, and how this preference is influenced by the pragmatic bias. If there is such a preference, Q2 in (7a) should produce more ‘yes’ responses than in (7b). It should be noted, however, that responses to Q2 may be biased toward ‘yes’ since people in general tend to say ‘yes’ more often rather than ‘no’, especially when the putative preferred interpretation is associated with ‘yes’. The following is a summary of the conditions and the sentences given for judgment in Q2.

Table 5.1. Experiment 3: Summary of conditions and interpretation for Q2.

| Pragmatic bias | Gap type | Embedded predicate | Closer filler | Distant filler | Interpretation presented to participants |
|----------------|----------|--------------------|-----------------|-----------------|--|
| Strong | S-gap | <i>reserved</i> | <i>seat</i> | <i>customer</i> | <i>The customer reserved the seat.</i> |
| | O-gap | <i>reserved</i> | <i>customer</i> | <i>seat</i> | |
| Mild | S-gap | <i>called</i> | <i>clerk</i> | <i>customer</i> | <i>The customer called the clerk.</i> |
| | O-gap | <i>called</i> | <i>customer</i> | <i>clerk</i> | |
| Null | S-gap | <i>called</i> | <i>wife</i> | <i>husband</i> | <i>The husband called the wife.</i> |
| | O-gap | <i>called</i> | <i>husband</i> | <i>wife</i> | |

For Q3, the interpretation given for judgment is syntactically incorrect, requiring the intermediate predicate to be incorrectly associated with the immediately following NP. This was to test if the probability of an anomalous association varies across conditions. For a majority of the non-experimental sentences, the interpretation given for judgment had one of two or more possible interpretations. For the rest, the number of correct and incorrect answers was counterbalanced. Overall, approximately half of the sentences were grammatical interpretations and the other half were ungrammatical interpretations.

The instruction and sample questions were provided on the first page of the questionnaire. Test sentences started on the second page, and participants were asked to give their intuitive judgments to each sentence without spending too much time. The non-experimental sentences were all grammatical; some involved ambiguity.

5.1.1.6 Predictions

There are two types of information sources that the parser is assumed to use in interpreting a double-gap RC – pragmatic information and a preference for assigning the distant filler to a subject gap. The first information source comes from an assumption that the parser will make use of semantic/pragmatic information in an analysis of double-gap RCs that involve structural ambiguity. The second information source was based on the putative computational advantage of a dependency between a filler and a subject gap versus an object gap. (See Chapter 4 for supporting evidence for a subject gap preference.) Also, scholars who have analyzed these sentences showed an intuitive preference for associating the distant filler with a subject gap (e.g., Haig 1979, 1996, 2000, Huang 1984, Hasegawa 1984-5, Kuno 1973, among others). It is important to note

that the preference for forming a dependency with a subject gap is manifested most straightforwardly at the distant filler, rather than at the close filler. At the close filler, there are two gaps which the filler can be potentially associated with. Then, the parsing decision can be influenced by not only the computational cost in favor of a subject gap, but also other factors, such as a preference to fill an object gap so that the resultant structure conforms to the more frequent subject-drop pattern or a preference to fill the theme slot of an argument grid. Furthermore, even if there is a subject gap preference at the close filler, it is not clear how strongly the preference influences the parsing decision at this early point in a sentence and how costly the processing becomes when such a preference is violated. For these reasons, it is assumed that the preference for a subject gap becomes evident at the distant filler.

5.1.1.6.1 Predictions for Q1: Sentence naturalness

Question 1 asked about the overall naturalness of a sentence. Two different patterns of responses were predicted. Figure 5.1 presents the first pattern.

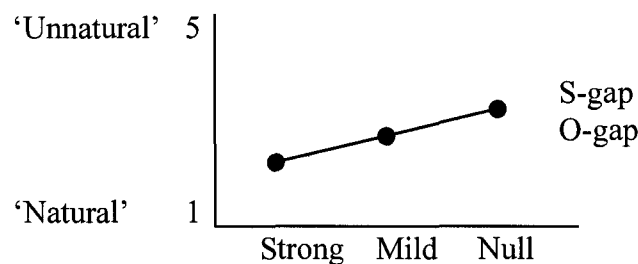


Figure 5.1. Experiment 3: Predictions for Q1 – (1).

This pattern represents the cases where sentence naturalness is judged solely based on the clarity of the information. When the information is clear, it is easy to

interpret a sentence. Thus, the sentence is judged to be natural. Assuming that the plausibility of fillers is the only information available in a sentence that provides a clue about the structure of the double-gap RC, it was predicted that the stronger the pragmatic bias, the more natural the sentence seems.

Figure 5.2 presents the second predicted response pattern.

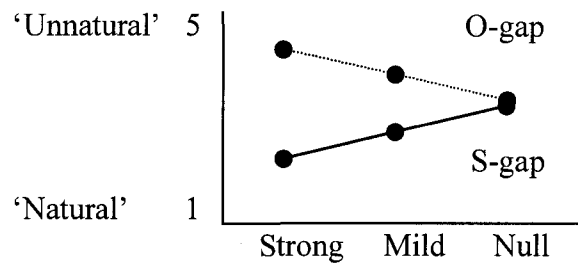


Figure 5.2. Experiment 3: Predictions for Q1 – (2).

In this pattern, sentence naturalness is determined by evaluating how well the preferred structure is supported by other information. Simply, the more plausible it is to interpret the distant filler as the subject of an embedded predicate, the more natural the sentence is.

First, double-gap RCs in the subject-gap condition should be judged more natural than sentences in the object-gap condition since the distant filler in the former condition is more plausible as agent than as theme. Within the subject-gap conditions, the naturalness scores will increase as the pragmatic bias becomes stronger. It follows that the stronger the bias, the easier it is to interpret the distant filler as the subject. In other words, the weaker the bias, the more difficult it is to say that the distant filler is the agent.

Under these circumstances, the interpretation becomes unstable and the naturalness scores will show variation.

Within the object-gap conditions, in contrast, the sentence is judged more unnatural as the pragmatic bias becomes stronger. For example, in the strong bias condition, pragmatics clearly indicates that the distant filler is the theme. This creates the strong mismatch with the preferred structure. In the mild bias condition, the mismatch between pragmatic information and the preferred structure still exists. But since the pragmatic bias is weak, it leaves more possibility of interpreting the distant filler as the agent. Therefore, fewer ‘unnatural’ responses are predicted compared to the strong bias condition.

As for sentences in the null bias condition, no distinction is predicted between subject-gap and object-gap conditions. This is because, with no pragmatic bias, there is no match or mismatch with the preferred structure.

5.1.1.6.2 Predictions for Q2: Gap assignment preference for two fillers

Question 2 asked, for example, whether or not the interpretation ‘the customer reserved the seat’ is a legitimate interpretation for a given strong-bias double-gap RC. Three different response patterns were predicted.

Figure 5.3 shows the first prediction.

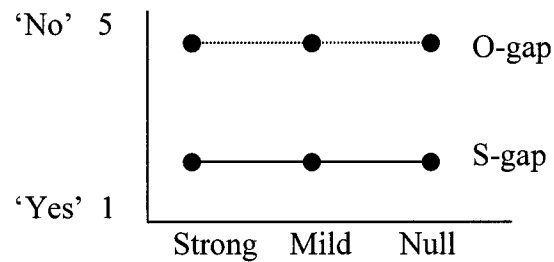


Figure 5.3. Experiment 3: Predictions for Q2 – (1).

This prediction assumes that a judgment is made solely on the basis of structural preference, namely, assigning a distant filler to a subject gap. Since the distant filler of a test sentence is interpreted as the subject of the sentence given for judgment, predominant ‘yes’ responses should be obtained for sentences in the subject gap conditions. On the other hand, predominant ‘no’ responses should be obtained when the distant filler of a double-gap RC is interpreted as the direct object of the sentence given for judgment. RCs in the object gap condition belong to this category. Overall, there is expected to be a robust main effect of Gap type, with no main effect of Pragmatic bias or the interaction. If the above pattern is observed, that would imply that people interpret the distant filler of a double-gap RC as the subject of the embedded predicate, no matter how pragmatically implausible the interpretation is.

Figure 5.4 presents the second prediction, in which both structural preference and pragmatic bias are taken into account for judgment.

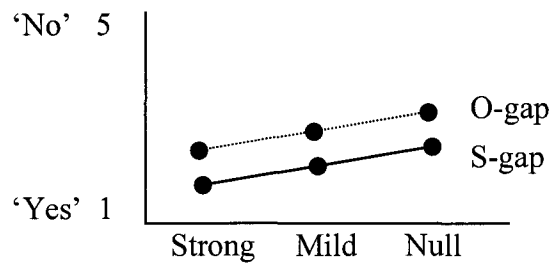


Figure 5.4. Experiment 3: Predictions for Q2 – (2).

Following a preference for interpreting the distant filler as the subject of an embedded predicate, double-gap RCs in the subject-gap condition will produce more ‘yes’ responses than double-gap RCs in the object-gap condition. However, judgment will also be strongly influenced by the pragmatic plausibility of the interpretation.

Consider the subject-gap condition first. In this condition, the ‘yes’ response represents an interpretation in which the distant filler is taken to be the subject of an embedded clause. The gradual decrease in ‘yes’ responses from the strong bias to the null bias reflects the relative strength of the pragmatic support for the structural preference. The more strongly the pragmatic bias supports the subject gap interpretation of the distant filler, the more ‘yes’ responses will be obtained. For example, in the strong bias condition, ‘customer’ at the distant filler is the only plausible subject for ‘reserving a seat’. In the mild bias condition, ‘customer’ at the distant filler is more plausible as the subject of ‘called (the clerk)’. However, because the reverse assignment is still possible (‘the clerk called the customer’), judgment will be less definite. When the bias is null, ‘husband’ at the distant filler is a plausible subject of ‘called (the wife)’. But it is equally good as the direct object. Therefore, more variation is expected, which leans responses toward ‘no’.

Now consider the object-gap condition, in which the ‘yes’ response represents an interpretation in which the close filler is taken as the subject of an embedded clause. The more strongly the pragmatic information biases the close filler to be the subject, the more ‘yes’ responses will be obtained. In the strong bias condition, the close filler ‘customer’ is the only pragmatically possible subject of ‘reserved (a seat)’. Therefore, there will be a strong tendency to respond ‘yes’, even though it is structurally dispreferred. In the mild bias condition, the structural preference favors interpretation of the distant filler ‘clerk’ as the subject of ‘called’, while the pragmatic information weakly favors interpreting the close filler ‘customer’ as the subject. Since pragmatics is not so strongly constraining, fewer ‘yes’ responses are produced than in the strong bias condition. In the null bias condition, structural preference favors the distant filler ‘wife’ as the subject of ‘called’, while pragmatic information does not provide any bias to either interpretation. Therefore, more ‘no’ responses are predicted.

Overall, the tendency to say ‘no’ is slightly greater in the object-gap condition than in the subject-gap condition. This reflects the presence of a mismatch between structural preference and pragmatic support in the object-gap condition. That is, in the subject-gap condition, the stronger the pragmatic bias, the more the structural preference is reinforced. On the other hand, in the object-gap condition, the stronger the pragmatic bias, the less the structural preference is supported.

Finally, at this point it is not yet clear which information source – structural or pragmatic – has a stronger influence on judgments. For example, in object-gap RCs in the mild bias condition, pragmatics favors interpretation of the close filler to be

interpreted as the subject, while structural preference favors the opposite. If the structural preference is more influential than pragmatic information, then more ‘no’ responses will be obtained than in Figure 5.4 above. Likewise, more ‘no’ will be found in the object-gap null bias condition, since pragmatics is assumed to provide no bias. Figure 5.5 below presents an alternative version to Figure 5.4, assuming a stronger structural preference.

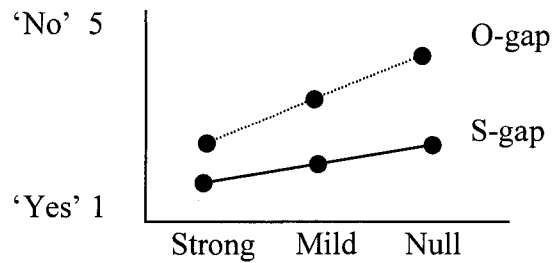


Figure 5.5. Experiment 3: Predictions for Q2 – (3).

5.1.1.6.3 Predictions for Q3: Anomalous interpretation of intermediate predicate

Question 3 investigated the probability of misanalyzing the intermediate predicate as modifying the immediately following NP. Figure 5.6 presents the prediction.

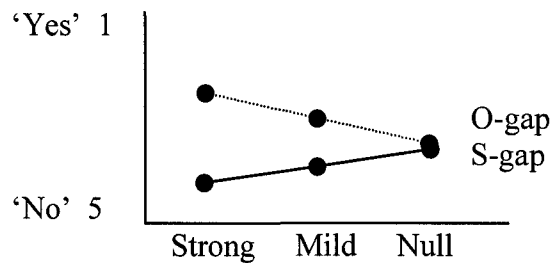


Figure 5.6. Experiment 3: Predictions for Q3.

It has been reported that the parser may permit an ungrammatical analysis when sentences are structurally complex and/or computationally demanding (Gibson &

Thomas 1999, Frazier 1985, Christianson et al. 2001). Taking these insights to the present study, I interpret the ‘perceptual difficulty’ of a sentence as an index of computational cost. That is, more misanalysis will be observed as the perceptual difficulty of a sentence increases. I assume that ‘perceptual difficulty’ increases as a sentence becomes more ambiguous and when the sentence involves more conflicting information, such as the case where structural information does not coincide with the pragmatic information. In Q3, ‘yes’ responses represent an interpretation in which the intermediate predicate is misanalyzed as modifying the following NP.

Taking these factors into consideration, it is predicted that sentences in the weaker pragmatic bias conditions should produce more ‘yes’ responses. A sentence becomes more ambiguous when the pragmatic bias becomes weaker. Furthermore, sentences in the object-gap condition are predicted to produce more ‘yes’ responses than other sentences. This is because two information sources – pragmatic bias and structural preference – conflict with each other in these sentences. Since the pragmatic bias strongly favors the structurally dispreferred interpretation in the strong bias condition, more ‘yes’ responses are predicted in this condition than in the mild bias condition. As for sentences in the null bias condition where the two fillers are equally good as agent or theme, no conflict should arise. Therefore, no distinction is predicted.

5.1.1.7 Data analysis

The grand mean for each participant was first calculated based on the nineteen filler sentences that had unambiguous answers for Questions 2 and 3. Then, any participant whose mean was above or below all participants’ $\langle \text{grand mean} \pm \text{SD} \rangle$ was

discarded. With this criterion, one participant's data was discarded. The results presented below, therefore, were based on the data from a total of twenty-four participants.

For each question, a condition's mean was calculated for each participant (F_1) and for each item (F_2). A 3×2 ANOVA with repeated measures on both Pragmatic bias (strong, mild, and null) and Gap type (subject-gap and object-gap) was performed for each question, by treating the factors as within-participants (F_1) variables. A separate 3×2 ANOVA with repeated measures was carried out for each question, treating Pragmatic bias and Gap type as within-items (F_2) variables. When the interaction of two factors turned out to be significant, subsequent analyses (e.g., one-way ANOVAs) were conducted to examine the nature of the interaction.

5.1.2 Results

5.1.2.1 Question 1: Sentence naturalness

Table 5.2 and Figure 5.7 present the results for Q1, addressing the overall naturalness of each sentence.

Table 5.2. Experiment 3: Mean naturalness scores (Q1)
(1 natural ~ 5 unnatural).

| | Subject-gap | Object-gap |
|-------------|-------------|------------|
| Strong bias | 2.2917 | 3.5521 |
| Mild bias | 3.3542 | 3.6563 |
| Null bias | 3.5729 | 3.6771 |

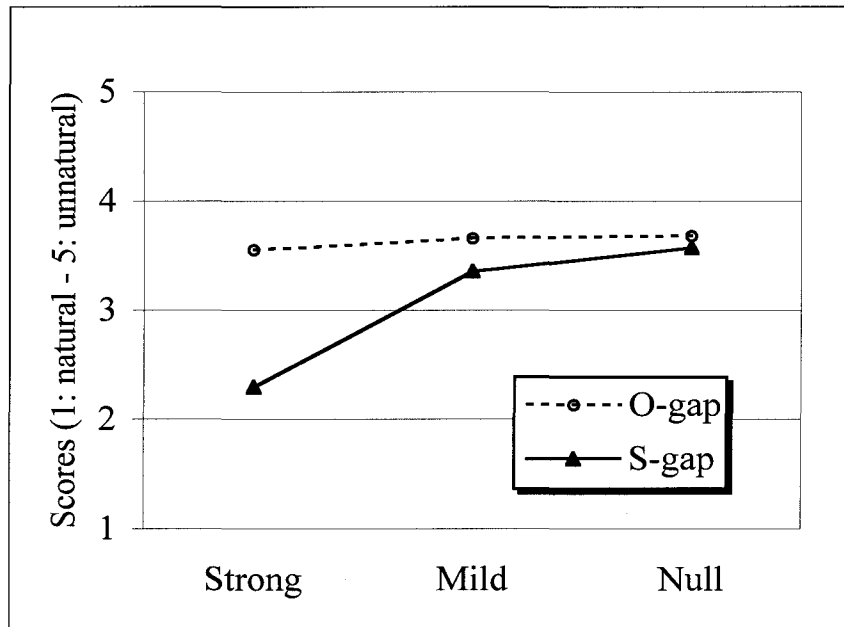


Figure 5.7. Experiment 3: Mean naturalness scores (Q1) (1 natural ~ 5 unnatural).

Two-way ANOVA results produced robust effects of Pragmatic bias, Gap type, and their interaction (Pragmatic bias: $F_1(2,46)=17.199$, $p < .001$, $F_2(2,46)=8.502$, $p = .001$; Gap type: $F_1(1,23)=34.464$, $p < .001$, $F_2(1,23)=33.638$, $p < .001$; Interaction: $F_1(2,46)=15.845$, $p < .001$, $F_2(2,46)=7.542$, $p = .001$). As Figure 5.7 shows, the magnitude of the subject-object gap difference varied across the pragmatic bias conditions. When the distant filler was strongly biased as agent, the sentences received more ‘natural’ responses. When the distant filler was strongly biased as theme, the sentence was judged as more ‘unnatural’. The gap difference was significant in both participant and item analyses ($F_1(1,23)=62.371$, $p < .001$; $F_2(1,23)=23.041$, $p < .001$) in this strong bias condition. A similar but much weaker tendency was found in the mild bias condition with fillers such as ‘customer’ and ‘clerk’. Sentences with a plausible agent ‘customer’ at the distant filler were judged as more ‘natural’ than those with a plausible theme

'clerk' at the distant filler. But the difference was significant only in the participant analysis ($F_1(1,23)=4.529$, $p=.044$; $F_2(1,23)=2.567$, $p=0.123$). In the null bias condition (i.e., sentences with fillers that were equally good as agent or theme), sentences were rated as equally unnatural ($F_1(1,23)=0.328$, $p=.572$; $F_2(1,23)=0.444$, $p=.512$).

The overall results matched neither of the predictions given in Figures 5.1 and 5.2. Contrary to the first prediction, there was no evidence that sentence naturalness was judged solely on how clearly the pragmatic information marked the thematic role of fillers. The type of gap linked to a distant filler seemed to be an important factor in determining the naturalness of a sentence. Also, contrary to the second prediction, there was no gradual decrease or increase in sentence naturalness along with the pragmatic bias in either the subject gap or the object gap conditions. Rather, the results showed that the judgment of sentence naturalness splits into two groups – the natural one and the unnatural one.

The results of Question 1 can be summarized into the following three major findings. First, sentences were split into two categories, natural and unnatural. When the distant filler of a sentence was pragmatically disambiguated as the agent of an embedded verb, the sentence was judged to be natural. The other sentences were judged as almost equally unnatural, regardless of the pragmatic bias or gap type. These results suggest that pragmatically 'unambiguous' marking and a distant filler linked to a subject gap are both necessary for a double-gap RC to be acceptable. Second, sentences in the mild bias condition received a high percentage of 'unnatural' ratings, regardless of whether the distant filler was (mildly) biased as an agent or a theme. Although the sentences with a

mildly agent-biased distant filler were judged to be less unnatural than the sentences with a mildly theme-biased distant filler, the difference was very small and significant only in the participant analysis. It seems that sentences in the mild bias condition were treated in a similar manner to those in the null bias condition. Third, sentences in the object-gap condition were rated as equally unnatural, as indicated by the flat line across the three pragmatic bias conditions. Taken together with the second finding, i.e., no distinction between the mild and null bias conditions, the results suggest that pragmatic bias had almost no effect as far as the sentence naturalness is concerned. It helped only when the bias unambiguously indicated that the distant filler was an agent.

To summarize, the results for Q1 showed a preference for linking the distant filler to a subject gap only when the filler was unambiguously marked as the agent (i.e., the strong bias condition). All other sentences were rated as equally ‘unnatural’. Since there was no distinction in naturalness ratings between the unambiguous dispreferred structure (i.e., strong bias object-gap condition) on the one hand and the ambiguous sentences (i.e., sentences in the mild and null bias conditions) on the other, it seems that the naturalness judgment draws on both the ambiguity and the structural preference of a sentence. It will be interesting to examine whether the online processing of these sentences would show the same interaction of these factors as well.

5.1.2.2 Question 2: Gap assignment preference

Question 2 tested how Japanese native speakers interpreted the two fillers in relation to the embedded verb. For convenience, Table 5.3, repeated from Table 5.1,

provides a summary of the six conditions and the sentences given for judgment. Table 5.4 and Figure 5.8 present the results.

Table 5.3. Experiment 3: Summary of conditions and interpretations for Q2.

| Pragmatic bias | Gap type | Embedded predicate | Closer filler | Distant filler | Interpretation presented to participants |
|----------------|----------|--------------------|-----------------|-----------------|--|
| Strong | S-gap | <i>reserved</i> | <i>seat</i> | <i>customer</i> | <i>The customer reserved the seat.</i> |
| | O-gap | <i>reserved</i> | <i>customer</i> | <i>seat</i> | |
| Mild | S-gap | <i>called</i> | <i>clerk</i> | <i>customer</i> | <i>The customer called the clerk.</i> |
| | O-gap | <i>called</i> | <i>customer</i> | <i>clerk</i> | |
| Null | S-gap | <i>called</i> | <i>wife</i> | <i>husband</i> | <i>The husband called the wife.</i> |
| | O-gap | <i>called</i> | <i>husband</i> | <i>wife</i> | |

Table 5.4. Experiment 3: Gap assignment preference for fillers (Q2) (1 yes ~ 5 no).

| | Subject-gap | Object-gap |
|----------------|-------------|------------|
| 1. Strong bias | 1.8542 | 1.9063 |
| 2. Mild bias | 2.0938 | 2.9896 |
| 3. Null bias | 2.5938 | 3.4583 |

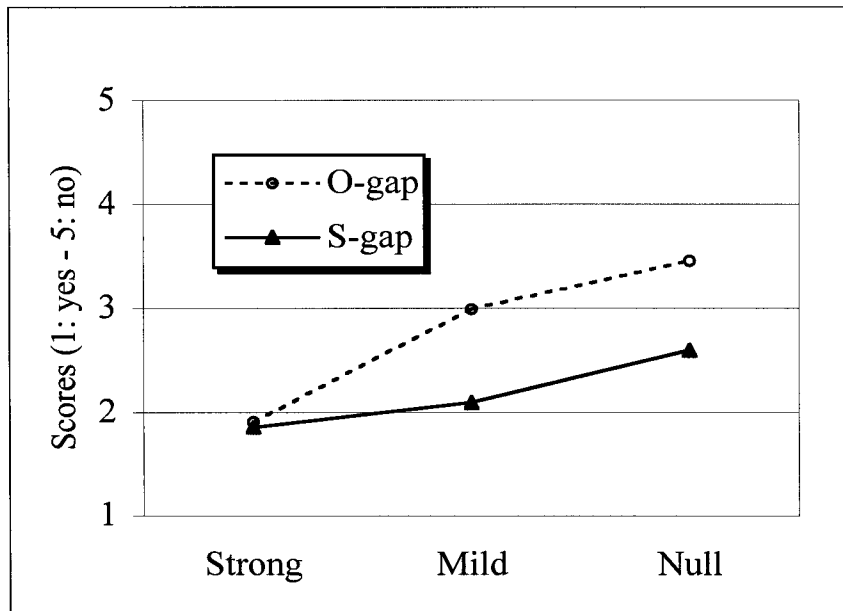


Figure 5.8. Experiment 3: Gap assignment preference for fillers (Q2).

The results of two-way ANOVAs found significant main effects of Pragmatic bias and Gap type and their interaction (Pragmatic bias: $F_1(2,46)=33.604$, $p < .001$, $F_2(2,46)=27.278$, $p < .001$; Gap type: $F_1(1,23)=12.858$, $p = .002$, $F_2(1,23)=12.429$, $p = .002$; Interaction: $F_1(2,46)=7.047$, $p = .002$, $F_2(2,46)=4.169$, $p = .022$). The interaction was due to the absence of a Gap effect in the strong bias condition, while there was a clear Gap difference in the mild and null conditions. The results of one-way ANOVAs confirmed this: a null effect of Gap type in the strong bias condition ($F_1(1,23)=0.099$, $p=0.756$; $F_2(1,23)=0.094$, $p=0.762$), and a significant main effect of Gap type in the other two conditions (mild bias, $F_1(1,23)=12.266$, $p = .002$, $F_2(1,23)=16.042$, $p = .001$; null bias, $F_1(1,23)=13.048$, $p = .001$, $F_2(1,23)=6.288$, $p = .02$).

The null effect of Gap type in the strong bias condition suggests that Japanese speakers consistently accepted the given interpretation (e.g., ‘the customer reserved the seat’), whether ‘customer’ appeared at the distant filler or at the close filler in the sentence they read. Although it was predicted that the strong bias condition would produce more ‘yes’ responses than other bias conditions due to the strong pragmatic constraint, the complete absence of a gap asymmetry in the strong bias condition was unexpected. If there is a preference for assigning the distant filler to a subject gap, sentences in the strong bias object-gap condition should produce more ‘no’ responses because of the mismatch between structural preference and pragmatic support. Interestingly, recall that sentences in this condition were rated as ‘unnatural’ in Q1. It seems that Japanese speakers were forced to interpret the close filler as linked to the

subject gap since the pragmatic information was so strong that no alternative interpretation was possible. But they did not like this (strong bias object-gap) structure.

The absence of gap difference in the strong bias condition clearly contrasted with the patterns found in the mild and null bias conditions, where both the pragmatic bias factor and the gap factor seem to be at work. With regard to the gap difference, more 'no' responses were obtained in the object gap conditions than in the subject gap conditions. Recall that 'yes' response in the subject gap condition corresponded to an interpretation in which the distant filler is associated with a subject gap. In the object-gap condition, the 'yes' response corresponded to an interpretation in which the distant filler is linked to an object gap. The fewer 'yes' responses in the object gap condition than in the subject gap condition suggests that there is a preference among Japanese native speakers for assigning the distant filler to a subject gap over to an object gap. It is, however, important to note that such a preference is manifested only when the pragmatic information constrains weakly enough for an alternative interpretation to be possible. As for the pragmatic bias difference, more 'no' responses were produced in the null bias conditions than in the mild bias conditions. This suggests that the pragmatic bias was weak as intended in the null bias conditions, thus allowed a greater possibility of alternative interpretations compared to the mild bias condition. Whether the pragmatic information supports the preferred structure or the dispreferred structure, interpretation becomes more unstable as the pragmatic bias becomes weaker.

In summary, the results for Q2 revealed two important findings. First, there was a preference to associate the distant filler with a subject gap. Second, pragmatic bias

interacted with gap type. When the bias was so strong that no alternative interpretation was possible, people accepted the dispreferred structure, even though they did not like it. When the bias was not so strong, people's responses became less definitive, reflecting the possibility of alternative interpretations.

5.1.2.3 Question 3

Question 3 examined the possibility of an anomalous association between an intermediate predicate and the immediately following noun. Recall that sentences given for judgment were all syntactically incorrect, with the intermediate predicate anomalously associated with the following noun. Table 5.5 and Figure 5.9 present the results.

Table 5.5. Experiment 3: Anomalous interpretation of intermediate predicate (Q3) (1: yes – 5: no).

| | Subject-gap | Object-gap |
|-------------|-------------|------------|
| Strong bias | 3.6875 | 2.5521 |
| Mild bias | 3.5417 | 3.1354 |
| Null bias | 3.3958 | 3.3854 |

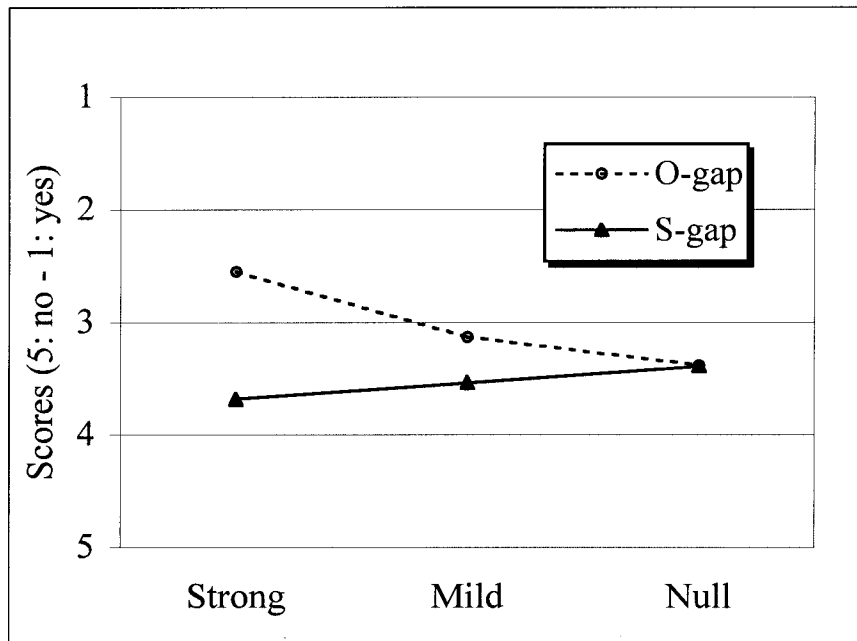


Figure 5.9. Experiment 3: Anomalous interpretation of intermediate predicate (Q3).

A main effect of Gap type and the interaction of Pragmatic bias and Gap type were significant (Gap type: $F_1(1,23)=14.941$, $p = .001$, $F_2(1,23)=23.684$, $p < .001$; Interaction: $F_1(2,46)=6.932$, $p = .002$, $F_2(2,46)=4.749$, $p = .013$). The main effect of Pragmatic bias did not reach significance ($F_1(2,46)=1.628$, $p=.208$, $F_2(2,46)=0.967$, $p=.388$). Sentences in the object-gap condition were in general more prone to the anomalous interpretation than sentences in the subject-gap condition. Moreover, the interaction shows that the difference between the gap conditions differs across the three pragmatic bias conditions.

The results of one-way ANOVAs found that Gap type had a significant effect in the strong bias condition ($F_1(1,23)=21.324$, $p < .001$; $F_2(1,23)=16.647$, $p < .001$), a marginal effect in the mild bias condition ($F_1(1,23)=4.145$, $p=.053$; $F_2(1,23)=3.158$, $p=.089$), and no effect in the null bias condition ($F_1(1,23)=.002$, $p=.962$; $F_2(1,23)=.003$,

p=.96). In separate ANOVA analyses, Pragmatic bias was found to be significant in the object gap condition ($F_1(2,46)=7.019$, $p=.002$; $F_2(2,46)=5.04$, $p=.02$), but not significant in the subject gap condition ($F_1(2,46)=.932$, $p=.401$; $F_2(2,46)=.522$, $p=.597$). Bonferroni pairwise comparisons showed that in the object gap condition, the strong bias condition was significantly different from the null bias condition with both the participant analysis ($p_1=.003$) and the item analysis ($p_2=.047$). None of the other pairs reached significance. These results suggest that the interaction of Pragmatic bias and Gap type seems to be primarily due to the higher rate of ‘yes’ responses in the strong bias object gap condition.

One conclusion drawn from Q3 is that there was only one sentence type that stood out among the six. The sentence in the strong bias object gap condition was more likely to lead to anomalous interpretations, while sentences in the other five conditions were not. This is interesting if we compare these results with those from Question 1 in which sentence naturalness was examined. Recall that in Q1, the sentence in the strong bias subject gap condition was the one that stood out. That is, it is the only sentence type that was judged as ‘natural’. Sentences in all other conditions were rated as ‘unnatural’. If we assume that anomalous interpretations are associated with sentence difficulty as indexed by naturalness ratings, all sentences except for those in the strong bias subject gap condition should have produced an equally high percentage of misinterpretations. What the results in Q3 indicated, however, is that not all ‘difficult’ sentences led to anomalous interpretations. It is the dispreferred structure forced by the strong pragmatic information that seems to cause anomalous interpretations. That is, people wanted to analyze the sentence using a preferred structure (distant filler with a subject gap), but this

was not pragmatically possible. This strong conflict between the pragmatic information and the desired structure somehow impeded the correct interpretation of a sentence, resulting in the high frequency of anomalous interpretations. Other difficult sentences which involved ambiguity did not lead to anomalous interpretations.

5.1.3 Summary

The offline survey reported in this section investigated Japanese native speakers' intuitions about double-gap RCs. Questions were asked concerning the overall naturalness of sentences, the argument relationship of the fillers with an embedded verb, and the possibility of an anomalous association of an intermediate predicate with the following NP.⁶⁹

The major conclusions drawn from this study are as follows. First, double-gap RCs were difficult constructions as demonstrated by a high percentage of 'unnatural' ratings for those structures. The only sentence type that was rated as 'natural' was the subject gap sentence in the strong bias condition. This is the type in which two fillers contrast in animacy and the distant filler corresponds to a subject gap.

Second, there is a preference for interpreting the distant filler as involving a subject gap. A sentence in the (strong bias) subject gap condition was rated as more natural than the other types (Q1). More 'yes' responses were obtained for the sentences whose distant filler was interpreted as the subject of the embedded predicate than the sentences whose close filler was interpreted as the subject (Q2). Furthermore, sentences

⁶⁹ In an analysis including List as a between-participants variable in addition to the two within-participant variables (Pragmatic bias and Gap type), some of the two-way and three-way interactions turned out to be significant for Question 1 and Question 2. I have no explanation for these results.

in the subject condition had a lower rate of misanalysis involving an intermediate predicate (Q3).

This study also found that Gap type and Pragmatic bias interacted with each other in some interesting ways. When the pragmatic information unambiguously supported the preferred structure (with the distant filler linked to a subject gap), the sentence was judged as natural and the interpretation was consistent among participants and items (as shown in Q1 and Q2). On the other hand, when the pragmatic information strongly biased toward the dispreferred structure, more disruption occurred. The sentence was judged as unnatural and more prone to misinterpretation (Q1 and Q3), although people still seemed to maintain the pragmatically plausible interpretation (Q2). When the pragmatic information was not so strongly constraining so that an alternative interpretation was possible, people tended to interpret the distant filler as agent so that the resultant structure conformed to the preferred structure (Q2). The weaker the pragmatic bias, the more likely the alternative interpretations were considered (Q2).

Finally, sentences in the mild bias condition require some comment. The overall results show that this condition patterned more with the null bias condition than with the strong bias condition. For example, the subject-object gap difference was much smaller in the mild bias condition than in the strong bias condition, as demonstrated by a marginal significance both in Q1 (overall naturalness) and Q3 (anomalous association). For question 2 (argument relationship), however, when the relative strength of the pragmatic bias was relevant in the evaluation of how much the preferred or dispreferred structure is supported, there was a distinction between the mild and null bias conditions.

These results suggest that the plausibility contrast used in the mild bias condition is a weak cue and useful only to the extent that it provides additional support for a given structure. In this sense, it differs from the animacy contrast manipulated in the strong bias condition, which is a strong reliable cue that could be used immediately in processing.

To conclude, this survey demonstrated that Japanese native speakers preferred a subject gap to an object gap in interpreting possible gaps for distant fillers of double-gap RCs. This asymmetry was more apparent in sentences whose fillers differed in animacy (i.e., the strong bias condition) than sentences whose fillers were both animate but differed in their plausibility for agency (i.e., the mild bias condition). In the sections that follow, the results of this survey are further examined in two online experiments to see how these different types of information sources are used in online processing and where differences are observed.

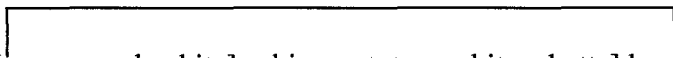
5.2 Experiment 4

This study examined the real-time effect of the subject-object gap asymmetry using a self-paced reading experiment. The offline survey reported in the previous section found that there is a preference among native Japanese speakers for interpreting the distant filler as involving a subject gap. If this preference stems from a difference in computational cost in the process of licensing an RC, i.e., identifying a gap and resolving a filler-gap dependency, the asymmetry should appear at the head noun of the RC and should be detectable experimentally. (See Chapter 3 for related findings from previous studies and chapter 4 for supporting evidence from single-gap RCs.)

The previous chapter tested two different hypotheses that predict the processing difficulty of RCs by making reference to distance between gap and filler. The hypotheses are the Linear Distance Hypothesis and the Structural Distance Hypothesis. The former hypothesis claims that the longer the linear distance between gap and filler, the more difficult it is to process. This account measures distance by counting the number of words (or new discourse referents) intervening between gap and filler (e.g., Gibson 1998, 2000). The latter hypothesis claims that the longer the structural distance, the more difficult to process, where distance is defined structurally in the syntactic representation (O’Grady 1997).

As in the case of single-gap RCs, these two hypotheses make different predictions for the relative difficulty of double-gap RCs. To illustrate them, consider the double-gap RCs in (8). (Here, I am only concerned with the distance between a gap and the distant filler. See Section 5.2.1.6 for reasons.)

(8) a. Double-gap RC with distant filler involving a subject gap




 [[e_i e_j yoyakushita] seki_j-ga totemo kitanakatta] kyaku_i-wa okotteita.

 reserved seat-NOM very dirty-was customer-TOP angry-was

 ‘(Lit)The customer_i [that the seat_j [that e_i reserved e_j] was very dirty] was angry.’

b. Double-gap RC: with distant filler involving an object gap



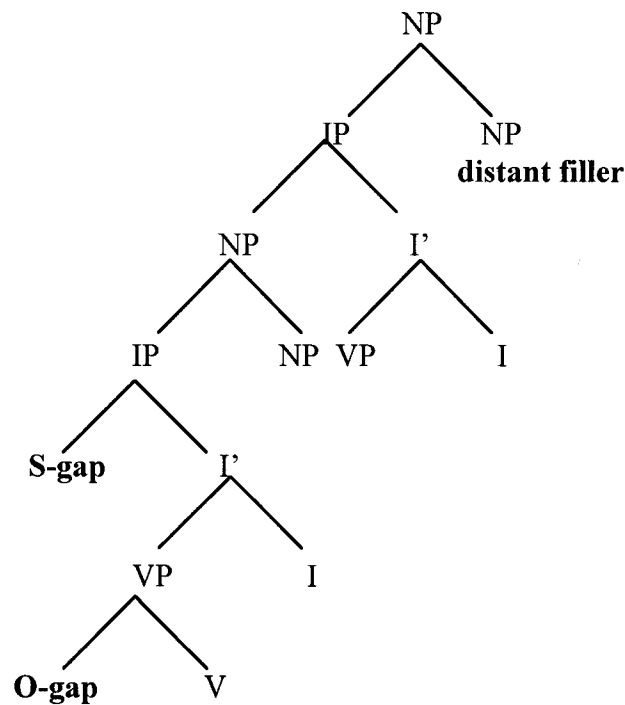
 [[e_i e_j yoyakushita] kyaku_i-ga jikan-ni okureta] seki_j-wa katadukerareteita.

 reserved customer-NOM time-to late-was seat-TOP put-away-was

 ‘(Lit)The seat [that the customer [that e_i reserved e_j] was late] was put away.’

The Linear Distance Hypothesis predicts that sentences (8a) and (8b) will show no differences since the linear distance, calculated in terms of intervening words between ‘customer’ and the subject gap in (8a) is the same as the distance between ‘seat’ and the object gap in (8b). In both cases, four words (three words if the time adverb is not included) intervene between the gap and filler. On the other hand, the Structural Distance Hypothesis predicts that (8a) should be easier to process than (8b) since a subject gap is higher in the structure and thus closer to the distant filler, as illustrated in (9).

(9) Structure of a double-gap RC



This online study tested double-gap RCs only in the strong bias condition (fillers such as ‘customer’ and ‘seat’ as in (8)). There were two reasons to limit the materials to this condition. First, it was the condition that showed the greatest subject-object

asymmetry in the offline study. Therefore, it is likely that an online experiment could detect a difference. If there is a difference, this would serve as baseline data for a subsequent online experiment in which the effect of pragmatic bias could be investigated in more detail. Second, because the two double-gap RCs in (8) contain different lexical items in the critical region (i.e., distant filler), they had to be compared with a pair of control sentences which did not involve a long-distance filler-gap dependency. If an asymmetry is found both in double-gap RCs and control sentences, it is likely that the difference is not due to the computational cost involving the dependency resolution but to different lexical items at critical regions. On the other hand, if an asymmetry is found only in the double-gap RC, it suggests that the difference is a processing effect pertaining to the resolution of filler-gap dependencies. (A more detailed description of control sentences is given later.)

5.2.1 Method

5.2.1.1 Participants

Thirty-two graduate students at NAIST and people from the surrounding community were paid for their participation. All were native speakers of Japanese.

5.2.1.2 Materials

Twenty-four sets of double-gap RCs were prepared for the experiment. Each set consisted of four sentences that differed in terms of two factors, Sentence type (double-gap RCs vs. adverbial clause) and Gap type (subject vs. object) of the distant filler. A sample set of sentences is shown below.

(10) a. Double-gap RC, distant filler involving a subject gap

[[**e_i** e_j yoyakushita] seki_j-ga kitsuenseki-no tonariniatta] **kyaku_i**-wa
reserved seat-NOM smoking-area-GEN next-to-was customer-TOP
hoka-no seki-ni kaesasete.
other-GEN seat-to made-changed
'The customer that the seat that (he) reserved was next to the smoking section
made (them) change to another seat.'

b. Double-gap RC, distant filler involving an object gap

[[**e_i** e_j yoyakushita] kyaku_i-ga jikan-ni okureta] **seki_j**-wa hoka-no
reserved customer-NOM time-to late-was seat-TOP other-GEN
kyaku-ni mawasareta.
customer-to was-given
'The seat that the customer that reserved (it) was late was given to another
customer.'

c. Adverbial clause, matrix topic involving a subject pro

[**pro_i** e_j yoyakushita] seki_j-ga kitsuenseki-no tonariniatta-node **kyaku_i**-wa
reserved seat-NOM smoking-area-GEN next-to-because customer-TOP
hoka-no seki-ni kaesasete.
other-GEN seat-to made-changed
'Because the seat that (pro) reserved was next to the smoking section, the
customer made (them) change to another seat.'

d. Adverbial clause, matrix topic involving an object pro

[**e_i** **pro_j** yoyakushita] kyaku_i-ga jikan-ni okureta-node **seki_j**-wa hoka-no
reserved customer-NOM time-to late-was-because seat-TOP other-GEN
kyaku-ni mawasareta
customer-to was-given
'Because the customer that reserved (pro) was late, the seat was given to another
customer.'

Sentences (a) and (b) are double-gap RCs, and sentences (c) and (d) are control sentences with adverbial clauses. In sentence (a), the distant filler 'customer' is associated with a subject gap in the most embedded clause, while in sentence (b), the distant filler 'seat' is associated with an object gap. For each sentence, the thematic role

of each filler is pragmatically disambiguated. For example, ‘customer’ is the only plausible agent and ‘seat’ is the only plausible theme for the verb ‘reserve’. Furthermore, the intermediate predicate (words 3 and 4) was constructed so that it was semantically incompatible with the immediately following NP (word 5). This was to avoid a possible misanalysis, as was reported in the Experiment 3.

The structural difference between double-gap RCs and control sentences with adverbial clauses needs some explanation. The control sentences consisted of an adverbial clause and a matrix clause. The adverbial clause started from the beginning of the sentence and ended with a conjunction ‘because’ that was attached to its predicate. Half of the test sentences contained the conjunction *node* and the other half contained the conjunction *tameni*, both of which mean ‘because’ in Japanese. This was to prevent participants from paying attention to sentences with a particular lexical item. The most important difference between the double-gap RCs and the control sentences was the function of the critical word (in bold). In double-gap RCs, it was the matrix topic serving as the second filler of a preceding RC. This filler formed a filler-gap dependency with one of the gaps. In the control sentences, it was the matrix topic. Because the immediately preceding clause was not an RC, the matrix topic did not form a filler-gap dependency. Instead, it formed a coreferential relationship with a null pronoun in the most embedded RC.

Except for the conjunction ‘because’ attached to the predicate of the adverbial clause, the control sentences (c) and (d) were identical to the double-gap RCs (a) and (b) respectively. A complete set of test sentences is provided in Appendix G.

These twenty-four sets of quadruplets were distributed into the four lists for presentation to participants. Sixty non-experimental sentences with various structures were inserted into each list in a pseudo-random order so that at least one non-experimental sentence intervened between any two test sentences.

5.2.1.3 Design

Experiment 4 was designed for a two-way ANOVA with repeated measures on two factors – Sentence type and Gap type. The first factor, Sentence type, had two levels (double-gap RC vs. control sentence), and the second factor, Gap type, had two levels (subject gap vs. object gap). Crossing these two factors, the experiment had a total of four conditions. There were two dependent variables – response accuracy to the end-of-sentence comprehension questions (%) and reading times (msec.) of each region of a sentence. See Section 5.2.1.7 for the procedure to calculate each dependent measure.

5.2.1.4 Pretest norming study 3

Since Experiment 4 used slightly different sets of materials from those used in Experiment 3, a plausibility norming study was conducted in order to ensure two points – (1) whether the pragmatic bias manipulated in the fillers had the intended effect, and (2) whether the intermediate predicate was semantically incompatible with the immediately following NP. A complete description of the pretest and the results are provided in Appendix B.

5.2.1.5 Procedure

The procedure for the main experiment was identical to that described for single-gap RCs in chapter 4. Participants read sentences silently in a word-by-word self-paced reading experiment with moving-window presentation. The slashes in (11) show the segmentation of a test sentence.

(11) a. Double-gap RC, distant filler involving a subject gap

| | | | | |
|-------------------|--------------|------------------|----------------|--------------|
| w1 | w2 | w3 | w4 | w5 |
| Yoyakushita / | seki-ga / | kitsuenseki-no / | tonariniatta / | kyaku-wa / |
| reserved | seat-NOM | smoking-area-GEN | next-to-was | customer-TOP |
| | | | | |
| w6 | w7 | | | |
| hoka-no seki-ni / | kaesaseta. | | | |
| other-GEN seat-to | made-changed | | | |

‘The customer that the seat that (he) reserved was next to the smoking section made (them) change to another seat.’

At the end of each sentence, a comprehension question appeared and asked about the content of the embedded clause, the intermediate clause, or the main clause. The participant answered by pressing either the ‘yes’ or ‘no’ button. The number of correct ‘yes’ and ‘no’ answers and question types were counterbalanced across lists. No feedback was provided for participant’s answers.

5.2.1.6 Predictions

This experiment tested the predictions proposed by the two distance metrics. The Linear Distance Hypothesis counts the number of words (discourse referents) between gap and filler, and predicts no difference between the subject and the object conditions of

double-gap RCs. This is because a subject gap and an object gap are adjacent to each other in the most embedded clause, and consequently equally far from the distant filler. The Structural Distance Hypothesis, on the other hand, predicts that double-gap RCs with a distant filler involving a subject gap are easier to process than double-gap RCs with a distant filler involving an object gap. A subject gap is structurally higher than an object gap in the structure, and thus closer to the distant filler.

The critical region of comparison was region 5, which contained the distant filler for a double-gap RC and the matrix topic for a control sentence. There are several reasons why the distant filler was chosen as the critical region. At the close filler (region 2), the reader has only seen a verb and a filler. Upon seeing a transitive verb, the parser postulates two gaps. When the close filler is received, a decision has to be made about its dependency. There are two options – to resolve the dependency with a subject gap or with an object gap. However, it is possible that this decision can be influenced by multiple factors, such as an inherent processing cost between different gaps, the relative frequency of a dropped argument, a preference for filling either one of the positions in an argument grid, and so forth. At the distant filler, on the other hand, the processing of the filler is more constrained, since one of the gaps has already been filled (at the close filler). Recall that in this experiment, the thematic roles of the fillers were pragmatically disambiguated. It is assumed that regardless of the various factors involved, the resolution of the first dependency is completed at the close filler or soon after that, and so little ambiguity would be carried over to the distant filler. Since it is pragmatically clear

which gap the distant filler must be assigned to, it is possible to detect any inherent processing cost associated with resolving a filler-gap dependency.

The following summarizes the predictions for Experiment 4. The Linear Distant hypothesis predicts that there should be no difference between sentences in which the distant filler corresponds to a subject gap and those in which the distant filler corresponds to an object gap. Thus, reading times of the distant filler in the two gap conditions should be the same. The Structural Distance Hypothesis predicts that a dependency with a subject gap should be easier than a dependency with an object gap. Therefore, the reading time of the distant filler should be shorter when it corresponds to a subject gap than when it corresponds to an object gap.

As for the control sentences, which do not involve a long-distance filler-gap dependency, neither hypothesis predicts a difference between the matrix topic coindexed with a dropped subject argument and the matrix topic coindexed with a dropped object argument. Therefore, unless there is a difference that stems from different lexical items at these positions, no processing difference is expected within these control sentences.

Assuming that there is no difference attributed to different lexical items at the critical region, the Structural Distance Hypothesis predicts a significant effect of Gap type for the double-gap RC construction, while the Linear Distance Hypothesis predicts a null effect of Gap type for the double-gap RC construction. On the other hand, neither hypothesis predicts an effect of Gap type in the control sentences, which do not involve a filler-gap dependency at the critical region. Therefore, the Structural Distance Hypothesis also predicts a reliable interaction of Gap type and Sentence type, while the

Linear Distance Hypothesis predicts no such interaction. Finally, both hypotheses should predict a main effect of Sentence type. Previous studies including Experiment 1 and 2 of the present study have shown that the processing of a filler-gap dependency is costly compared to structures without such a dependency. If this is true, double-gap RCs should be generally more difficult than the control sentences, regardless of Gap type.

5.2.1.7 Data analysis

All participants' data were used for the data analysis. The mean percentage of correct response for all test sentences plus the twenty-eight filler sentences was 89.5%, ranging from 71.2 to 100%.

The experiment had two dependent variables – response accuracy to end-of-sentence comprehension questions and the reading time for each region of a test sentence. For the comprehension questions, each condition's mean response accuracy (%) was calculated for each participant and for each item. For the reading times, each condition×region mean reading time was calculated for each participant and for each item. For each dependent variable, two-way ANOVAs with repeated measures on both Sentence type (RC vs. Control) and Gap type (Subject vs. Object) were carried out in order to examine the effect of each independent variable and an interaction of the two factors. Separate ANOVAs were performed, one treating the two factors as within-participant (F_1) variables and one treating them as within-item (F_2) variables. When the interaction of the two factors turned out to be significant, subsequent analyses were conducted in order to examine the nature of the interaction.

For reading times, no data was removed from analyses and no trimming procedure was conducted. The results presented below are thus raw reading times for each region.

5.2.2 Results

5.2.2.1 Comprehension questions

The mean percentage of correct response to end-of-sentence comprehension questions is given below.

Table 5.6. Experiment 4: Mean response accuracy for comprehension questions.

| | Double-gap RC | Control |
|-------------|---------------|---------|
| Subject gap | 93.2% | 94.8% |
| Object gap | 87.5% | 89.1% |

There was a significant main effect of Gap type ($F_1(1,31)=7.699$, $p = .009$; $F_2(1,23)=4.41$, $p = .047$), as demonstrated by the higher percentage of correct responses to subject gap conditions than to object gap conditions. The tests of Sentence type and the interaction of the two factors did not reach significance ($p < .1$). In sum, subject gap sentences were comprehended better than object gap sentences regardless of sentence type.

Neither the Structural Distance Hypothesis nor the Linear Distance Hypothesis predicted a main effect of Gap type without an interaction of Gap and Sentence type. However, it is too early to draw any conclusion at this point. Overall sentence comprehension does not necessarily reflect processing difficulty at particular points in a sentence but could also reflect other factors, such as sentence plausibility and discourse

integration. What seems important here is that the response accuracy was generally high, which suggests that the sentences were comprehensible.

5.2.2.2 Reading times

Table 5.7 and Figure 5.10 present the reading time results.

Table 5.7. Experiment 4: Mean reading times (msec.).

| | W1 (V) | W2 (NP) | W3 (NP/PP) | W4 (V) | W5 (NP) | W6 (NP/PP) | W7 (V) |
|-------------------|-----------|------------|---------------|-----------|------------|---------------|-----------|
| a. RC, S-gap | 790 | 777 | 739 | 771 | 885 | 593 | 703 |
| b. RC, O-gap | 787 | 966 | 902 | 814 | 1149 | 648 | 774 |
| c. Control, S-gap | 727 | 864 | 695 | 903 | 630 | 570 | 741 |
| d. Control, O-gap | 768 | 925 | 870 | 965 | 617 | 582 | 705 |

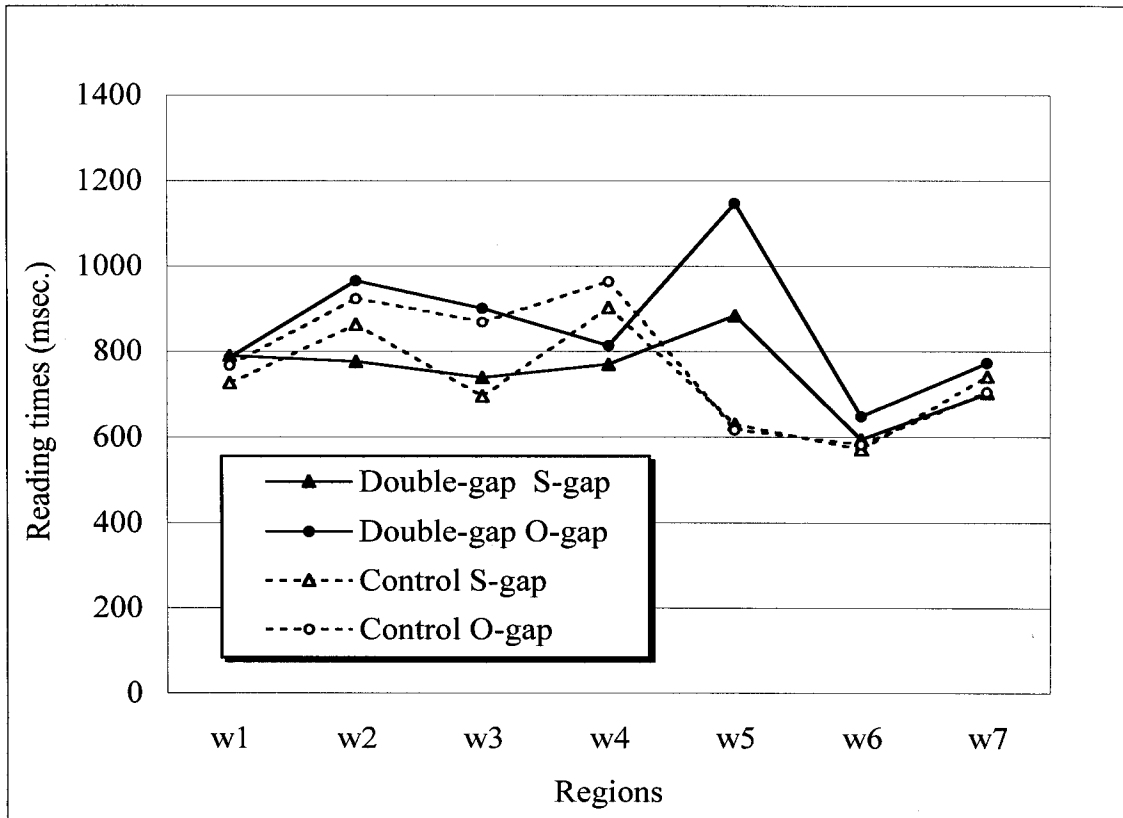


Figure 5.10. Experiment 4: Mean reading times (msec.)

At word 2 (the close filler), sentences in the object gap condition were read significantly more slowly than sentences in the subject gap condition regardless of the sentence type (Gap type: $F_1(1,31)=6.710$, $p = .014$, $F_2(1,23)=16.906$, $p < .001$), and this effect was extended into the next region, word 3 (Gap type: $F_1(1,31)=13.430$, $p = .001$, $F_2(1,23)=8.461$, $p = .008$). Other factors were not significant in any of the regions ($p < .1$). (See the discussion section for possible interpretations for these results.)

At word 4 (the verb of the intermediate/adverbial clause), there was a significant main effect of Sentence type ($F_1(1,31)=9.980$, $p = .004$, $F_2(1,23)=8.697$, $p = .007$), as demonstrated by the longer reading time in the control sentences (mean = 934) than in the double-gap RCs (mean = 792.5). This seems to be due to an extra morpheme (*-node* or *-tameni* ‘because’) attached to the predicate of an adverbial clause. Other effects were not significant ($p > .1$).

At word 5 (the distant filler), there was a reliable effect of Sentence type ($F_1(1,31)=40.462$, $p < .001$, $F_2(1,23)=49.097$, $p < .001$), Gap type ($F_1(1,31)=5.337$, $p = .028$, $F_2(1,23)=6.333$, $p = .019$) and an interaction of the two factors ($F_1(1,31)=4.734$, $p = .037$, $F_2(1,23)=5.258$, $p = .031$). A main effect of Sentence type was due to the fact that Japanese readers spent significantly longer reading the distant filler of double-gap RCs than reading the matrix topic of control sentences. This suggests that the processing of sentences with a long-distance filler-gap dependency is more costly than sentences without such a dependency. Furthermore, the interaction indicates that the Gap type did not have a uniform effect across Sentence types. In double-gap RCs, the distant filler involving a subject gap was read significantly faster than the distant filler involving an

object gap. (One-way ANOVAs found a reliable effect, $F_1(1,31)=5.968$, $p = .02$; $F_2(1,23)=6.31$, $p = .019$). In the control sentences, by contrast, the reading time did not differ between the matrix topic linked to a dropped subject in an adverbial clause and the matrix topic linked to a dropped object. (One-way ANOVAs found a null effect of Gap type: $F_1(1,31)=.068$, $p = .796$; $F_2(1,23)=.128$, $p = .724$). The absence of a gap asymmetry in the control sentences suggests that the gap contrast found in the double-gap RCs was unlikely to be due to the difference in lexical items. If it were, a similar contrast should have been observed in the control sentences. These results suggest that there is an inherent processing difference between filler-gap dependencies and antecedent-pronoun anaphoric processes, and the former process is sensitive to the position of a gap involved. Overall, a processing advantage for a subject gap in the processing of double-gap RCs is consistent with the prediction of the Structural Distance Hypothesis.

No other effects were significant in any other regions.

5.2.3 Discussion

Experiment 4 examined the online processing of double-gap RCs.⁷⁰ The results of a self-paced reading experiment provided additional support for a subject gap advantage. A distant filler (of a double-gap RC) associated with a subject gap was read significantly faster than a distant filler associated with an object gap. Since the

⁷⁰ A statistical note: ANOVAs including List as a between-participant variable found various two-way and three-way interactions at each region of a sentence and in comprehension questions. Since some of the interactions, such as a Sentence type×List interaction, were found in the regions where lexical items were identical across lists, these interactions seem to be due to a difference in participants who were randomly assigned to each list. As suggested in the previous chapter, increasing the number of participants for each list and data trimming may resolve these problems in future studies.

corresponding regions in the control sentences did not show any asymmetry, the subject-object asymmetry found at the distant filler of double-gap RCs seems to reflect a processing consequence of resolving a filler-gap dependency at the filler, as predicted by the Structural Distance Hypothesis.

Experiment 4 found two major differences between double-gap RCs and the control sentences. The distant filler of a double-gap RC was generally read more slowly than the corresponding region of a control sentence. Also, there was a gap asymmetry in double-gap RCs, while there was no equivalent asymmetry found in control sentences. It seems that two different processes are taking place at the critical region (region 5). In a double-gap RC, the recognition of an RC structure and the resolution of a dependency take place at the head noun position. It is therefore reasonable to assume that greater processing resources are required at this position. Furthermore, because the resolution of a filler-gap dependency is a computational operation on syntactic structure for the purpose of licensing an RC, processing gaps at different structural positions must have an immediate processing effect. In the control sentences, the matrix topic does not involve a filler-gap dependency. It only serves as the antecedent of a missing argument that appears in the most embedded RC. This involves a pronoun-antecedent anaphoric process. It has been proposed by many researchers that the interpretation of plain pronouns is resolved pragmatically rather than syntactically (O'Grady 2001, and references therein). For example, "there is no principled limit on the set of potential antecedents for a plain pronoun, which can have a more distant antecedent and can even be used deictically" (p.9). The well-known constraint that a pronoun cannot have a local

antecedent can also be achieved through a general functional principle that a plain pronoun should not occur in a context whose referential dependency can be fulfilled by a more restrictive reflexive pronoun (p.9). The structural position of a (null) pronoun therefore has no relevance for its interpretation. Since it is not computed on structure, the structural position of a (null) pronoun has no relevance for its interpretative process. It follows that the greater processing cost and the gap asymmetry found at the distant filler of a double-gap RC is likely to be a result of the online resolution of a filler-gap dependency on the basis of structure.

Another finding that needs discussion is the increased processing load observed at the close filler (word 2) and the following region (word 3) in the double-gap RC, object gap condition. A sentence example is given below.

(12) Double-gap RC, distant filler involving an object gap (=10b))

| | | | | | | |
|---------------------------------|---|------------------------|----------|-----------|-----------------------|-----------|
| | w1 | w2 | w3 | w4 | w5 | w6.... |
| [[e _i e _j | yoyakushita] | kyaku _i -ga | jikan-ni | okureta] | seki _j -wa | hoka-no |
| | reserved | customer-NOM | time-to | late-was | seat-TOP | other-GEN |
| | kayku-ni | mawasareta. | | | | |
| | customer-to | was-given | | | | |
| | 'The seat that the customer that reserved (it) was late was given to another customer.' | | | | | |

As stated earlier, the exact cause of this increased processing load is difficult to determine because there are multiple possibilities. Whatever the reason is, however, it appears that when two gaps are being postulated, filling a subject gap with the close filler is dispreferred over filling an object gap with that filler. The assumption that the parser recognizes the presence of two gaps is especially important here. If it is just a matter of

resolving a single filler-gap dependency, previous results (including ones from this thesis) have shown that a subject gap has an advantage over an object gap. In that case, filling a subject gap with the close filler should be easier. But the results from the current experiment suggest that when two gaps are presented, filling an object gap with the close filler was much easier.

There are two likely factors that may account for this reversal – the consideration of pro-drop frequency and a preference for filling the theme slot over the agent slot on the theta grid of a transitive predicate. In Japanese, both subject drop and object drop are permitted. But the former is more common than the latter. If the parser is informed online by such frequency, it may want to assign the close filler to an object gap since the resultant configuration conforms to the more frequent structure, i.e., a sentence with a dropped subject. Alternatively, the parser may prefer to assign the close filler to an object gap first over a subject gap because of thematic/argument relations. It has been argued that there is an asymmetry among verbal arguments and that a direct object has a closer relationship with its predicate than does a subject (Chomsky 1981, Marantz 1984, O’Grady 1999, among others). For example, Marantz (1984:27) argues that “choice of object (or other argument of a verb) affects the semantic role of the logical subject whereas choice of logical subject does not affect the semantic role of the object”. That is, the thematic role of a subject can be determined by the choice of a direct object, but the thematic role of a direct object cannot be determined by the choice of a subject. If one of the major tasks of sentence processing is to assign thematic roles to verbal arguments, assigning the filler to an object gap facilitates the thematic role assignment process and as

a consequence, facilitates the building of a sentence structure. However, further studies are needed in order to examine what the preference is in assigning a filler to multiple gaps and what kind of factors affect such a decision-making process.

Finally, one limitation of this experiment should be noted. The grammatical relation of the head noun was not manipulated. Recall that in the study of single-gap RCs, it was found that relation mismatch between a filler and a gap makes the processing of object-gap RCs more difficult. If the same is true for the double-gap RC construction, the processing difficulty involved in a sentence whose distant filler corresponds to an object gap may be caused or increased by the relation mismatch between the gap and the distant filler, which had a topic marker in this study. Whether or not changing the topic marker to an accusative marker can reduce the processing difficulty at this position is an empirical question that can be tested independently.

In conclusion, the results of the first online experiment on double-gap RCs found a preference for double-gap RCs whose distant filler involves a subject gap over those with an object gap. This is consistent with the results of an offline study which collected native speakers' intuitive judgments about the construction. A close examination of the time course of processing revealed that the asymmetry appeared at the predicted distant filler position. This suggests that the subject-object asymmetry is due to a processing consequence of resolving a filler-gap dependency on the basis of syntactic structure, as was found in single-gap RCs in Chapter 4. Furthermore, a clear subject-object asymmetry observed in double-gap RCs and no equivalent asymmetry in control sentences suggests that resolving a filler-gap dependency is fundamentally different from

coreferential process between a (null) pronominal and its antecedent. The former is a computational operation on syntactic structure, and the structural position of a gap is crucial in predicting the computational cost required to resolve a dependency. The latter, on the other hand, is a process resolved by making reference to discourse or pragmatic knowledge, which does not need to be defined on syntactic structure. Therefore, an immediate computational effect, the subject-object gap asymmetry, does not need to be manifested at the point of encountering an antecedent. Rather, its pragmatic or discourse effect is more likely to appear in the global interpretation process as demonstrated by the gap asymmetry in response accuracy to comprehension questions.

5.3 Experiment 5

The two experiments on the processing of double-gap RCs (Experiment 3 and 4) have shown that a general preference for interpreting the distant filler as the subject of the embedded predicate in fact stems from a computational advantage of a subject gap in the resolution of a long-distance filler-gap dependency. The distant filler involving a subject gap was read significantly faster than the distant filler involving an object gap, while there was no equivalent asymmetry in the control sentences without such a dependency. Given that double-gap RCs are structurally ambiguous with no morphosyntactic information specifying the dependencies between gaps and fillers, the results of these experiments suggest that the Japanese parser actively makes use of plausibility information of the fillers in the analysis of this construction. Then, a question arises as to how the manipulation of plausibility information affects the online processing of double-gap RCs, in particular, the gap asymmetry observed at the distant filler. In Experiment 4,

the test materials were all pragmatically disambiguated, meaning that for a given pair of fillers (close filler and distant filler), their thematic roles were uniquely identified pragmatically. In order to test the effect of manipulating pragmatic information, Experiment 5 included two additional levels of pragmatic bias, mild bias and null bias. In the mild bias conditions, one of the fillers was more plausible as an agent than the other one. In the null bias conditions, the two fillers were equally good as agent and theme. See Section 5.3.1.6 for specific predictions prepared for Experiment 5.

5.3.1 Method

5.3.1.1 Participants

Twenty-four graduate students at NAIST and people from the surrounding community were paid for their participation. All were native speakers of Japanese and naïve to the purpose of this study.

5.3.1.2 Materials

Twenty-four sets of sentences related to those used in the offline survey served as the test sentences for this experiment.⁷¹ Each set had the following six conditions, crossing Pragmatic bias (strong bias vs. mild bias vs. null bias) and Gap type (subject gap vs. object gap). A sample set of the test sentences is shown below.

⁷¹ In the offline survey, all six conditions had an intermediate predicate (i.e., word 4) that was semantically compatible with the immediately following noun (i.e., the distant filler). In Experiment 5, the intermediate predicate of the strong bias sentences (i.e., sentences (11a) and (11b)) was semantically incompatible with the immediately following noun (as in Experiment 4), whereas that of mild bias and null bias sentences (i.e., sentences (11c) ~ (11f)) was semantically compatible.

(13) a. Strong bias, distant filler involving a subject gap

[[e_i e_j yoyakushita] seki_j-ga kitsuenseki-no tonariniatta] kyaku_i-wa hoka-no
reserved seat-NOM smoking-area-GEN next-to-was customer-TOP other-GEN
seki-ni kaesasete.
seat-to made-changed

Plausible interpretation: 'The customer that the seat that (he) reserved was next to the
smoking section made (them) change to another seat.'

Implausible interpretation: 'The customer that the seat that reserved (him) was next to
the smoking section made (them) change to another seat.'

b. Strong bias, distant filler involving an object gap

[[e_i e_j yoyakushita] kyaku_i-ga jikan-ni okureta] seki_j-wa hoka-no kayku-ni
reserved customer-NOM time-to late-was seat-TOP other-GEN customer-to
mawasareta.
was-given

Plausible interpretation: 'The seat that the customer that reserved (it) was late was
given to another customer.'

Implausible interpretation: 'The seat that the customer that (it) reserved was late was
given to another customer.'

c. Mild bias, distant filler involving a subject-gap

[[e_i e_j yonda] teni_j-ga totemo shitsureidatta] kyaku_i-wa tenchoo-ni koogishita.
called clerk-NOM very rude-was customer-TOP manager-to complained

More plausible interpretation: 'The customer that the clerk that (he) called was very
rude complained to the manager.'

Less plausible interpretation: 'The customer that the clerk that called (him) was very
rude complained to the manager.'

d. Mild bias, distant filler involving an object-gap

[[e_i e_j yonda] kyaku_i-ga totemo shitsureidatta] teni_j-wa tenchoo-ni soodanshita.
called customer-NOM very rude-was clerk-TOP manager-to consulted

More plausible interpretation: 'The clerk that the customer that called (him) was
very rude consulted with the manager.'

Less plausible interpretation: 'The clerk that the customer that (he) called was very
rude consulted with the manager.'

e. Null bias, distant filler involving a subject-gap

[[e_i e_j yonda] tsuma_j-ga terebi-o miteita] otto_i-wa niwa-ni deta.
called wife-NOM TV-ACC watching-was husband-TOP yard-to went

Assigned interpretation: 'The husband that the wife that (he) called was watching TV went out to the yard.'

Equally possible interpretation: 'The husband that the wife that called (him) was watching TV went out to the yard.'

f. Null bias, distant filler involving an object-gap

[[e_i e_j yonda] otto_i-ga terebi-o miteita] tsuma_j-wa niwa-ni deta.
called husband-NOM TV-ACC watching-was wife-TOP yard-to went

Assigned interpretation: 'The wife that the husband that called (her) was watching TV went out to the yard.'

Equally possible interpretation: 'The wife that the husband that (she) called was watching TV went out to the yard.'

The definition of each factor was the same as in the offline study. Pragmatic bias refers to the strength of any pragmatic bias (i.e., people's world knowledge or common sense) that constrained the interpretation of fillers. In the strong bias condition, the thematic role of fillers was pragmatically unambiguous. In the mild bias condition, one filler was pragmatically more plausible than the other. In the null bias condition, both fillers were equally plausible as agent or theme.

The second factor, Gap type, refers to the gap in the most embedded clause with which the distant filler is associated. In the subject-gap condition, the distant filler was associated with a subject-gap, while in the object-gap condition, the distant filler was associated with an object-gap. The assignment of gap type in the null bias condition was made arbitrarily since the fillers in this condition were biased as neither an agent nor a theme. A complete list of experimental materials used in Experiment 5 is given in Appendix H.

These twenty-four sets of six sentences were distributed into six presentation lists using a Latin Square procedure. Sixty-one non-experimental sentences were inserted into each list in a pseudo-random order so that at least one non-experimental sentence intervened between any two test sentences.

5.3.1.3 Design

Experiment 5 was designed for a two-way ANOVA with repeated measures on both of the independent variables – Pragmatic bias and Gap type. Pragmatic bias had three levels (strong vs. mild vs. null) and Gap type had two levels (subject gap vs. object gap). Crossing these two factors, Experiment 5 had a total of six experimental conditions. The effect of these independent variables was examined on two types of dependent measures – interpretation choice and reading time of each region. See Section 5.3.1.7 for the calculation procedure of these dependent measures.

5.3.1.4 Pretest norming study 4

A plausibility norming study was conducted in order to examine the plausibility of each filler as an agent or a theme. Unlike the pretest reported for Experiment 3 and 4, participants judged the plausibility of each filler as an agent or a theme without making reference to the other filler. The results of this survey were particularly useful for Experiment 5 in certain respects. Note that in the online processing of double-gap RCs, the parser has to make a decision about the dependency at the close filler without knowing the upcoming distant filler. In this sense, the plausibility judgment that was made on the basis of one filler and a transitive predicate gives us a clue about the

dependency decision the parser has to make at the close filler. A complete description of the survey and the results are provided in Appendix C.

5.3.1.5 Procedure

The present experiment used a word-by-word self-paced reading experiment with moving-window presentation. The basic procedure was identical to the one described for the other experiments. The only difference was the type of end-of-sentence question. An interpretation was presented at the end of each sentence, and the participant was asked to respond by pressing the ‘yes’ or ‘no’ button depending whether or not the interpretation was consistent with the content of the sentence just read. Table 5.8 provides a sample interpretation for each condition.

Table 5.8. Experiment 5: Sample end-of-sentence interpretation choices.

| Pragmatic bias | Gap type | Embedded predicate | Closer filler | Distant filler | Interpretation presented to participants |
|----------------|----------|--------------------|-----------------|-----------------|--|
| Strong | S-gap | <i>reserved</i> | <i>seat</i> | <i>customer</i> | <i>The customer reserved the seat.</i> |
| | O-gap | <i>reserved</i> | <i>customer</i> | <i>seat</i> | |
| Mild | S-gap | <i>called</i> | <i>clerk</i> | <i>customer</i> | <i>The customer called the clerk.</i> |
| | O-gap | <i>called</i> | <i>customer</i> | <i>clerk</i> | |
| Null | S-gap | <i>called</i> | <i>wife</i> | <i>husband</i> | <i>The husband called the wife.</i> |
| | O-gap | <i>called</i> | <i>husband</i> | <i>wife</i> | |

5.3.1.6 Hypotheses and predictions

Before presenting the predictions for Experiment 5, several assumptions need to be made clear. First, it is assumed that the Japanese parser conducts a structural analysis incrementally by making use of available information in a sentence. Second, in the absence of overt morphosyntactic information, the parser is assumed to utilize other information sources, such as semantic/pragmatic information, in order to make structural

decisions. Third, the Japanese parser recognizes an RC structure when the filler is received. That is, the postulation of a gap does not automatically lead to the postulation of an RC structure. In the case of double-gap RCs, this means that the parser will not recognize the second relativization until the distant filler is encountered. Upon encountering the close filler, the parser assumes that the sentence involves a single-gap dependency and interprets the unfilled gap as a missing argument. This analysis is maintained until the distant filler appears.

In Experiment 5, the predictions regarding processing cost at the distant filler are constructed in relation to the processing decisions that are assumed to be made at the close filler. This is because the inclusion of the mild and null bias conditions would introduce ambiguity to the decision making at each filler. In the case of the strong bias condition, both the close filler and the distant filler are fully pragmatically disambiguated. Therefore, the resolution of the first dependency is assumed to be completed at the close filler or soon after that, and little ambiguity would be carried over to the distant filler. The distant filler would be assigned to an unfilled gap rapidly following the strong pragmatic bias. In the case of mild bias and null bias conditions, on the other hand, both fillers are human, animate entities, and thus the thematic roles of fillers are more or less pragmatically ambiguous. It is likely that processing decisions at the close filler would exhibit variation, and consequently a certain amount of reanalysis, interference, and conscious evaluation of the thematic plausibility of two fillers would take place at the distant filler. It follows that the processing cost at the distant filler depends on the analysis the parser conducted at the close filler.

A list of factors that are assumed to play a role at the close filler is presented in (14). Among the four factors, I assume that animacy/thematic fit of a filler is the most important factor (e.g., Hirose 1999, MacDonald, Pearlmutter, Seidenberg 1994a, Trueswell, Tanenhaus, Garnsey 1994, among others that found a role for semantic/pragmatic information during processing).

(14) Factors at the close filler

a. Animacy/thematic fit of the filler

If animacy is the sole factor that influences a parsing decision, there is a preference to associate an animate noun to the agent and an inanimate noun to the theme of a verb. For verbs that take two animate arguments, an animate noun at the close filler is likely to be interpreted as the agent. This is because without information from the other argument, it is difficult to evaluate the plausibility of its thematic role on the basis of the close filler alone. Alternatively, the parser may use more detailed thematic plausibility of the close filler even without receiving the distant filler. In this case, the more plausible agent NP is assigned to the subject gap and the more plausible theme NP to the object gap.

b. Computational cost associated with gaps

There is a preference for assigning the filler to a subject gap over an object gap. A subject gap is higher in the structure, thus closer to the filler. Therefore, a dependency with a subject gap is computationally less costly than with an object gap.

c. The Argument hierarchy

There may be a preference to fill the theme slot of a verb's argument grid first. This would fulfill the thematic role requirement of an internal argument, create a VP node earlier, and/or determine the thematic role of the subject argument (Chomsky 1981, Marantz 1984, O'Grady 1999, and references therein.).

d. Pro-drop frequency

Subject drop is more frequent and natural than object drop. Therefore, there may be a preference for assigning a filler to an object gap so that the resultant configuration contains a missing subject argument.

Two different types of predictions are made at the close filler based on the following two hypotheses.

(15) Hypothesis 1

The assignment of a gap for the close filler is determined based on the thematic fit of the filler. [$X \rightarrow Y$] is interpreted as 'if the filler has the property of X, then it is assigned to Y']

- Strong bias: animate \rightarrow subject gap; inanimate \rightarrow object gap
- Mild bias: plausible agent \rightarrow subject gap; plausible theme \rightarrow object gap
- Null bias: ambiguous \rightarrow other factors determine the decision
e.g., Follow animacy \rightarrow subject gap
Follow argument hierarchy or pro-drop \rightarrow object gap

Under this hypothesis, the parsing decision is determined on the basis of the plausibility of the close filler as a possible argument of the embedded verb. The animate filler in the strong bias condition is assigned to the subject gap, and the inanimate filler to the object gap. In the mild bias condition, the plausible agent filler will be assigned to a subject gap and the plausible theme filler will be assigned to an object gap. In the null bias condition, since the fillers are ambiguous in terms of thematic plausibility, the decision will be influenced by various factors, such as the animacy of the filler, pro-drop frequency, and argument hierarchy. As a result, the gap assignment pattern in this condition will exhibit variation. The following is a summary of the predictions under this hypothesis.

Table 5.9. Experiment 5: Predictions for closer filler – Hypothesis 1:
Parsing decision based on thematic fit.

| Condition | | W1 | W2 | | Cost | |
|----------------|----------|-----------------|-----------------|--------------|--------------------|---------------------|
| Pragmatic bias | Gap type | Verb | Close filler | Assigned gap | Confirming factors | Conflicting factors |
| Strong | Subject | <i>reserved</i> | <i>seat</i> | Object gap | a, c, d | b |
| | Object | <i>reserved</i> | <i>customer</i> | Subject gap | a, b | c, d |
| Mild | Subject | <i>called</i> | <i>clerk</i> | Object gap | a, c, d | b |
| | Object | <i>called</i> | <i>customer</i> | Subject gap | a, b | c, d |
| Null | Subject | <i>called</i> | <i>wife</i> | Subject gap | b | c, d |
| | | | | Object gap | c, d | b |
| | Object | <i>called</i> | <i>husband</i> | Subject gap | b | c, d |
| | | | | Object gap | c, d | b |

*Cost factors: a = animacy/thematic fit of the filler; b = computational cost associated with gaps; c = argument hierarchy; d = pro-drop frequency

In terms of the processing cost, the strong bias subject-gap and mild bias subject-gap conditions are likely to be equally easy because of more confirming factors than in other conditions.

The following presents another hypothesis that determines the processing decision at the close filler.

(16) Hypothesis 2

The assignment of a gap for the close filler is determined based on its animacy or plausibility as an agent.

- Strong bias: animate → subject; inanimate → object
- Mild bias: animate → subject
- Null bias: animate → subject

In this hypothesis, the parsing decision at the close filler is strongly influenced by the animacy of the filler. This is based on the assumption that the evaluation of thematic plausibility requires the presence of a verb and two arguments. Without information

from the distant filler, the parser may not be able to determine the thematic plausibility of the close filler. Since animacy is generally associated with agency, this information may be utilized to make a parsing decision at the close filler. The following table is the summary of gap assignment patterns (Hypothesis 2).

Table 5.10. Experiment 5: Predictions for closer filler – Hypothesis 2:
Parsing decision based on animacy.

| Condition | | W1 | W2 | | Cost | |
|----------------|----------|-----------------|-----------------|--------------|--------------------|---------------------|
| Pragmatic bias | Gap type | Verb | Close filler | Assigned gap | Confirming factors | Conflicting factors |
| Strong | Subject | <i>reserved</i> | <i>seat</i> | Object gap | a, c, d | b |
| Strong | Object | <i>reserved</i> | <i>customer</i> | Subject gap | a, b | c, d |
| Mild | Subject | <i>called</i> | <i>clerk</i> | Subject gap | a, b | c, d |
| Mild | Object | <i>called</i> | <i>customer</i> | Subject gap | a, b | c, d |
| Null | Subject | <i>called</i> | <i>wife</i> | Subject gap | a, b | c, d |
| Null | Object | <i>called</i> | <i>husband</i> | Subject gap | a, b | c, d |

*Cost factors: a = animacy/thematic fit of the filler; b = computational cost associated with gaps; c = argument hierarchy; d = pro-drop frequency

Under this hypothesis, the strong bias subject-gap is more advantaged than other conditions with respect to the processing cost.

At the distant filler, information from both fillers is available. Therefore, it is likely that the final parsing decision is made on the basis of the thematic fit of the two fillers, as specified in the following hypothesis.

(17) Hypothesis 3

The assignment of a gap for the distant filler is determined based on the thematic fit of the close and the distant fillers.

- Strong bias: animate → subject gap; inanimate → object gap
- Mild bias: plausible agent → subject gap; plausible theme → object gap
- Null bias: ambiguous → other factors determine the decision
 - e.g., Follow animacy → subject gap
 - Follow gap cost → subject gap
 - Avoid reanalysis → depends on earlier decisions (S-gap or O-gap)

In both the strong bias and mild bias conditions, the parsing decision follows the respective pragmatic bias. In the null bias condition, the thematic plausibility of the distant filler is still ambiguous. Therefore, the decision is subjected to other factors such as animacy and gap cost. Following either factor, the distant filler is preferably assigned to a subject gap. Note that only two factors – thematic fit (a) and gap cost (b) – are assumed to be at play at the distant filler. That is, the argument hierarchy and pro-drop frequency are not assumed to be applicable here because one of the gaps has already been filled and there is only one gap left unfilled. The following tables summarize the predictions that are assumed to take place at the distant filler. Table 5.11 presents the prediction based on Hypothesis 1 and 3.

Table 5.11. Experiment 5: Predictions for distant filler – Hypothesis 1 & 3.

| | W1 | W2 | W2 | W5 | W5 | Cost | Difficul-ty |
|----|-----------------|-----------------|----------------|-----------------|---------------|-----------------------------------|-------------|
| | Verb | Close filler | Assigned gap | Distant filler | Preferred gap | | |
| SS | <i>reserved</i> | <i>seat</i> | O-gap | <i>customer</i> | S-gap | | |
| SO | <i>reserved</i> | <i>customer</i> | S-gap | <i>seat</i> | O-gap | Gap | * |
| MS | <i>called</i> | <i>clerk</i> | O-gap | <i>customer</i> | S-gap | (Ambiguity?) | (*) |
| MO | <i>called</i> | <i>customer</i> | S-gap | <i>clerk</i> | O-gap | Gap (Ambiguity?) | * (*) |
| NS | <i>called</i> | <i>wife</i> | S-gap or O-gap | <i>husband</i> | S-gap | Reanalysis Ambiguity Interference | ** |
| NO | <i>called</i> | <i>husband</i> | S-gap or O-gap | <i>wife</i> | S-gap | Reanalysis Ambiguity Interference | ** |

*SS: strong bias, S-gap; SO: strong bias, O-gap; MS: mild bias, S-gap; MO: mild bias, O-gap; NS: null bias, S-gap; NO: null bias, O-gap.

*Asterisks in Difficulty indicate the relative processing difficulty of each condition. The more asterisks, the more difficult the processing of the sentence.

In this hypothesis, a processing advantage is expected for the strong bias subject-gap (SS) and mild bias subject-gap (MS) conditions. Strong bias object-gap (SO) and mild bias object-gap (MO) are more costly than the former two conditions in that a long-distance dependency must be formed with an object gap, which requires additional computational cost. Sentences with a null bias are assumed to incur the greatest processing cost. A certain amount of reanalysis is expected depending on the gap assignment at the close filler. The reanalysis is also predicted to be very difficult because of non-distinctiveness of the two fillers. Furthermore, some similarity-based interference may impede a parsing decision from being made. Finally, although the strong bias subject-gap and mild bias subject-gap conditions were predicted to be equally easy, it is possible that the mild bias subject-gap condition would be a little more costly than the strong bias condition because the pragmatic bias is mild and thus may lead to variability

in interpretation. In sum, a strong interaction between bias type and gap type is predicted, as indicated by the absence of gap asymmetry in the null bias condition and a processing preference for a subject gap in both strong and mild bias conditions.

Table 5.12 presents the second prediction at the distant filler that is made based on Hypothesis 2 and 3 described earlier.

Table 5.12. Experiment 5: Predictions for distant filler – Hypothesis 2 & 3.

| | W1 | W2 | W2 | W5 | | | |
|----|-----------------|-----------------|--------------|-----------------|---------------|---|------------|
| | Verb | Close filler | Assigned gap | Distant filler | Preferred gap | Cost | Difficulty |
| SS | <i>reserved</i> | <i>seat</i> | O-gap | <i>customer</i> | S-gap | | |
| SO | <i>reserved</i> | <i>customer</i> | S-gap | <i>seat</i> | O-gap | Gap | * |
| MS | <i>called</i> | <i>clerk</i> | S-gap | <i>customer</i> | S-gap | Reanalysis (Ambiguity?) | * (*) |
| MO | <i>called</i> | <i>customer</i> | S-gap | <i>clerk</i> | O-gap | Gap (Ambiguity?) | * (*) |
| NS | <i>called</i> | <i>wife</i> | S-gap | <i>husband</i> | S-gap | Reanalysis Ambiguity Interference | ** |
| NO | <i>called</i> | <i>husband</i> | S-gap | <i>wife</i> | S-gap | Reanalysis Ambiguity Interference | ** |

*SS: strong bias, S-gap; SO: strong bias, O-gap; MS: mild bias, S-gap; MO: mild bias, O-gap; NS: null bias, S-gap; NO: null bias, O-gap.

In this hypothesis, the strong bias subject-gap (SS) condition has an advantage. The strong bias object-gap (SO) and sentences in the mild bias condition (MS, MO) are predicted to be more difficult than the strong bias subject-gap (SS) because of some cost-inducing factors. It is also possible that sentences in the mild bias conditions (MS, MO) are overall more difficult than those in the strong bias conditions (SS, SO) because of ambiguity stemming from the weak pragmatic bias. The null bias conditions should be the most difficult of all because of possible reanalysis, ambiguity, and interference. Note

that the subject gap assignment for the distant filler in the null bias conditions is predicted based on the assumption that the parser considers either animacy or gap cost (i.e., avoiding an object gap). Yet, it is also possible that the parser may avoid reanalysis and choose to assign an object gap for the distant filler. Without pragmatic bias, there is in principle nothing to prevent the distant filler from being assigned to an object gap. In this case, the processing cost is still predicted to increase due to the inherent computational cost associated with an object gap. At this point, it is not possible to distinguish between the cost caused by reanalysis and the cost caused by a dependency involving an object gap. Therefore, the processing cost observed at the distant filler in the null bias condition can be explained by two possibilities. To summarize the predictions in this scenario, a strong interaction between bias type and gap type is predicted, as demonstrated by the absence of gap asymmetry in the mild and null bias conditions, contrasting with the presence of an asymmetry in the strong bias condition.

5.3.1.7 Data analysis

Data from all participants were used for analysis. The mean response accuracy of all participants to thirty-five filler sentences with unambiguous answers was 90.8%, with individual scores ranging from 74.3% to 100%.

This experiment had two types of dependent measures – responses to the end-of-sentence interpretation and mean reading times. For the interpretation choice, the probability of choosing the ‘yes’ response (out of a total of four tokens) in each condition was calculated for each individual. These scores were subjected to one-sample T-Tests to examine whether the ‘yes’ response was chosen above chance. A 3×2 ANOVA with

repeated measures on both Pragmatic bias and Gap type was also performed to examine whether the probability of choosing ‘yes’ responses differed across conditions.

With respect to reading time data, each condition’s mean reading time was calculated for each participant and for each item. Then, a 3×2 ANOVA with repeated measures was performed for each region, treating Pragmatic bias and Gap type as within-participants (F_1) variables. A separate ANOVA was also conducted by treating the two factors as within-items (F_2) variables. When an interaction of Pragmatic bias and Gap type turned out to be significant, subsequent analyses were conducted to determine the nature of the interaction. The critical region of comparison was the distant filler position (i.e., word 5) at which a double-gap RC structure is recognized and a long-distance filler-gap dependency is resolved. No data was removed from analyses and no data-trimming procedure was conducted. The reading time results presented below are thus raw reading times for each region.

5.3.2 Results

5.3.2.1 Interpretation choice

Table 5.13 presents the mean number (and percentage) of ‘yes’ responses to end-of-sentence interpretations. Figure 5.11 shows the mean percentage of ‘yes’ responses for each condition. (See Table 5.8 above for sample sentences.)

Table 5.13. Experiment 5: Number (percentage) of choosing ‘yes’ responses.⁷²

| | Strong bias | Mild bias | Null bias |
|-------------|--------------|--------------|--------------|
| Subject gap | 3.79 (94.8%) | 3.17 (80.2%) | 2.30 (55.2%) |
| Object gap | 3.38 (84.4%) | 2.33 (58.3%) | 1.57 (40.3%) |

*The scores are out of four tokens.

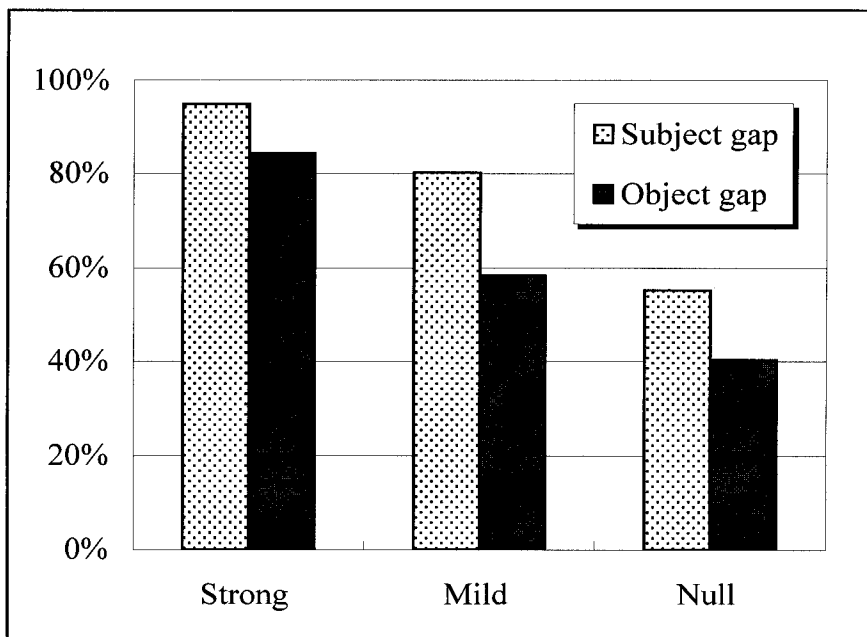


Figure 5.11. Experiment 5: Percentage of choosing ‘yes’ responses (%).

The subject-gap condition produced more ‘yes’ responses than the object-gap condition. There was also a relation between the ‘yes’ response and the strength of pragmatic bias: the stronger the pragmatic bias, the more the ‘yes’ responses. ANOVA results found significant main effects of Pragmatic bias ($F_1(2,46)=54.952$, $p < .001$;

⁷² Because of some errors involved in the recording of responses, the participant analysis and the item analysis yielded different means. The numbers shown in Table 5.13. are those for the participant analysis. Means for the item analysis are:

| | Strong bias | Mild bias | Null bias |
|-------------|-------------|-----------|-----------|
| Subject gap | 91.7% | 79.9% | 55.5% |
| Object gap | 84.4% | 58.3% | 40.3% |

$F_2(2,46)=29.222, p <.001$ and Gap type ($F_1(1,23)=12.382, p =.002$; $F_2(1,23)=12.665, p =.002$). No interaction was observed ($p >.1$).⁷³

Table 5.14 presents the results of the one-sample T-tests.⁷⁴

Table 5.14. Experiment 5: One-sample T-test results ($H_0:\mu=.5$).

| Pragmatic bias | Gap type | % of 'yes' | T-value | df | Significance (2-tailed) |
|----------------|----------|------------|---------|----|-------------------------|
| Strong bias | Subject | 94.8% | 17.245 | 23 | .000* |
| | Object | 84.4% | 8.752 | 23 | .000* |
| Mild bias | Subject | 80.2% | 6.355 | 23 | .000* |
| | Object | 58.3% | 1.356 | 23 | .188 |
| Null bias | Subject | 55.2% | .816 | 23 | .423 |
| | Object | 40.3% | -1.909 | 23 | .069 |

* $p <.05$

'Yes' responses were chosen above chance in the strong bias (both subject gap and object gap) sentences and the mild bias subject-gap sentences. For the other conditions, the choice of 'yes' or 'no' showed no consistency, except for a marginal significance for more 'no' responses in the null bias object-gap condition.

In sum, the results of end-of-sentence interpretation choices found the predicted effect of a structural preference and pragmatic information. Japanese speakers preferred a sentence in which the distant filler of an RC is interpreted as the subject to a sentence in which the distant filler is interpreted as a direct object, regardless of pragmatic bias. When structural preference and pragmatic information matched (as in the strong bias S-gap and mild bias S-gap conditions), judgments were more consistent with the a given

⁷³ ANOVAs including List as a between-participant variable found a Gap×List two-way interaction and a Bias×Gap×List three-way interaction.

⁷⁴ The data from item analysis showed an identical pattern, with significance obtained in strong bias (S-gap and O-gap) sentences, mild S-gap sentences, and marginal significance in null bias O-gap sentences.

interpretation than when those information sources mismatched (as in the strong bias O-gap and mild bias O-gap conditions). Also, the stronger the pragmatic bias, the more consistent the judgments with the given interpretation. When pragmatic information provided little information (as in the null bias conditions), responses exhibited more variability, resulting in chance or near chance performance.

5.3.2.2 Reading times

Table 5.15 and Figure 5.12 present the mean reading time for each region of a sentence.

Table 5.15. Experiment 5: Mean reading times (msec.).

| | W1 | W2 | W3 | W4 | W5 | W6 | W7 |
|--------------------|--------|--------------|--------|--------|----------------|-------|--------|
| | Verb 1 | Close filler | PP/adv | Verb 2 | Distant filler | NP/PP | Verb 3 |
| Strong bias, S-gap | 788 | 851 | 813 | 734 | 1000 | 575 | 633 |
| Strong bias, O-gap | 837 | 991 | 855 | 726 | 1562 | 751 | 876 |
| Mild bias, S-gap | 768 | 970 | 986 | 753 | 2043 | 663 | 1045 |
| Mild bias, O-gap | 800 | 929 | 874 | 934 | 2290 | 713 | 1239 |
| Null bias, S-gap | 816 | 1272 | 960 | 776 | 2478 | 790 | 1225 |
| Null bias, O-gap | 744 | 1096 | 809 | 1003 | 2283 | 716 | 1276 |

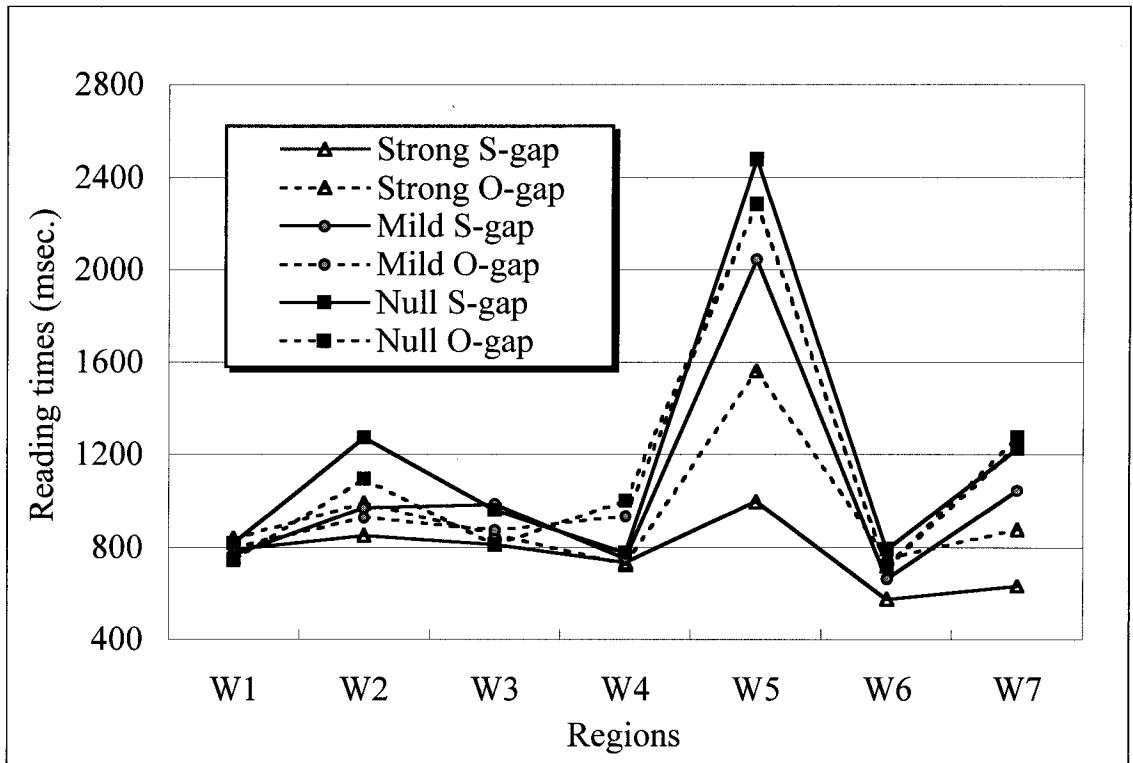


Figure 5.12. Experiment 5: Mean reading times (msec.).

At word 2 (the close filler), there was a significant main effect of Pragmatic bias ($F_1(2,46)=6.169, p=.004; F_2(2,46)=5.78, p=.006$). A main effect of Gap type and a bias \times gap interaction did not reach significance (Gap type: $F_1(1,23)=.127, p=.725; F_2(1,23)=.276, p=.604$; Interaction: $F_1(2,46)=1.607, p=.212; F_2(2,46)=2.848, p=.068$). For the pragmatic bias effect, reading times were the longest in the null bias condition, followed by the mild, and the strong bias conditions. Bonferroni pairwise comparisons found a significant difference between the strong and null bias conditions ($p_1=.023, p_2=.026$), but not in other pairs (mild \times null: $p_1=.052, p_2=.092$; strong \times mild: $p=1$). The results seem to suggest that ambiguous thematic roles of the distant filler (in the null bias) incurred a processing cost at an early point in a sentence.

At word 4 (the predicate of the intermediate clause), the Gap type revealed a reliable effect in the item analysis ($F_2(1,23)=4.488$, $p=.045$), but it was marginally significant in the participant analysis ($F_1(1,23)=3.590$, $p=.071$). A main effect of Pragmatic bias and a bias \times gap interaction were not significant (Bias: $F_1(2,46)=2.55$, $p=.089$; $F_2(2,46)=2.005$, $p=.146$; Interaction: $F_1(2,46)=1.833$, $p=.171$; $F_2(2,46)=2.438$, $p=.099$). The results showed that object-gap sentences were read more slowly than subject-gap sentences. However, this pattern seems to be only limited to the mild and null bias conditions. The results of one-way ANOVAs testing the gap effect found no effect in the strong bias condition ($F_1(1,23)=.047$, $p_1=.831$; $F_2(1,23)=.016$, $p_2=.899$), but found some effects in the mild bias ($F_1(1,23)=4.502$, $p_1=.045$; $F_2(1,23)=3.683$, $p_2=.067$) and null bias conditions ($F_1(1,23)=2.222$, $p_1=.150$, $F_2(1,23)=4.320$, $p_2=.049$). It is not clear why the effect of gap type was found at this position especially in the null bias condition, where the pragmatic bias should be minimum.

Figure 5.13 presents the reading time at the distant filler (word 5).

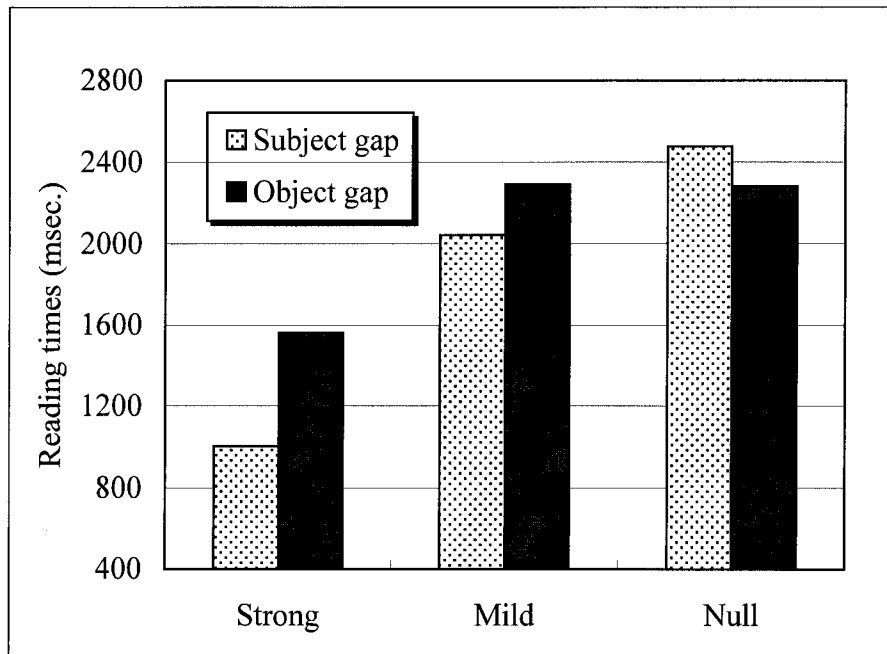


Figure 5.13. Experiment 5: Mean reading times at distant filler (msec.).

A robust main effect of Pragmatic bias was found ($F_1(2,46)=14.452, p < .001$; $F_2(2,46)=10.272, p < .001$). The results of Bonferroni pairwise comparisons found that the distant filler in the strong bias condition was read significantly faster than the distant filler in the mild bias ($p_1 = .002, p_2 = .001$) and null bias conditions ($p_1 = .003, p_2 < .001$). There was no difference between the mild bias and null bias conditions ($p = 1$). With respect to the Gap type, no main effect was found ($F_1(1,23)=1.270, p = .271$; $F_2(1,23)=2.063, p = .164$). The interaction of Pragmatic bias and Gap type was significant, but only in the participant analysis ($F_1(2,46)=3.325, p = .045$; $F_2(2,46)=2.319, p = .110$). The interaction seemed to be due to the fact that there was a gap asymmetry in the strong bias condition (i.e., shorter reading times for subject-gap sentences than object-gap sentences), but there was no such an asymmetry in the mild bias and null bias sentences. One-way ANOVAs testing the effect of Gap type confirmed this pattern: there was a gap

effect in the strong bias condition ($F_1(1,23)=4.819$, $p = .039$; $F_2(1,23)=7.078$, $p = .014$), but not in the mild bias ($F_1(1,23)=1.223$, $p = .280$; $F_2(1,23)=.811$, $p = .377$) or the null bias condition ($F_1(1,23)=.536$, $p = .472$; $F_2(1,23)=.575$, $p=.456$). Also, Bonferroni pairwise comparisons testing the bias effect found that within the subject gap sentences, the strong bias condition was significantly different from other two bias conditions (strong×mild: $p<.01$, strong×null: $p<.01$). Within the object gap sentences, the strong bias condition was significantly different from the mild bias ($p_1=.018$, $p_2=.09$), and marginally different from the null bias ($p_1=.09$, $p_2=.083$).

To summarize the results at the critical region, there was a processing advantage for the strong bias condition over the mild and null bias conditions, suggesting ease of processing when the thematic roles of fillers were strongly constrained. Furthermore, within the strong bias condition, there was a preference for the distant filler to be linked to the subject gap over the object gap. There was no gap asymmetry in the conditions where pragmatic information provided little or no constraint on the thematic roles of fillers.

At word 7 (matrix predicate), only a main effect of Pragmatic bias was found to be significant ($F_1(2,46)=6.654$, $p=.003$; $F_2(2,46)=7.46$, $p=.002$). Bonferroni pairwise comparisons showed that the reading time was significantly shorter in the strong bias than the two other conditions: strong vs. mild, $p_1=.008$, $p_2=.007$; strong vs. null, $p_1=.04$, $p_2=.006$; mild vs. null, $p=1$).

5.3.3 Discussion

Experiment 5 investigated the role of pragmatic information in the processing of globally ambiguous structure and its effect on the subject-object asymmetry. In addition to the conditions tested in Experiment 4 (i.e., the strong bias condition), in which the thematic role of fillers was pragmatically unambiguous, Experiment 5 included two additional pragmatic bias conditions – mild and null. In the mild bias condition, the two fillers were both animate, but one of them was more plausible as agent of the action denoted by the most embedded verb. In the null bias condition, the two fillers were fully interchangeable in the sense that they were equally good as agent or theme.

The word-by-word reading times at the distant filler showed two major findings. First, the sentences in the strong bias condition were read significantly faster than the sentences in the mild and null conditions. Second, there was a clear gap asymmetry, favoring a subject gap over an object gap, in the strong bias condition, while no such asymmetry was found in the mild and null bias conditions. In the both mild and null bias conditions, the reading times were extremely long, presumably showing processing overload.

The overall reading time results were more consistent with the prediction under hypothesis 2 and 3 (as shown in Table 5.12) than the prediction under hypothesis 1 and 3 (as shown in Table 5.11). Recall that the major difference between the two predictions was that in hypothesis 1, the gap assignment at the close filler was determined on the basis of the thematic fit of the filler, while in hypothesis 2 it was determined on the basis of the animacy of the filler. However, caution is needed before drawing a conclusion

about the processing decision at two fillers. First, the predictions were formulated under an assumption that each cost factor leads to an equal amount of processing difficulty. However, whether or not object gap assignment, ambiguity, and reanalysis incurs equal processing difficulty needs to be investigated independently. Second, the processing difficulty observed at the distant filler in the mild bias condition could be because the pragmatic bias in this condition was too weak to be distinguished from the pragmatic bias in the null bias condition.

The results of end-of-sentence interpretation choices also revealed similar patterns to those of reading times. Across the three pragmatic bias conditions, there was a preference for interpreting the distant filler as the subject of the embedded clause over interpreting the close filler as the subject of the embedded clause. And this preference was stronger and more consistent as the pragmatic bias becomes stronger. When the pragmatic bias was not constraining (i.e., the null bias) or when the distant filler was weakly biased toward the theme (i.e., the mild bias object-gap condition), the preferred interpretation in which the distant filler is encoded as the subject was not chosen consistently, showing at chance or near chance probability.

Taken these results together, two conclusions can be drawn from Experiment 5. Double-gap RCs are parsable or easy enough to construct syntactic and semantic representations online only when the pragmatic information unambiguously indicates the possible thematic roles of fillers. And, it is only under these circumstances that a subject-object gap asymmetry is manifested. In the remainder of this section, I will discuss the

processing difficulty/ease of double-gap RCs from the three approaches in sentence processing, and the relationship between ambiguity and gap asymmetry.

5.3.3.1 Processing difficulty in the mild and null bias conditions

There are three types of accounts that would predict the processing difficulty observed at the distant filler of the double-gap RCs in the mild and null bias conditions. First, it has been reported that the processing load increases from ‘similarity-based interference’ between NPs from the same semantic and/or syntactic class (Gordon, Hendrick, & Johnson 2001:1412, Lewis & Nakayama 2002). Memory representations of similar constituents are similar enough to interfere with each other when processing or retrieving information associated with them. In the case of double-gap RCs in the mild and null bias conditions, this account would predict that reading time increases at the distant filler because of interference from the close filler. Both fillers are human, animate, and plausible agents. Therefore, when the parser encounters the distant filler and makes a decision about the filler’s role in the embedded clause, the information from the close filler could interfere with this evaluation process.

Alternatively, the increased reading time at the distant filler may reflect the difficulty involved in revising the initial analysis of a structure. The Garden Path model assumes that the parser considers only one analysis at a time and corrects it when subsequent information contradicts the analysis (Frazier 1987a, 1989, Frazier & Rayner 1982). In this model, the initial parsing is assumed to proceed solely on the basis of structural considerations, such as phrase structure rules and the syntactic categories of words. When an ambiguity is detected, a processing decision is guided by parsing

strategies, such as Minimal Attachment and Late Closure. Non-structural information, such as pragmatic and detailed lexical information, becomes available at a later evaluation stage, and reanalysis occurs if necessary. Under this account, the increased reading time found at the distant filler in the mild and null conditions could be accounted for by the difficulty involved in reanalysis. Suppose the parser detects ambiguity at the closer filler and assigns it to a subject gap by following some sort of parsing principle, such as one that prefers a computationally less costly operation to a costly one. When the distant filler is received, the parser initially assigns it to an object gap since the gap has not been filled. Soon after this assignment is completed, a strong error signal should appear due to the mismatch between the object gap and the plausible agent property of the distant filler. And, this triggers reanalysis.

There are several reasons to assume that such reanalysis may impose substantial processing demands. First, a double-gap RC is highly complex. It has two filler-gap dependencies. A large portion of working memory may have been consumed by the time the distant filler is integrated, and consequently fewer resources would be available for reanalysis.

Second, reanalysis would also be difficult because both the close filler and the distant filler are potentially good agents, and this may not be constraining enough to make a quick decision about the dependencies.

Third, it has been proposed that “revising semantically interpreted decisions is more costly than revising semantically uninterpreted ones” (Frazier & Clifton 1998:148). Since reanalysis of the two dependencies will involve the revision of the thematic role

that has been assigned to the close filler, it is reasonable to assume that reanalysis at the distant filler would be very difficult.

Fourth, due to the limitation of processing/attentional resources, the revision of a structure that has been built earlier is assumed to be more difficult than the revision of a structure that has been built more recently (Frazier & Clifton 1998:163-4). Again, reanalysis of the two dependencies requires access to information that appeared earlier in a sentence – the embedded predicate and the close filler – as well as the distant filler. Therefore, these revisions would be very difficult.

In sum, although it is not clear whether all these factors combine to make reanalysis more difficult or whether one is more crucial than another, a great deal of difficulty is predicted for reanalysis at the distant filler.

In contrast to the model described above, a third view of sentence processing would claim that the processing difficulty observed at the distant filler reflects the difficulty of selecting a particular structure, presumably as a result of insufficient information. In the interactive approach to sentence comprehension (e.g., MacDonald, Pearlmutter & Seidenberg 1994b, Trueswell, Tanenhaus, & Kello 1993), both syntactic and non-syntactic factors are assumed to influence simultaneously the activation level of a particular structure. In the case of double-gap RCs, the syntactic cue is very weak since the structure is formally ambiguous with respect to the dependencies between gaps and fillers. The pragmatic cue is also weak in the mild and null bias conditions in that it does not help activate one structure more strongly than the other. For example, being animate and a good agent, the close filler in the null bias condition may activate a subject-gap

analysis. The activation of this analysis may become stronger since assigning a filler to a subject gap is computationally less costly. When the distant filler is encountered, this filler would activate a subject-gap analysis for the same reason outlined for the close filler. Therefore, the two subject analyses that have been activated in the system would compete with each other. Without sufficient information that would strengthen the activation of one analysis over the other, dependencies may not be resolved, resulting in great processing difficulty.

5.3.3.2 Easy processing in the strong bias condition

In contrast to the processing difficulty in the mild and null bias conditions, all these approaches predict generally easy processing for sentences in the strong bias condition. In the similarity-based interference account, parsing can proceed without interference because an animate NP and an inanimate NP at the fillers are semantically and pragmatically distinct. Then, what makes a difference at the distant filler is the structural position of the gap. A subject gap is structurally higher, thus easier to form a dependency with.

Consider the Garden Path model. Recall that in this model, initial parsing is guided only by structural information such as the phrase structure rules. Without such information at the closer filler, an ambiguity-resolution parsing strategy will be applied. Again, suppose that the parsing strategy initially assigns a subject gap to the close filler. In the case of the subject-gap condition, the close filler is 'seat'. Soon after a subject gap is assigned to this filler, a strong error signal will appear because of the mismatch between the subject gap and the thematic plausibility of the filler. Thus, reanalysis must

be initiated. However, reanalysis will be conducted with relative ease due to the strongly constraining pragmatic information. As a result, an object gap will be linked to the close filler. At the distant filler 'customer', only a subject gap is available, and is thus assigned to the filler. No error signal will be detected because of the feature match between the gap and the filler. In the case of double-gap RCs in the object-gap condition, the close filler is 'customer'. The parsing strategy initially links the subject gap to this filler. No feature mismatch will be detected and thus no reanalysis is needed. At the distant filler 'seat', only an object gap is available and it is therefore linked to the filler. No error signal will appear. However, forming a dependency with an object gap is computationally more costly. This makes the processing of the distant filler more difficult in the object-gap condition than in the subject-gap condition. In summary, in the Garden Path model, the reading times of the distant filler in the strong bias condition should be relatively short because no reanalysis is involved at this position. A subject-object asymmetry is expected because there is an inherent computational difference between the two gaps.

In an interactive model, the relative ease of the strong bias condition is also predicted. Recall that multiple information sources are assumed to be used simultaneously in parsing. In the both subject-gap and object-gap conditions, the strong pragmatic bias unambiguously selects a structure at each filler. For example, 'seat' is assigned to an object gap and 'customer' to a subject gap. Then, the difference at the distant filler between 'customer' and 'seat' will be computationally determined. A subject-gap is easier to compute than an object gap.

5.3.3.3 Gap asymmetry in the absence of ambiguity

From the above discussion and the finding that a subject-object gap asymmetry appeared only in the strong bias condition, it seems clear that a gap asymmetry is manifested when a sentence contains no ambiguity. However, it is not clear how ‘the absence of ambiguity’ leads to the emergence of a gap asymmetry.

It seems that there are two necessary conditions for an asymmetry to appear. The parser needs to recognize that there is a gap in a clause preceding the filler. More importantly, the parser also needs to know the position of a gap. As for the first condition, it is likely that for all double-gap RCs, the parser is able to postulate two gaps in the most embedded clause on the basis of the argument structure of a predicate and the absence of overt NPs in the clause. It is thus the second condition that seems to separate the strong bias condition from other bias conditions in terms of the appearance of a gap asymmetry.

In the strong bias condition, the strongly constraining pragmatic information uniquely specifies the thematic role of fillers and thus makes clear about the position of a gap. This enables the parser to assign the filler to a gap rapidly as soon as the filler is received. Then, what emerges in this process is a difference in computational cost. The subject gap is higher in the structure, where it can enter into a dependency with the filler at relative little computational cost.

Consider the mild and null bias conditions where a gap asymmetry was not observed. Again, it is assumed that the parser recognizes that there are two gaps in the most embedded clause. What is missing in these conditions seems to be a reliable

information about the position of a gap that is to be associated with each filler. There is no morphosyntactic information in this construction that specifies the dependencies between gaps and fillers. The pragmatic information is also weak. This creates variation in the interpretation of the role of the fillers (across participants and items) as evidenced by the results of the end-of-sentence interpretation choice in Experiment 5. Recall that the response to a given interpretation was inconsistent (i.e., at chance or near chance performance) in the mild bias object-gap condition and the null bias conditions. Since the parser is not able to make a rapid and consistent decision about the two dependencies, a gap asymmetry, a computational consequence of the rapid integration of the filler with a gap, is less likely to occur.

Clarification is necessary with regard to the considerable processing difficulty observed at the distant filler of double-gap RCs in the weakly biased conditions. Although ambiguity may reduce or remove the gap asymmetry, it is less likely that it is the sole cause of the considerable processing difficulty found at the distant filler in these conditions. As acknowledged in the sentence processing literature, not all ambiguous structures are extremely difficult to process. It seems that the involvement of two filler-gap dependencies together with the presence of ambiguity combine to make the double-gap RC in the mild and null bias conditions very difficult to process.⁷⁵ A filler-gap dependency has been shown to incur processing cost. (See Chapter 3 for previous

⁷⁵ A double-gap RC contains three clauses. Assuming that the parser needs to construct both syntactic and semantic representations of a sentence, the processing of double-gap RCs is both syntactically and semantically complex.

findings on this issue). The present study also found that the reading time increased at the filler of a single-gap RC (Experiment 1 and 2). The reading time was also significantly longer at the distant filler of a double-gap RC than at the corresponding region of a control sentence without a filler-gap dependency (Experiment 4). When the thematic roles of the fillers are ambiguous, the parser not only computes a long-distance dependency involving the distant filler but also reevaluates the dependency involving the close filler, and if necessary revises the initial analysis. Dealing with two filler-gap dependencies (one of which is also long distance) must thus tax the memory resources considerably.

To conclude Experiment 5, the present study found that a subject-object gap asymmetry emerges only when the pragmatic information strongly constrains the thematic roles of two fillers. Strong pragmatic information helps the parser uniquely identify the position of the gaps and thus resolve the dependencies rapidly as soon as the filler is encountered. Given that the same asymmetry was observed in the processing of single-gap RCs, where the position of a gap is inferred by the case marking of an overt NP within the RC and the argument structure of a verb, the results of Experiment 5 suggest that strongly constraining pragmatic information serves a similar function to that of morphosyntactic information such as case marking, and is used rapidly in the processing of double-gap RCs in Japanese.

5.4 General discussion

This section will compare and contrast some of the results found in the offline survey (Experiment 3) and online experiments (Experiment 4 and 5), and will discuss

some issues involved in this construction. Then, some limitations of the study will be addressed, and a summary of major findings will conclude the chapter.

5.4.1 Processing difficulty in naturalness ratings and online experiments

The comparison of the offline and online studies revealed that ‘processing difficulty’ may tap different aspects of sentence processing and can be teased apart in different measurements. Recall the results of Question 1 from the offline survey (Experiment 3). In this question, the participant was asked to rate the naturalness of a sentence on a 5-point scale. The results found that sentences were split into two groups. The sentences in the strong bias subject-gap condition were rated as natural, while the sentences in the other five conditions were rated as unnatural. In Experiment 5, the reading times of the distant filler showed three major groupings. The easiest condition was the strong bias subject-gap condition. The second easiest one was the strong bias object-gap condition. The other four conditions belonged to the same group, where the reading time of the distant filler was extremely long.

One apparent similarity between the two sets of data is the superior performance of the double-gap RC in the strong bias subject-gap condition. This is the condition in which the thematic roles of the two fillers were pragmatically unambiguous and the plausible agent appeared at the distant filler position. That is, when the preferred structure had strong pragmatic support, native speakers of Japanese found the sentence relatively easy to comprehend (thus natural), and the effect was manifested as the fastest reading times at the distant filler in the online experiment.

However, the two sets of data also had a noticeable difference. In the offline judgments, the double-gap RC in the strong bias object-gap condition was rated as unnatural along with other mild and null bias sentences, whereas in the online measurement, it was read faster than the other four conditions.

Judgment as ‘unnatural’ in an offline task seems to represent two types of difficulty. On the one hand, it represents difficulty that stems from a mismatch between the preferred structure and pragmatic plausibility. For example, in comprehending a double-gap RC in the strong bias object-gap condition, people were forced to interpret the sentence with a dispreferred structure because the pragmatic information was so strong that there was no other way to interpret it. On the other hand, ‘unnatural’ also seems to represent difficulty caused by ambiguity. Ambiguity leads to indeterminacy about the sentence structure, reanalysis, and so forth. Sentences in the mild and null bias conditions seem to belong to this category.

It appears that the results of the online experiment elucidated these different types of difficulties. Sentences with a strong mismatch between pragmatic bias and structural preference were read faster than sentences with ambiguity. This suggests that constraining information (even if it may contradict a structural preference) has an advantage over ambiguous information in sentence processing. Strongly constraining information provides at least a quick clue about a sentence’s syntactic representation, including a signal as to whether the structure is a preferred one or not. On the other hand, ambiguous information seems to impede or slow down rapid structure building.

Caution is necessary, however, in interpreting the two sets of data. It is possible that the predominant ‘unnatural’ rating for the strong bias object-gap sentence is due to the semantic compatibility of the intermediate predicate with the immediately following noun. Recall that the offline study found that sentences in this condition tended to be misanalyzed more often than the sentences in the other conditions. On the other hand, sentences in the strong bias condition in Experiment 5 contained an intermediate predicate that was semantically incompatible with the following noun. Therefore, the fact that the reading times in this condition are shorter than in mild and null bias conditions in Experiment 5 may be due to the absence of the potentially error-inducing factor. Further investigation is necessary to tease apart these possibilities.

5.4.2 Limitations of the study

The present study has several limitations and suggestions for future studies. First, more careful control may be necessary in order to draw a conclusion about how mild bias sentences differ from null bias sentences. The results of Experiment 3 and 5 showed that the mild bias condition patterned with the null bias condition in many respects, such as in the naturalness ratings, the possibility of misanalysis, reading times, and so forth. However, this may be due to insufficient difference in bias between the two conditions. Although what makes the bias difference ‘sufficient’ is an open question, it has been reported that thematic fit of fillers equivalent to the mild bias condition of the present study had some effect in the processing of RCs (Traxler et al. 2002, cf. Mak et al. 2002). Whether or not the absence of the bias difference is limited to the double-gap RC

construction (perhaps due to its highly complex structure and its structural ambiguity) or could be found in other constructions in Japanese is also an empirical question.

Second, the effect of intermediate clauses in the processing of double-gap RCs also needs to be tested. In Experiment 5, the intermediate predicate in the strong bias condition was semantically incompatible with the following noun, while those in the mild and null conditions were semantically compatible with it. This incompatibility in the strong bias may have facilitated structure building by preventing the parser from incorrectly misassociating the predicate with the following noun. Although the results of Experiment 3 (the offline survey) indicated that the incidence of anomalous interpretation was not very high in the mild and null bias conditions, its effect in a word-by-word online experiment has to be tested independently.

Finally, a study is needed to obtain more detailed information about a parsing decision at the close filler. For example, in Experiment 4, an increased processing load was observed at the close filler and the following regions in the strong bias object gap condition, i.e., in sentences whose close filler was a plausible agent. However, an equivalent asymmetry was not found in Experiment 5, although there was a numerical reading time difference suggesting the same tendency. Furthermore, the results of a pretest norming study (reported in Appendix C) found that sentences with a missing subject were rated overall as more natural than sentences with a missing object across the pragmatic bias conditions. These sets of results suggest that there is in fact a preference to fill an object gap at the close filler, which is opposite to the predictions that were constructed for Experiment 5 on the basis of animacy and thematic fit of fillers. Since a

parsing decision at the distant filler largely depends on the decision made at the close filler especially in the mild and null bias conditions, study of this issue will be a future priority.

5.5 Conclusion

This chapter investigated the issue of subject-object gap asymmetry in the processing of double-gap RCs in Japanese. One major finding is that there was an advantage for a subject gap over an object gap, supporting the predictions proposed by the Structural Distance Hypothesis. No equivalent asymmetry was found in a control sentence which involved a pronoun-antecedent referential dependency but did not involve a long-distance filler-gap dependency. This suggests that the subject-object gap asymmetry was a computational consequence of resolving a filler-gap dependency in a hierarchical representation. Another important finding is that this asymmetry emerged only in the sentences in which the plausible thematic role of the fillers was pragmatically disambiguated. When pragmatic information only weakly constrained the thematic role of fillers, the processing became extremely difficult and the asymmetry was no longer observed. These results suggest that strongly constraining pragmatic information is used rapidly in the analysis of structurally ambiguous double-gap RCs. Such information helps the parser identify the position of a gap, which in turn is crucial for the emergence of a gap asymmetry.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSION

The goal of this dissertation was to collect empirical evidence on the issue of a subject-object gap asymmetry in the processing of RCs in Japanese, a strict head-final language. A series of experiments conducted on single-gap and double-gap RCs showed that native speakers of Japanese found a subject gap easier to process than an object gap. This chapter reviews major findings from the experiments and discusses them in a wider perspective.

6.1 Summary of major findings

The central finding of this study is that there is a clear advantage of a subject gap over an object gap in the processing of both single-gap RCs and double-gap RCs. In single-gap RCs, the reading time of the filler (in Exp. 1 and 2) was faster and the response accuracy to end-of-sentence comprehension questions (in Exp. 1 only) was higher for subject-gap RCs than for object-gap RCs. In double-gap RCs, the asymmetry was restricted to the conditions in which the thematic roles of fillers are pragmatically unambiguous. In these conditions, the reading time of the distant filler was faster when it corresponded to a subject gap than when it corresponded to an object gap (Exp. 4 and 5). In the end-of-sentence interpretation choice, the preference for linking the distant filler to a subject gap was stronger in the strong bias condition than in the other conditions (Exp 1 and 5). In contrast, when the pragmatic information was weak, no corresponding asymmetry was observed. Not only was the distant filler in those conditions read with great difficulty, the preference for interpreting the distant filler as a subject was very

weak (Exp. 1 and 5), and there is no indication that such an interpretation was chosen consistently (Exp. 5).

The presence of a gap asymmetry in the double-gap RCs suggests that strongly constraining pragmatic information is used rapidly during processing. Assuming that a gap asymmetry is a computational consequence of the rapid integration of a filler with a gap in a hierarchical structure, the emergence of an asymmetry largely depends on how unambiguously and how consistently the parser identifies a type of dependency (subject gap or object gap). For instance, in the case of single-gap RCs, an overt case-marked NP and the verb's argument structure in the embedded clause inform the parser of a possible gap position. This allows the rapid association of the filler with the gap, as soon as the parser recognizes the filler. As a result, a subject-object gap asymmetry emerges. In the case of double-gap RCs, the first decision point is at the close filler. No morphosyntactic information indicates a dependency type. However, since the thematic plausibility of the filler is strongly constrained (as an agent or theme of the embedded predicate), the parser assigns the filler to one of the gaps. The same applies at the distant filler. Since the thematic plausibility of the distant filler is pragmatically unambiguous and compatible with a gap that has not been filled, the long-distance dependency is resolved rapidly. Then, what makes a difference is the computational cost associated with the structural position of the gap. The gap asymmetry in the absence of morphosyntactic information suggests that the strongly constraining pragmatic information informs the parser of the type of dependency in a similar way as the morphosyntactic information does in the single-gap RC.

When pragmatic information only weakly constrains the plausible thematic role of fillers, the type of dependency becomes more ambiguous. As a result, the processing becomes more difficult and variable because of possible reanalysis and processing costs associated with an object gap when it is chosen.

6.2 The absence of a subject-gap preference in the weakly biased conditions

Given that the two fillers in the mild and null bias conditions are plausible as agent or theme, it is still puzzling as to why there was no a strong preference for a subject interpretation of the distant filler. Recall that the end-of-sentence interpretation choice showed that the parser did not choose a particular interpretation consistently (Exp.5). This finding contrasts with previous findings in head-initial languages. For example, Frazier (1987b) examined globally ambiguous RCs in Dutch and found that native speakers of Dutch prefer to interpret a sentence as a subject-gap over an object-gap RC. Mak et al. (2002) reported a similar finding in an investigation of temporarily ambiguous RCs in Dutch. In Dutch, a sequence of <filler NP + relative pronoun + NP> can be temporary ambiguous since the primary disambiguating information (i.e., subject-verb agreement on the verb) comes at the end of the embedded clause. They found that the auxiliary verb was read more slowly when it disambiguates toward an object gap interpretation over a subject gap interpretation. This suggests that prior to the disambiguating region, native speakers of Dutch have already developed a preference for a subject gap interpretation for the ambiguous string. Note that the filler and the NP in the RC were pragmatically ambiguous in Frazier's study, and weakly ambiguous in Mak

et al.'s study, which roughly corresponds to the null bias and mild bias conditions of my study respectively.

The absence of a strong preference in the pragmatically ambiguous conditions in Japanese appears to suggest two things. First, it seems to provide additional evidence against the purely grammar-based account for the subject-object asymmetry in double-gap RCs. Recall that there is an issue that a double-gap RC with a long-distance dependency with an object gap is not merely computationally difficult but 'ungrammatical' due to the violation of a parsing constraint (Fodor's (1978) Nested Dependency Constraint) or the violation of a movement constraint (e.g., Hasegawa 1984-5, Huang 1984). If a particular configuration is ungrammatical, which is assumed to be a part of native speakers' grammatical knowledge of the language, there should be a stronger preference for associating the distant filler with a subject gap whenever possible, such as in the mild and null bias conditions.

Second, the absence of a strong preference in the mild and null bias conditions in Japanese and its presence in other languages seem to be related to a processing consequence due to different typological properties of RCs. As has been discussed in the literature, in head-initial languages such as English and Dutch, an RC is recognized earlier in a sentence, thanks to word order or the appearance of a relative pronoun following the filler. Whichever account one adopts (e.g., an active filler strategy, memory-based explanation, perspective shift, etc.), this creates an initial preference for the subject gap interpretation because of its computational, structural, and/or discourse advantage over the object gap interpretation. When the filler and the NP in the RC have no bias toward either interpretation, this initial preference remains, resulting in a

preference for a subject analysis. That is, a preference for the subject interpretation seems to be a processing consequence originated in an early signal that generates an expectation for a gap. In contrast, in head-final languages such as Japanese, where the filler comes after the RC, an RC structure is not recognized until the filler is received. Without the signal that indicates that an RC structure is being processed, no preference about the type of dependency needs to be developed prior to the filler.⁷⁶ When a filler is received, the parser resolves a dependency on the basis of the structure built so far and on available information (such as pragmatic bias) without being influenced by a previously developed preferences. The strength of pragmatic information therefore directly influences how rapidly and consistently an integration is conducted.

The interaction of pragmatic/semantic information and the initial preference for a subject gap structure is found in various studies in head-initial languages. For example, in the same study reported earlier, Mak et al. (2002) examined a similar set of temporarily ambiguous RCs with pragmatically unambiguous NPs. No asymmetry was found at the auxiliary verb (i.e., the disambiguating information), suggesting that animacy is used to guide an analysis of an ambiguous RC, overriding the preference for a subject-gap interpretation. Traxler et al. (2002) found that not all object-gap RCs are equally difficult. They found that the difficulty associated with an object-gap RC was significantly reduced when the filler (at the matrix subject position) was inanimate and the NP in the RC was animate. On the other hand, the processing of an object-gap RC

⁷⁶ Note that it is not entirely impossible that the detection of a gap may lead the parser to expect an appearance of an RC (Yamashita et al. 1993). However, the results of the present study (Experiment 1 and 2) found no reading time difference in the RC region between subject-gap and object-gap RCs. This at least suggests that the detection of a subject gap and an object gap does not lead to a particular processing difference prior to the filler.

became very difficult when the filler was animate and the NP in the RC was inanimate. These results suggest that the preference for a subject gap analysis was reinforced when the filler at the matrix subject is a good agent, while the preference was easier to revise when the filler is not a good agent.

In summary, in head-initial languages, an expectation of an RC structure appears early, and the processing of an RC is strongly influenced by how much the initial preference for a subject gap is reinforced or weakened by other information. In head-final languages, the incremental analysis of an RC does not need to compete with an expectation, and thus reflects the pure cost of integration at the filler.

6.3 Implications for sentence processing models

Although testing one parsing theory against another is beyond the scope of this thesis, various aspects of the processing of Japanese RCs seem to be compatible with a model which assumes that multiple sources of information simultaneously affect processing (e.g., Trueswell, Tanenhaus, Garnsey 1994, MacDonald, Pearlmutter, Seidenberg 1994a,b, MacWhinney & Bates 1989, Spivey-Knowlton, Trueswell, & Tanenhaus 1993). In this type of model, sentence comprehension is understood as a process of integrating various types of information and selecting the analysis (out of multiple possibilities) that most satisfies the constraints of those information sources. Different types of partial structures are activated and their activation levels change over time reflecting the strength of each type of information and the availability of alternative structures. Gibson and Pearlmutter (1998:262), for example, assume five major types of constraints that apply freely during sentence comprehension – (1) phrase-formation

constraints, (2) lexical, or word-level, constraints, (3) contextual constraints, (4) computational resource constraints, and (5) phrase-level contingent frequency constraints.

For example, the present study has shown that case marking information constrains the possible grammatical role of an NP. The number of gaps and their structural positions are determined on the basis of case marking information on an overt NP in the RC and a verb's argument structure. A thematic role is rapidly assigned to an NP (e.g., a relative head) when the semantic/pragmatic information of the NP strongly fits one of the verb's thematic roles. Accordingly, the NP's grammatical relation is determined. Processing becomes very difficult when there is little information that constrains a possible structure. For example, in the case of double-gap RCs, a pair of fillers that are animate and good potential agents compete for the subject gap position. Without further strongly constraining information to help determine the dependencies between gaps and fillers, the linking of a gap to each filler becomes unstable and takes longer to be completed. A clear subject-object asymmetry at the distant filler in the strongly biased double-gap RCs can be accounted for by the application of computational resource constraints, one of the five constraints assumed by Gibson and Pearlmuter (1998) above. As a subject gap is structurally higher and thus closer to the filler, it is easier to compute (i.e., resolve a filler-gap dependency).

These results do not fit neatly with the view that initial parsing decisions proceed exclusively on the basis of structural information. The Garden Path model proposed by Frazier and her colleagues (Ferreira & Clifton 1986, Frazier 1987a, 1989, Frazier & Rayner 1982, Rayner, Carlson, & Frazier 1983) assumes that initial parsing decisions are made strictly on the basis of phrase-structure rules and the syntactic category of the input.

At a point where the input is compatible with multiple phrase structures, a decision is made by parsing strategies such as Minimal Attachment (which prefers a syntactically simpler structure over a more complex one) and Late Closure (which favors an analysis that continues the phrase currently being built). The parser computes only one analysis at a time, and when the analysis turns out to be inconsistent with subsequent information, a reanalysis is initiated. Under this account, non-phrase structure information sources, such as the argument structure of a verb, the thematic fit of a noun to potential argument positions, animacy information, pragmatic plausibility, and the relative frequency of two alternative interpretations, are ignored during initial parsing. They become available only in a later evaluation stage or in a reanalysis stage if necessary.

One finding that would be problematic for this type of model is the considerable processing difficulty observed at the distant filler of the weakly biased double-gap RCs. The model needs to assume that there is a parsing strategy that selects one analysis over another at each ambiguous point (e.g., at the close filler and also possibly at the distant filler). The following table illustrates some of the possibilities predicted at each filler.

Table 6.1. Predictions for null bias double-gap RCs under the Garden Path model.

| | At the close filler 'wife' | | At the distant filler 'husband' | | Predicted processing cost & cost factor |
|---|-------------------------------|---------------------|------------------------------------|---------------------|---|
| | Initially assigned gap | After reanalysis | Initially assigned gap | After reanalysis | |
| 1 | S-gap | NA | O-gap | NA | Costly: O-gap |
| 2 | S-gap | NA | O-gap | S-gap | Costly: reanalysis |
| 3 | O-gap | NA | S-gap | NA | Easy |
| 4 | O-gap | S-gap | O-gap | NA | Costly: O-gap |
| 5 | O-gap | S-gap | O-gap | S-gap | Costly: reanalysis |

*NA means that reanalysis is not conducted.

As the right-most column shows, three types of processing cost are possible. If the processing proceeds as in prediction 3, null bias double-gap RCs should be as easy as the sentences in the strong bias subject-gap condition, since no reanalysis is involved and the S-gap analysis is chosen at the distant filler. This did not match with the actual results.

According to predictions 1 & 4, a certain degree of processing cost is expected because of the O-gap analysis chosen at the distant filler. However, if the O-gap analysis is the sole reason for the processing difficulty, null bias sentences would be no more difficult than sentences in the strong bias object-gap condition. The results found that they were, in fact, more difficult than sentences in the strong bias object-gap condition.

This leads to the two cases (predictions 2 and 5), where the processing cost would be predicted due to reanalysis. This is not impossible, but a question arises as to why reanalysis must be initiated when both the close filler and the distant filler are compatible with the agent and theme roles. An additional condition would be needed, such as that a human animate NP has to be associated with the subject/agent role.

6.4 Conclusion

This dissertation has presented evidence for a subject gap advantage in the processing of Japanese RCs. The preference for a subject gap was found not only in RCs with a single filler-gap dependency but also in RCs with two filler-gap dependencies. Given that this preference was not observed in sentences without a long-distance filler-gap dependency (as in the control sentences in Experiment 4), it was suggested that the asymmetry is a computational consequence of resolving a filler-gap dependency at the filler. Furthermore, the subject gap advantage in prenominal RCs suggests that the linear

distance between gap and filler is unlikely to be a key factor in determining the processing difficulty of filler-gap dependencies across languages. This dissertation proposes that the distance between gap and filler should be defined in structure-based terms, such as the number of syntactic nodes intervening between gap and filler. Since a structure in which the subject is higher than the direct object is assumed to be universal, crosslinguistic findings in favor of a subject gap can be explained.

The investigation of the two types of RCs also allowed examination of the roles of different types of information that the Japanese parser could potentially use during processing. Assuming that the gap asymmetry is a computational consequence of the rapid integration of a filler with a gap at different structural positions, the asymmetry observed in strongly biased double-gap RCs suggests that strongly constraining pragmatic information can be used rapidly to determine the type of dependency, just as morphosyntactic information is in single-gap RCs. It seems that the absence of ambiguity in terms of gap position is crucial for an asymmetry to appear.

The results of the present study are tentative, however. In order to draw a firm conclusion that structural distance can be an alternative to linear distance, it is necessary to test structural distance in a wider range of structures across languages. Furthermore, factors that potentially influence gap asymmetry such as the grammatical relation of the head noun and semantic/pragmatic information need to be investigated independently in order to gain a better understanding of the processing of filler-gap dependencies in human languages. Regretfully, I must leave these matters for future research.

APPENDIX A

PRETEST NORMING STUDY 2 (EXPERIMENT 3)

A paper-and-pencil questionnaire was conducted in order to test whether the pragmatic factors manipulated in Experiment 3 had the intended bias and whether the intermediate predicate was semantically compatible with not only the preceding NP but also the immediately following noun.

For each of the six double-gap RCs (as in sentences (5a)~(5f) in section 5.1.1.2 in Experiment 3), a simple transitive sentence was created by using the two fillers and the embedded predicate. Sentences (1a)~(1f) below are simple sentences corresponding to original double-gap RCs (5a)~(5f) respectively.

| (1) | Condition | Sample sentences | |
|-----|-----------|---|-------------|
| a. | Strong A: | Kyaku-ga seki-o yoyakushita. customer-NOM seat-ACC reserved 'The customer reserved the seat.' | (from (5a)) |
| b. | Strong B: | Seki-ga kyaku-o yoyakushita. seat-NOM customer-ACC reserved 'The seat reserved the customer.' | (from (5b)) |
| c. | Mild A: | Kyaku-ga tenin-o yonda. customer-NOM clerk-ACC called 'The customer called the clerk.' | (from (5c)) |
| d. | Mild B: | Tenin-ga kyaku-o yonda clerk-NOM customer-ACC called 'The clerk called the customer.' | (from (5d)) |
| e. | Null A: | Otto-ga tsuma-o yonda. husband-NOM wife-ACC called 'The husband called the wife.' | (from (5e)) |

- f. Null B: Tsuma-ga otto-o yonda. (from (5f))
 wife-NOM husband-ACC called
 ‘The wife called the husband.’

If the pragmatic biases were as intended, the following predictions should be borne out. For a strong bias pair, simple sentences in the Strong A condition should be plausible, while sentences in the Strong B condition should be implausible. For a mild bias pair, Mild A should be more plausible than Mild B. For a null bias pair, Null A and Null B should be equally plausible.

For the test of semantic compatibility of the intermediate predicate, two sentences were created for each of the three pragmatic bias conditions. In one version (condition A), the intermediate predicate was associated with the immediately following noun. In another version (condition B), the intermediate predicate was associated with the preceding noun. Note that these two versions were constructed from sentences in the subject-gap condition of each pragmatic bias. This is because the lexical items at the close filler and the distant filler in object-gap sentences were identical differing only in their positions, the same set of sentence versions would be produced. Sentences (2) below illustrate these.

- (2) a. Strong bias
- Condition A: Kyaku-ga kitanakatta. (from (5a))
 customer-NOM dirty-was
 ‘The customer was very dirty.’
- Condition B: Seki-ga kitanakatta. (from (5a))
 seat-NOM dirty-was
 ‘The seat was very dirty.’

b. Mild bias

Condition A: Kyaku-ga totemo shitsureidatta. (from (5c))
customer-NOM very rude-was
'The customer was very rude.'

Condition B: Tenin-ga totemo shitsureidatta. (from (5c))
clerk-NOM very rude-was
'The shop assistant was very rude.'

c. Null bias

Condition A: Otto-ga terebi-o miteita. (from (5e))
husband-NOM TV-ACC watching-was
'The husband was watching TV.'

Condition B: Tsuma-ga terebi-o miteita. (from (5e))
wife-NOM TV-ACC watching-was
'The wife was watching TV.'

Since the test materials were constructed so that the intermediate predicate of a double-gap RC was semantically compatible not only with the preceding NP but also with the immediately following NP, it was predicted that the two conditions (Condition A and Condition B) would be equally plausible for each pragmatic bias pair.

A total of 288 sentences – 144 sentences for the pragmatic bias test and 144 sentences for the intermediate predicate test – were distributed into four presentation lists using a Latin Square design.⁷⁷ Twenty-eight undergraduate students at the Kyoto Sangyo University in Japan rated the naturalness of each sentence on a 5-point scale from 1 (natural) to 5 (unnatural). Data analyses were conducted by calculating each condition's mean naturalness score for each participant (F_1) and item (F_2). A series of ANOVAs with repeated measures was carried out to test the significance of an effect.

⁷⁷ Only four presentation lists were necessary because lexical items at the critical regions (the two fillers and the intermediate predicate) were very similar only in the mild and null bias conditions. Items in the strong bias condition were inserted into each list later.

The results of the pragmatic bias test are presented in Table A.1 and Figure A.1.

Table A.1. Pretest 2: The results of pragmatic bias test (1: natural - 5: unnatural).

| | Strong | Mild | Null |
|-------------|--------|-------|-------|
| Condition A | 1.554 | 1.583 | 2.232 |
| Condition B | 4.851 | 3.095 | 1.923 |

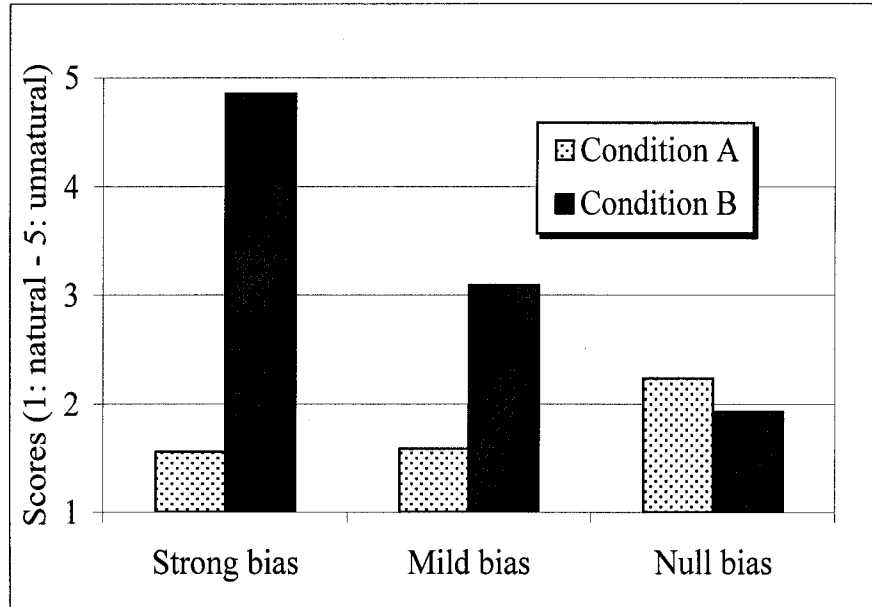


Figure A.1. Pretest 2: The results of pragmatic bias test.

As predicted, the largest difference was found in the strong bias pair. The thematic roles of the two fillers in this condition were so strongly constrained that only one interpretation (i.e., 'the customer reserved the seat') was pragmatically possible, while the other interpretation (i.e., 'the seat reserved the customer') was pragmatically impossible. In the mild bias pair, although the gap difference was smaller, one interpretation of the fillers (i.e., 'the customer called the clerk') was judged as more natural than the other (i.e., 'the clerk called the customer'). In the null bias pair, the gap difference was the smallest.

The results of 3×2 ANOVAs with repeated measures found the predicted interaction of the two factors ($F_1(2,54)=191.216, p <.001; F_2(2,46)=81.081; p <.001$) as well as the robust two main effects of Pragmatic bias ($F_1(2,54)=78.678; p <.001, F_2(2,46)=55.851, p <.001$) and Condition ($F_1(1,27)=608.305, p <.001; F_2(1,23)=154.636, p <.001$). In order to examine the effect of Condition in more detail, one-way ANOVAs were carried out for each pragmatic bias pair. The difference in condition was significant both in the strong bias pair ($F_1(1,27)=900.34, p <.001; F_2(1,23)=458.262, p <.001$) and in the mild bias pair ($F_1(1,27)=129.647, p <.001; F_2(1,23)=30.4, p <.001$). The difference was also found to be significant in the null bias pair, but only in the participant analysis ($F_1(1,27)=6.217, p =.019$). It was marginally significant in the item analysis ($F_2(1,23)=3.837, p =.062$).

In sum, the overall pattern across pragmatic bias conditions was consistent with the predictions. The only unpredicted result was the presence of a condition difference in the null bias pair where the two fillers were supposed to be equally good as agent or theme. Although the difference was the smallest among the three biases, this needs to be taken into consideration when the results of the main studies are interpreted.

Table A.2 below shows the results of the semantic compatibility test of the intermediate predicate.

Table A.2. Pretest 2: The results of semantic compatibility test (1: natural – 5: unnatural).

| | Strong bias | Mild bias | Null bias |
|-------------|-------------|-----------|-----------|
| Condition A | 2.065 | 1.554 | 1.72 |
| Condition B | 2.268 | 1.702 | 1.732 |

A series of one-way ANOVAs with repeated measures was performed to examine a difference between the two conditions (condition A and condition B) for each pragmatic bias. None of the pragmatic biases revealed the difference (Strong bias: $F_1(1,27)=2.253$, $p = .145$, $F_2(1,23)=.622$, $p = .438$; Mild bias: $F_1(1,27)=3.263$, $p = .082$, $F_2(1,23)=1.068$, $p = .312$; Null bias: $F_1(1,27)=.020$, $p = .888$, $F_2(1,23)=.010$, $p = .923$). This suggests that regardless of the pragmatic bias, the intermediate predicate was equally compatible with the preceding noun and the following noun in a sentence.

In order to examine whether the magnitude of the condition difference varied across the three pragmatic biases, two-way ANOVAs with repeated measures were carried out. Only a main effect of Pragmatic bias showed significance ($F_1(2,54)=27.308$, $p < .001$, $F_2(2,46)=7.705$, $p = .001$). Neither a main effect of Condition nor the Bias \times Condition interaction was significant (Condition: $F_1(1,27)=3.631$, $p = .067$, $F_2(1,23)=1.050$, $p = .316$; Interaction: $F_1(2,54)=.969$, $p = .386$, $F_2(2,46)=.324$, $p = .725$). The absence of an interaction suggests that the size of the condition difference was equal across the three pragmatic conditions.

APPENDIX B

PRETEST NORMING STUDY 3 (EXPERIMENT 4)

Experiment 4 used slightly different sets of materials from those used in Experiment 3. A plausibility norming study was conducted to ensure that the pragmatic factors manipulated in Experiment 4 had the intended bias and that the intermediate predicate was semantically compatible with both the preceding NP and the following NP. Note that in Experiment 4, the intermediate predicate in this experiment was constructed so that it was ‘incompatible’ with the following NP.

For the test of pragmatic bias, two versions of a simple transitive sentence were created from each pair of double-gap RCs as in sentences (10a) and (10b) in section 5.2.1.2. In one version (Condition A), the plausible theme of the double-gap RC served as the subject and the plausible agent as the object of the embedded predicate (‘the seat reserved the customer’). In the second version (Condition B), the plausible theme served as the subject and the plausible agent as the object (‘the customer reserved the seat’). Since Experiment 4 examined double-gap RCs only in the strong bias condition, it was predicted that Condition A should be implausible, while Condition B should be plausible.

For the test of semantic incompatibility, a simple sentence was constructed from each double-gap RC by combining a distant filler with the intermediate predicate. For example, ‘the customer was next to the smoking section’ was made from the original double-gap RC (10a) (Condition C), and ‘the seat was late (for the reservation time)’ was made from sentence (10b) (Condition D). Since the intermediate predicate was designed

to be incompatible with the following NP, both Condition C and D should be equally implausible.

Forty-eight sets of sentences (24 sets for argument relation and 24 for semantic incompatibility) were distributed into two presentation lists. Twenty-eight graduate students at Nara Institute of Science and Technology, who were the participants for other unrelated experiments, rated the naturalness of each sentence on a 5-point scale from 1 (natural) to 5 (unnatural).

The results of the pretest are shown in Table B.1.

Table B.1. Pretest 3: Mean naturalness scores (1: natural - 5: unnatural).

| | Pragmatic bias test | | Semantic compatibility test | |
|------|---------------------|-------------|-----------------------------|-------------|
| | Condition A | Condition B | Condition C | Condition D |
| Mean | 4.738 | 1.164 | 4.113 | 4.226 |

One-way ANOVAs with repeated measures revealed a significant pragmatic bias difference between Condition A and Condition B ($F_1(1,27)=2276.384$, $p < .001$; $F_2(1,23)=4714.01$, $p < .001$). Sentences in which the plausible theme served as the subject and the plausible agent as the direct object (i.e., Condition A) were consistently rated as unnatural, while sentences in which the plausible agent served as the subject and the plausible theme as the direct object (i.e., Condition B) were consistently rated as natural. The comparison between Condition C and Condition D produced no significant difference ($F_1(1,27)=2.102$, $p = .159$; $F_2(1,23)=0.217$, $p = .646$). This suggests that the intermediate predicate associated with the following NP was equally unnatural in the two gap configurations.

These results confirmed the following two things. First, the double-gap RCs used in this online experiment had the intended (strong) pragmatic bias. Second, the intermediate predicate was semantically incompatible with the immediately following NP, and a pair of double-gap RCs (i.e., sentence (10a) and (10b) in Section 5.2.1.2) was alike with regard to this point.

APPENDIX C

PRETEST NORMING STUDY 4 (EXPERIMENT 5)

A paper-and-pencil questionnaire was conducted in order to examine the plausibility of each filler as an agent or a theme. Unlike the pretest 2 reported for Experiment 3 (in Appendix A), this survey examined the plausibility of each filler as an agent or a theme without making reference to the other filler. This was another way to check if the pragmatic bias (strong, mild, and null) manipulated in the experiments had the intended effect.

For each pragmatic bias of double-gap RCs (as in sentences (13a)~(13f) in section 5.3.1.2 in Experiment 5), four versions of simple sentences were created. Conditions A, B, C and D shown in sentences (1) ~ (3) below illustrate these.

(1) Strong bias condition

- Condition A: Distant filler of the subject-gap sentence as agent (from 13a)
Kyaku-ga yoyakushita.
customer-NOM reserved
'The customer reserved.'
- Condition B: Distant filler of the object-gap sentence as agent (from 13b)
Seki-ga yoyakushita.
seat-NOM reserved
'The seat reserved.'
- Condition C: Close filler (of the subject-gap sentence) as theme (from 13a)
Seki-o yoyakushita.
seat-ACC reserved
'reserved the seat.'
- Condition D: Close filler (of the object-gap sentence) as theme (from 13b)
Kyaku-o yoyakushita.
customer-ACC reserved
'reserved the customer.'

(2) Mild bias condition

Condition A: Kyaku-ga yonda. (from 13c)
customer-NOM called
'The customer called.'

Condition B: Tenin-ga yonda. (from 13d)
clerk-NOM called
'The shop assistant called.'

Condition C: Tenin-o yonda. (from 13c)
clerk-ACC called
'called the shop assistant.'

Condition D: Kyaku-o yonda. (from 13d)
customer-ACC called
'called the customer.'

(3) Null bias condition

Condition A: Otto-ga yonda. (from 13e)
husband-NOM called
'The husband called.'

Condition B: Tsuma-ga yonda. (from 13f)
wife-NOM called
'The wife called.'

Condition C: Tsuma-o yonda. (from 13e)
wife-ACC called
'called the wife.'

Condition D: Otto-o yonda. (from 13f)
husband-ACC called
'called the husband.'

In condition A, the distant filler of the subject-gap sentence bears the agent role, and in condition B, the distant filler of the object-gap sentence bears the agent role. The comparison of Condition A and B will test how plausible the distant filler of each sentence is as an agent (i.e., agenthood test). In condition C, the close filler of the

subject-gap sentence carries the theme role, while in condition D, the close filler of the object-gap sentence carries the theme role. The comparison of Condition C and D will test how plausible the close filler of each sentence is as a theme. The following table presents the predictions for each condition.

Table C.1. Pretest 4: Predictions.

| | | Strong | Mild | Null |
|-------------------|-------------|-------------|----------------|-------------------|
| Test of agenthood | Condition A | Plausible | More plausible | Equally plausible |
| | Condition B | Implausible | Less plausible | |
| Test of themehood | Condition C | Plausible | More plausible | Equally plausible |
| | Condition D | Implausible | Less plausible | |

A total of 288 sentences (3 biases \times 4 conditions \times 24 sets) were distributed into four presentation lists (72 sentences per list) using a Latin Square design. Thirty-two undergraduate students at Yamanashi Junior College of Nursing participated in the survey for non-monetary compensation. They were asked to rate the naturalness of each sentence presented in a booklet on a 5-point scale from 1 (natural) to 5 (unnatural).

Table C.2 presents the results of the survey.

Table C.2. Pretest 4: Mean naturalness scores (1 natural – 5 unnatural).

| | | Strong | Mild | Null |
|----------------|-------------|--------|--------|--------|
| Agenthood test | Condition A | 2.0417 | 2.0156 | 2.2552 |
| | Condition B | 4.8542 | 2.8854 | 2.3177 |
| Themehood test | Condition C | 1.2292 | 1.375 | 1.7656 |
| | Condition D | 4.2865 | 1.849 | 1.75 |

Consistent with the predictions given in Table C.1, the magnitude of the agenthood difference between Condition A and Condition B varied across pragmatic bias conditions. The largest difference (favoring Condition A over Condition B) was found in the strong bias condition. There was almost no difference in the null bias condition, and a moderate

difference (favoring Condition A over Condition B) in the mild bias condition. Two-way ANOVAs with repeated measures found the expected interaction of Pragmatic bias and Condition ($F_1(2, 62)=140.120, p <.001$; $F_2(2, 46)=71.785, p <.001$). The subsequent analyses with one-way ANOVAs also found a significant effect of Condition in the strong bias condition ($F_1(1,31)=499.536, p <.001$; $F_2(1,23)=342.463, p <.001$) and in the mild bias condition ($F_1(1,31)=43.755, p <.001$; $F_2(1,23)=16.347, p =.001$), but no difference was found in the null bias condition ($F_1(1,31)=.271, p =.607$; $F_2(1,23)=.279, p =.602$).

The results of the themehood test showed a parallel pattern – the largest difference in the strong bias condition, no difference in the null bias condition, and an intermediate difference in the mild bias condition. Two-way ANOVAs produced a reliable interaction ($F_1(2,62)=218.135, p <.001$; $F_2(2,46)=110.210, p <.001$), and one-way ANOVAs found a significant difference in the strong bias and mild bias conditions (strong bias: $F_1(1,31)=564.598, p <.001$; $F_2(1,23)=216.396, p <.001$; mild bias: $F_1(1,31)=16.499, p <.001$; $F_2(1,23)=8.098, p =.009$) but not in the null bias condition ($F_1(1,31)=.019, p =.892, F_2(1,23)=.027, p =.827$).

In order to examine if there is a plausibility difference between sentences with a missing object argument (i.e., sentences in the agenthood test) and those with a missing subject argument (i.e., sentences in the themehood test), three-way ANOVAs with repeated measures were conducted by including Test type in addition to Condition and Pragmatic bias factors. Other than the effects found in two-way ANOVAs conducted earlier, a robust main effect of Test type ($F_1(1,31)=100.25, p <.001$; $F_2(1,23)=62.563,$

p<.001;) was found. Sentences in the themehood test were significantly rated as more natural than sentences in the agenthood test.

Overall, the results of Pretest 4 showed that the strength of pragmatic bias had the intended effect. That is, in the strong bias sentences, one of the two fillers was predominantly interpreted as the agent and the other filler as the theme. In the mild bias sentences, one of the fillers was a better agent and the other filler was a better theme. In the null bias sentences, the two fillers were equally good agent or theme. Furthermore, an additional ANOVA analyses found that sentences with a missing subject are in general more plausible than sentences with a missing object.

APPENDIX D

TEST SENTENCES FOR EXPERIMENT 1

The following list shows the subject-gap RC condition for each set. An object-gap RC can be created by replacing the (underlined) accusative marker *-o* with the nominative marker *-ga*. Slashes indicate segmentation as presented to participants in the reading task.

1. 年寄りのおばあさんをバス停まで見送った/女の子は/ぬいぐるみを/抱いていた。
2. 様子の変な男性を通りで見つめた/女性は/私立大学の/助教授だ。
3. 酔っ払いのホームレスをパチンコ屋でどなっていた/おじさんは/タバコを/よく吸う。
4. 民宿のおかみさんをとても信頼していた/外人客は/日本に/10年住んでいる。
5. 福岡出身の社員を妙に嫌っていた/同僚は/名古屋で/生まれた。
6. 迷子の子供を遊園地で探していた/お母さんは/20才の/ヤンママだ。
7. 金髪の少年をエレベーターの中でにらんでいた/お婆さんは/とても/厚化粧だった。
8. 若い係長を前から恐れていた/秘書は/来月/出産する。
9. 金持ちの部長を一昨日訪ねた/踊り子は/三味線を/おしえている。
10. 出来の悪い弟を図書館で待っていた/お兄さんは/京都大学に/通っている。
11. 運転の荒いドライバーを高速道路で見つけた/白バイは/車線を/変えた。
12. やる気のない店員を長い間無視していた/支店長は/あと一ヶ月で/退職する。
13. 理科の講師を実験室で手伝っていた/学生は/グラスを/落とした。
14. 物静かなモデルを一目で気に入った/デザイナーは/派手な生活を/している。
15. 無関心な夫をずっと放っておいた/妻は/カラオケに/夢中だ。
16. 陽気な留学生をパーティーでからかっていた/大学院生は/朝まで/飲んでいた。
17. 下校中の小学生を大声で呼んだ/友達は/犬を/散歩していた。
18. 生意気な家主をずっと避けていた/不動産屋が/事務所を/新築した。
19. 新人歌手をテレビ局で探していた/カメラマンは/まだ/見習いだ。
20. にぎやかな観光客をデジカメで写した/ガイドさんは/高校を/卒業したばかりだ。
21. 無邪気な子供をビーチで追いかけていた/お父さんは/小学校の/先生だ。
22. 帰省中の大学生を電話で誘っていた/幼なじみは/銀行で/働いている。
23. 分裂病の患者をとても怖がっていた/看護婦は/スポーツクラブに/よく通っている。
24. 酔っ払った父をタクシーの中で叱っていた/娘は/来月ハワイで/結婚する。
25. アメリカ人の選手を控え室で馬鹿にしていた/コーチは/台湾に/住んだことがある。
26. 昔のアイドルを楽屋でなくさめていた/マネージャーは/コーヒーを/入れた。
27. ずうずうしい主婦を満員電車の中で押した/サラリーマンは/埼玉に/住んでいる。
28. 謙虚な役者をテレビで誉めていた/監督は/とても/古風な人だ。
29. 暴力団の幹部を空港で待ち伏せていた/男は/サングラスを/かけていた。
30. 夜勤明けの医者を廊下で呼び止めた/入院患者は/話し出すと/止まらない。
31. 退屈そうな政治家を長いことながめていた/ガードマンは/たくましい体を/している。
32. 大企業の経営者を前から疑っていた/官僚は/とても/無口だ。

APPENDIX E

TEST SENTENCES FOR EXPERIMENT 2

The following list only shows the subject-gap RC condition in each set. Sentence (a) represents a subject-gap RC with topic-marked head noun, (b) a subject-gap RC with nominative-marked head noun, and (c) a subject-gap RC with accusative-marked head noun. An object-gap RC can be created for each sentence by replacing the accusative case marker *-o* on word 2 with the nominative case marker *-ga*. Slashes indicate the segmentation of a sentence.

- 1a. 年寄りの/おばあさんを/バス停まで/見送った/女の子は/ぬいぐるみを/抱いていた。
- 1b. 年寄りの/おばあさんを/バス停まで/見送った/女の子が/ぬいぐるみを/抱いていた。
- 1c. 年寄りの/おばあさんを/バス停まで/見送った/女の子を/お巡りさんが/呼び止めた。

- 2a. 様子の変な/男性を/通りで/見つめた/女性は/私立大学の/助教授だ。
- 2b. 様子の変な/男性を/通りで/見つめた/女性が/私立大学の/助教授だ。
- 2c. 様子の変な/男性を/通りで/見つめた/女性を/魚屋さんが/呼び止めた。

- 3a. 酔っ払いの/ホームレスを/パチンコ屋で/どなっていた/おじさんは/タバコを/よく吸う。
- 3b. 酔っ払いの/ホームレスを/パチンコ屋で/どなっていた/おじさんが/タバコを/よく吸う。
- 3c. 酔っ払いの/ホームレスを/パチンコ屋で/どなっていた/おじさんを/奥さんが/迎えに行った。

- 4a. 民宿の/おかみさんを/とても/信頼していた/外人客は/神奈川県に/10年住んでいる。
- 4b. 民宿の/おかみさんを/とても/信頼していた/外人客が/神奈川県に/10年住んでいる。
- 4c. 民宿の/おかみさんを/とても/信頼していた/外人客を/近所の人が/歓迎した。

- 5a. 下校中の/小学生を/大声で/呼んだ/友達は/犬を/散歩していた。
- 5b. 下校中の/小学生を/大声で/呼んだ/友達が/犬を/散歩していた。
- 5c. 下校中の/小学生を/大声で/呼んだ/友達を/犬が/追いかけた。

- 6a. 生意気な/家主を/ずっと/避けていた/不動産屋は/事務所を/新築した。
- 6b. 生意気な/家主を/ずっと/避けていた/不動産屋が/事務所を/新築した。
- 6c. 生意気な/家主を/ずっと/避けていた/不動産屋を/税務署が/調査した。

- 7a. 新人/歌手を/テレビ局で/探していた/カメラマンは/まだ/見習いだ。
- 7b. 新人/歌手を/テレビ局で/探していた/カメラマンが/まだ/見習いだ。
- 7c. 新人/歌手を/テレビ局で/探していた/カメラマンを/妹が/待っていた。

- 8a. 福岡出身の/社員を/妙に/嫌っていた/同僚は/野球に/凝っている。
- 8b. 福岡出身の/社員を/妙に/嫌っていた/同僚が/野球に/凝っている。
- 8c. 福岡出身の/社員を/妙に/嫌っていた/同僚を/主任が/呼び出した。

- 9a. 迷子の/子供を/遊園地で/探していた/お母さんは/20才の/ヤンママだ。
9b. 迷子の/子供を/遊園地で/探していた/お母さんが/20才の/ヤンママだ。
9c. 迷子の/子供を/遊園地で/探していた/お母さんを/警備員が/見かけた。
- 10a. 金髪の/少年を/エレベーターの中で/にらんでいた/お婆さんは/とても/美人です。
10b. 金髪の/少年を/エレベーターの中で/にらんでいた/お婆さんが/とても/美人です。
10c. 金髪の/少年を/エレベーターの中で/にらんでいた/お婆さんを/店員が/目撃した。
- 11a. 若い/係長を/前から/恐れていた/秘書は/この秋に/出産する。
11b. 若い/係長を/前から/恐れていた/秘書が/この秋に/出産する。
11c. 若い/係長を/前から/恐れていた/秘書を/清掃員が/探した。
- 12a. 無邪気な/子供を/ビーチで/追いかけていた/お父さんは/高校の/先生だ。
12b. 無邪気な/子供を/ビーチで/追いかけていた/お父さんが/高校の/先生だ。
12c. 無邪気な/子供を/ビーチで/追いかけていた/お父さんを/ハチが/刺した。
- 13a. 帰省中の/大学生を/電話で/誘っていた/幼なじみは/横須賀の銀行で/働いている。
13b. 帰省中の/大学生を/電話で/誘っていた/幼なじみが/横須賀の銀行で/働いている。
13c. 帰省中の/大学生を/電話で/誘っていた/幼なじみを/セールスマンが/邪魔した。
- 14a. 酔っ払った/父を/タクシーの中で/叱っていた/娘は/ハワイで/結婚する。
14b. 酔っ払った/父を/タクシーの中で/叱っていた/娘が/ハワイで/結婚する。
14c. 酔っ払った/父を/タクシーの中で/叱っていた/娘を/運転手が/見ていた。
- 15a. 金持ちの/部長を/一昨日/訪ねた/踊り子は/三味線を/おしえている。
15b. 金持ちの/部長を/一昨日/訪ねた/踊り子が/三味線を/おしえている。
15c. 金持ちの/部長を/一昨日/訪ねた/踊り子を/歯医者が/診察した。
- 16a. 出来の悪い/弟を/図書館で/待っていた/お兄さんは/京都大学に/通っている。
16b. 出来の悪い/弟を/図書館で/待っていた/お兄さんが/京都大学に/通っている。
16c. 出来の悪い/弟を/図書館で/待っていた/お兄さんを/学級担任が/訪問した。
- 17a. 運転の荒い/ドライバーを/高速道路で/見つけた/白バイは/車線を/変えた。
17b. 運転の荒い/ドライバーを/高速道路で/見つけた/白バイが/車線を/変えた。
17c. 運転の荒い/ドライバーを/高速道路で/見つけた/白バイを/バスが/追いこした。
- 18a. やる気のない/店員を/長い間/無視していた/支店長は/あと半年で/退職する。
18b. やる気のない/店員を/長い間/無視していた/支店長が/あと半年で/退職する。
18c. やる気のない/店員を/長い間/無視していた/支店長を/お客さんが/手招きした。
- 19a. アメリカ人の/選手を/控え室で/馬鹿にしていた/コーチは/台湾に/住んだことがある。
19b. アメリカ人の/選手を/控え室で/馬鹿にしていた/コーチが/台湾に/住んだことがある。
19c. アメリカ人の/選手を/控え室で/馬鹿にしていた/コーチを/息子が/笑わせた。

- 20a. 夜勤明けの/医者を/廊下で/呼び止めた/入院患者は/とても/お喋りだ。
 20b. 夜勤明けの/医者を/廊下で/呼び止めた/入院患者が/とても/お喋りだ。
 20c. 夜勤明けの/医者を/廊下で/呼び止めた/入院患者を/家族が/見舞った。
- 21a. 昔の/アイドルを/楽屋で/なぐさめていた/マネージャーは/コーヒーを/入れた。
 21b. 昔の/アイドルを/楽屋で/なぐさめていた/マネージャーが/コーヒーを/入れた。
 21c. 昔の/アイドルを/楽屋で/なぐさめていた/マネージャーを/女子高生が/インタビューした。
- 22a. 謙虚な/役者を/テレビで/誉めていた/監督は/亭主関白で/有名だ。
 22b. 謙虚な/役者を/テレビで/誉めていた/監督が/亭主関白で/有名だ。
 22c. 謙虚な/役者を/テレビで/誉めていた/監督を/映画会社が/引き抜いた。
- 23a. 暴力団の/幹部を/空港で/待ち伏せていた/男は/サングラスを/かけていた。
 23b. 暴力団の/幹部を/空港で/待ち伏せていた/男が/サングラスを/かけていた。
 23c. 暴力団の/幹部を/空港で/待ち伏せていた/男を/英国の刑事が/尾行した。
- 24a. 大企業の/経営者を/前から/疑っていた/官僚は/とても/無口だ。
 24b. 大企業の/経営者を/前から/疑っていた/官僚が/とても/無口だ。
 24c. 大企業の/経営者を/前から/疑っていた/官僚を/記者が/取材した。
- 25a. 理科の/講師を/実験室で/手伝っていた/学生は/グラスを/落とした。
 25b. 理科の/講師を/実験室で/手伝っていた/学生が/グラスを/落とした。
 25c. 理科の/講師を/実験室で/手伝っていた/学生を/同級生が/からかった。
- 26a. 物静かな/モデルを/一目で/気に入った/デザイナーは/派手な生活を/している。
 26b. 物静かな/モデルを/一目で/気に入った/デザイナーが/派手な生活を/している。
 26c. 物静かな/モデルを/一目で/気に入った/デザイナーを/隣的美容師が/ひやかした。
- 27a. 無関心な/夫を/ずっと/放っておいた/妻は/カラオケに/夢中だ。
 27b. 無関心な/夫を/ずっと/放っておいた/妻が/カラオケに/夢中だ。
 27c. 無関心な/夫を/ずっと/放っておいた/妻を/証券マンが/誘った。
- 28a. 陽気な/留学生を/パーティーで/からかっていた/大学院生は/朝まで/飲んでた。
 28b. 陽気な/留学生を/パーティーで/からかっていた/大学院生が/朝まで/飲んでた。
 28c. 陽気な/留学生を/パーティーで/からかっていた/大学院生を/後輩が/誘った。
- 29a. にぎやかな/観光客を/デジカメで/写した/ガイドさんは/短期大学を/卒業したばかりだ。
 29b. にぎやかな/観光客を/デジカメで/写した/ガイドさんが/短期大学を/卒業したばかりだ。
 29c. にぎやかな/観光客を/デジカメで/写した/ガイドさんを/大家さんが/かわいがった。
- 30a. ずうずうしい/主婦を/満員電車の中で/押した/サラリーマンは/埼玉に/住んでいる。
 30b. ずうずうしい/主婦を/満員電車の中で/押した/サラリーマンが/埼玉に/住んでいる。
 30c. ずうずうしい/主婦を/満員電車の中で/押した/サラリーマンを/駅員が/知っている。

APPENDIX F

TEST SENTENCES FOR EXPERIMENT 3

The following are the conditions for each set.

- a. Strong bias with distant filler involving a subject gap
- b. Strong bias with distant filler involving an object gap
- c. Mild bias with distant filler involving a subject gap
- d. Mild bias with distant filler involving an object gap
- e. Null bias with distant filler involving a subject gap
- f. Null bias with distant filler involving an object gap

- 1a. 予約した/席が/とても/汚かった/客は/ウェイトレスを/呼んだ。
- 1b. 予約した/客が/とても/汚かった/席は/ウェイトレスが/掃除した。
- 1c. 呼んだ/店員が/とても/失礼だった/客は/店長に/抗議した。
- 1d. 呼んだ/客が/とても/失礼だった/店員は/店長に/報告した。
- 1e. 呼んだ/妻が/テレビを/見ていた/夫は/庭に/出た。
- 1f. 呼んだ/夫が/テレビを/見ていた/妻は/庭に/出た。

- 2a. 注文した/料理が/地元で/有名だった/男優は/残さず/食べた。
- 2b. 注文した/男優が/地元で/有名だった/料理は/特別に/用意された。
- 2c. 誘った/女性が/明るい/性格だった/男優は/機嫌よく/帰宅した。
- 2d. 誘った/男優が/明るい/性格だった/女性は/機嫌よく/帰宅した。
- 2e. 誘った/建築家が/明るい/性格だった/設計士は/機嫌よく/帰宅した。
- 2f. 誘った/設計士が/明るい/性格だった/建築家は/機嫌よく/帰宅した。

- 3a. 拾った/子犬が/3日後に/死んだ/祖母は/さみしがって/泣いた。
- 3b. 拾った/祖母が/3日後に/死んだ/子犬は/さみしがって/ないた。
- 3c. 出迎えた/孫が/子犬を/抱いていた/祖母は/目を/丸くした。
- 3d. 出迎えた/祖母が/子犬を/抱いていた/孫は/目を/丸くした。
- 3e. 出迎えた/妹が/恋人を/連れていた/姉は/目を/丸くした。
- 3f. 出迎えた/姉が/恋人を/連れていた/妹は/目を/丸くした。

- 4a. 採点した/テストが/ちょっと/やさしすぎた/先生は/追試を/宣言した。
- 4b. 採点した/先生が/ちょっと/やさしすぎた/テストは/全員が/合格した。
- 4c. 見送った/卒業生が/校門に/立っていた/先生は/手を/ふった。
- 4d. 見送った/先生が/校門に/立っていた/卒業生は/手を/ふった。
- 4e. 見送った/会社員が/駐車場に/立っていた/同僚は/手を/ふった。
- 4f. 見送った/同僚が/駐車場に/立っていた/会社員は/手を/ふった。

- 5a. 盗んだ/お金が/川に/落ちた/強盗は/そのまま/逃げた。
- 5b. 盗んだ/強盗が/川に/落ちた/お金は/橋の上に/あった。
- 5c. 襲った/OLが/自転車で/逃げた/強盗は/仲間に/電話した。
- 5d. 襲った/強盗が/自転車で/逃げた/OLは/友人に/電話した。

5e. 襲った/チンピラが/自転車で/逃げた/不良少年は/仲間に/電話した。
5f. 襲った/不良少年が/自転車で/逃げた/チンピラは/仲間に/電話した。

6a. 建てた/病院が/テレビに/写った/医者は/親戚に/自慢した。
6b. 建てた/医者が/テレビに/写った/病院は/村で/評判になった。
6c. 説得した/患者が/とても/頑固だった/医者は/病院長に/相談した。
6d. 説得した/医者が/とても/頑固だった/患者は/家族に/相談した。
6e. 説得した/神父が/とても/頑固だった/牧師は/知人に/相談した。
6f. 説得した/牧師が/とても/頑固だった/神父は/知人に/相談した。

7a. 運転した/自家用車が/雨に/ぬれた/営業マンは/スタンドに/向かった。
7b. 運転した/営業マンが/雨に/ぬれた/自家用車は/シートが/湿っていた。
7c. 無視した/後輩が/北海道の/出身だった/営業マンは/同僚に/確かめた。
7d. 無視した/営業マンが/北海道の/出身だった/後輩は/同僚に/確かめた。
7e. 無視した/弁護士が/北海道の/出身だった/検察官は/同僚に/確かめた。
7f. 無視した/検察官が/北海道の/出身だった/弁護士は/同僚に/確かめた。

8a. 経営した/会社が/不正で/噂になった/社長は/一年後/自殺した。
8b. 経営した/社長が/不正で/噂になった/会社は/一年後/倒産した。
8c. からかった/秘書が/とても/のんきだった/社長は/専務に/話した。
8d. からかった/社長が/とても/のんきだった/秘書は/家族に/話した。
8e. からかった/会計士が/とても/のんきだった/税理士は/主任に/話した。
8f. からかった/税理士が/とても/のんきだった/会計士は/主任に/話した。

9a. 買った/ランドセルが/かなり/大きかった/小学生は/こっけいに/見えた。
9b. 買った/小学生が/かなり/大きかった/ランドセルは/全然/似合わない。
9c. いじめた/転入生が/近所を/歩いていた/小学生は/驚いて/隠れた。
9d. いじめた/小学生が/近所を/歩いていた/転入生は/驚いて/隠れた。
9e. いじめた/看護婦が/近所を/歩いていた/薬剤師は/驚いて/隠れた。
9f. いじめた/薬剤師が/近所を/歩いていた/看護婦は/驚いて/隠れた。

10a. 召集した/緊急会議が/都合で/遅れた/支店長は/機嫌が/悪かった。
10b. 召集した/支店長が/都合で/遅れた/緊急会議は/雰囲気/悪かった。
10c. もてなした/国会議員が/急用で/帰宅した/支店長は/機嫌が/悪かった。
10d. もてなした/支店長が/急用で/帰宅した/国会議員は/機嫌が/悪かった。
10e. もてなした/首相が/急用で/帰国した/大統領は/機嫌が/悪かった。
10f. もてなした/大統領が/急用で/帰国した/首相は/機嫌が/悪かった。

11a. 鑑賞した/漫才が/あまりに/下品だった/観客は/だんだん/呆れてきた。
11b. 鑑賞した/観客が/あまりに/下品だった/漫才は/漫才師も/呆れた。
11c. 応援した/投手が/審判を/ばかにした/観客は/呆れて/見ていた。
11d. 応援した/観客が/審判を/ばかにした/投手は/呆れて/見ていた。
11e. 応援した/空手部員が/審判を/ばかにした/柔道部員は/呆れて/見ていた。
11f. 応援した/柔道部員が/審判を/ばかにした/空手部員は/呆れて/見ていた。

- 12a. 食べた/寿司が/見た目の/ひどかった/老人は/板前に/知らせた。
- 12b. 食べた/老人が/見た目の/ひどかった/寿司は/まずそうに/見えた。
- 12c. 雇った/家政婦が/タイガースを/けなした/老人は/表情を/変えた。
- 12d. 雇った/老人が/タイガースを/けなした/家政婦は/表情を/変えた。
- 12e. 雇った/アメリカ人が/ビートルズを/けなした/イギリス人は/表情を/変えた。
- 12f. 雇った/イギリス人が/ビートルズを/けなした/アメリカ人は/表情を/変えた。

- 13a. 演じた/芝居が/アメリカで/好評だった/役者は/記者会見が/続いた。
- 13b. 演じた/役者が/アメリカで/好評だった/芝居は/前売り券が/完売した。
- 13c. 励ました/子役が/真剣に/稽古していた/役者は/その様子に/感心した。
- 13d. 励ました/役者が/真剣に/稽古していた/子役は/その様子に/感心した。
- 13e. 励ました/女優が/真剣に/稽古していた/俳優は/その様子に/感心した。
- 13f. 励ました/俳優が/真剣に/稽古していた/女優は/その様子に/感心した。

- 14a. 試飲した/健康茶が/キャンパスで/人気だった/女子大生は/友達に/報告した。
- 14b. 試飲した/女子大生が/キャンパスで/人気だった/健康茶は/すぐに/広まった。
- 14c. 訪問した/恩師が/昔と/変わっていた/女子大生は/ちょっと/戸惑った。
- 14d. 訪問した/女子大生が/昔と/変わっていた/恩師は/ちょっと/戸惑った。
- 14e. 訪問した/市長が/仕事で/疲れていた/知事は/休暇を/すすめた。
- 14f. 訪問した/知事が/仕事で/疲れていた/市長は/休暇を/すすめた。

- 15a. 演奏した/セレナーデが/注目を/集めた/ピアニストは/音楽家の/娘だった。
- 15b. 演奏した/ピアニストが/注目を/集めた/セレナーデは/ショパンの/名曲だった。
- 15c. ほめた/少女が/コンクールに/来ていた/ピアニストは/にっこり/微笑んだ。
- 15d. ほめた/ピアニストが/コンクールに/来ていた/少女は/にっこり/微笑んだ。
- 15e. ほめた/写真家が/展示会に/来ていた/画家は/にっこり/微笑んだ。
- 15f. ほめた/画家が/展示会に/来ていた/写真家は/にっこり/微笑んだ。

- 16a. 操縦した/飛行機が/異常を/感知した/機長は/管制塔に/連絡した。
- 16b. 操縦した/機長が/異常を/感知した/飛行機は/空港に/引き返した。
- 16c. 注意した/訓練生が/飛行中/黙っていた/機長は/ラジオを/つけた。
- 16d. 注意した/機長が/飛行中/黙っていた/訓練生は/ラジオを/つけた。
- 16e. 注意した/サーファーが/ビーチで/寝ていた/ダイバーは/横を/通り過ぎた。
- 16f. 注意した/ダイバーが/ビーチで/寝ていた/サーファーは/横を/通り過ぎた。

- 17a. 発見した/化石が/雑誌に/載った/男の子は/学校で/ほめられた。
- 17b. 発見した/男の子が/雑誌に/載った/化石は/恐竜の/骨だった。
- 17c. 押した/女の子が/イスに/つまずいた/男の子は/大声で/笑った。
- 17d. 押した/男の子が/イスに/つまずいた/女の子は/大声で/笑った。
- 17e. 押した/横綱が/一瞬/わき見した/大関は/うわてを/かけた。
- 17f. 押した/大関が/一瞬/わき見した/横綱は/うわてを/かけた。

- 18a. 捜査した/事件が/暴力団と/絡んでいた/刑事は/3日間/徹夜した。
- 18b. 捜査した/刑事が/暴力団と/絡んでいた/事件は/世間を/騒がせた。
- 18c. 追いかけた/犯人が/けん銃を/持っていた/刑事は/冷静に/考えた。

- 18d. 追いかけた/刑事が/けん銃を/持っていた/犯人は/冷静に/考えた。
 18e. 追いかけた/双子の兄が/花びんを/壊した/双子の弟は/ほうきを/取ってきた。
 18f. 追いかけた/双子の弟が/花びんを/壊した/双子の兄は/ほうきを/取ってきた。
- 19a. はめた/婚約指輪が/ちょっと/地味だった/芸能人は/別のものと/取り替えた。
 19b. はめた/芸能人が/ちょっと/地味だった/婚約指輪は/1億円に/見えない。
 19c. 招いた/レポーターが/ベンツに/乗っていた/芸能人は/中を/のぞいた。
 19d. 招いた/芸能人が/ベンツに/乗っていた/レポーターは/中を/のぞいた。
 19e. 招いた/ロシア大使が/ベンツに/乗っていた/ドイツ大使は/中を/のぞいた。
 19f. 招いた/ドイツ大使が/ベンツに/乗っていた/ロシア大使は/中を/のぞいた。
- 20a. 購入した/絵画が/フランスから/やって来た/美術館長は/展示会を/計画した。
 20b. 購入した/美術館長が/フランスから/やって来た/絵画は/抽象画が/ほとんどだ。
 20c. 案内した/来賓が/ピカソの/ファンだった/美術館長は/自宅に/招いた。
 20d. 案内した/美術館長が/ピカソの/ファンだった/来賓は/自宅に/招いた。
 20e. 案内した/博物館長が/ピカソの/ファンだった/美術館長は/自宅に/招いた。
 20f. 案内した/美術館長が/ピカソの/ファンだった/博物館長は/自宅に/招いた。
- 21a. 発表した/論文が/あまり/面白くなかった/教授は/急いで/帰った。
 21b. 発表した/教授が/あまり/面白くなかった/論文は/だれも/読まなかった。
 21c. 推薦した/学生が/あまり/やる気のない/教授は/気にも/とめなかった。
 21d. 推薦した/教授が/あまり/やる気のない/学生は/気にも/とめなかった。
 21e. 推薦した/総務課長が/あまり/やる気のない/経理課長は/気にも/とめなかった。
 21f. 推薦した/経理課長が/あまり/やる気のない/総務課長は/気にも/とめなかった。
- 22a. 計画した/事業が/みんなに/嫌われた/部長は/ショックで/寝込んだ。
 22b. 計画した/部長が/みんなに/嫌われた/事業は/途中で/中止になった。
 22c. 責めた/部下が/ミーティングに/出席した/部長は/何だか/気になった。
 22d. 責めた/部長が/ミーティングに/出席した/部下は/何だか/気になった。
 22e. 責めた/小児科医が/ミーティングに/出席した/内科医は/何だか/気になった。
 22f. 責めた/内科医が/ミーティングに/出席した/小児科医は/何だか/気になった。
- 23a. 製作した/映画が/アカデミー賞を/とった/監督は/授賞式で/泣いた。
 23b. 製作した/監督が/アカデミー賞を/とった/映画は/公開が/早まった。
 23c. 殴った/選手が/試合後も/怒っていた/監督は/さっさと/帰った。
 23d. 殴った/監督が/試合後も/怒っていた/選手は/さっさと/帰った。
 23e. 殴った/自民党員が/ロビーに/入ってきた/社会党員は/部屋を/出た。
 23f. 殴った/社会党員が/ロビーに/入ってきた/自民党員は/部屋を/出た。
- 24a. 書いた/新聞記事が/軍縮に/批判的だった/女性議員は/国会で/問題にされた。
 24b. 書いた/女性議員が/軍縮に/批判的だった/新聞記事は/国会で/問題にされた。
 24c. 見舞った/被災者が/雨の中/働いていた/女性議員は/カサを/さし出した。
 24d. 見舞った/女性議員が/雨の中/働いていた/被災者は/カサを/さし出した。
 24e. 見舞った/作家が/とても/お喋りだった/編集長は/黙って/聞いていた。
 24f. 見舞った/編集長が/とても/お喋りだった/作家は/黙って/聞いていた。

APPENDIX G

TEST SENTENCES FOR EXPERIMENT 4

The following are the conditions for each set.

- a. Double-gap RC with distant filler involving a subject gap
 - b. Double-gap RC with distant filler involving an object gap
 - c. Control sentence with the matrix topic coindexed with a dropped subject
 - d. Control sentence with the matrix topic coindexed with a dropped object
-
- 1a. 予約した/席が/喫煙席の/隣にあった/客は/他の席に/変えさせた。
 - 1b. 予約した/客が/時間に/遅れた/席は/他の客に/まわされた。
 - 1c. 予約した/席が/喫煙席の/隣にあったために/客は/他の席に/変えさせた。
 - 1d. 予約した/客が/時間に/遅れたために/席は/他の客に/まわされた。
-
- 2a. 注文した/料理が/和牛の/ステーキだった/男性は/赤ワインを/追加した。
 - 2b. 注文した/男性が/店の/常連だった/料理は/盛りが/よかった。
 - 2c. 注文した/料理が/和牛の/ステーキだったので/男性は/赤ワインを/追加した。
 - 2d. 注文した/男性が/店の/常連だったので/料理は/盛りが/よかった。
-
- 3a. 拾った/時計が/まだ/新しかった/祖母は/交番に/向かった。
 - 3b. 拾った/祖母が/お金に/困っていた/時計は/質屋に/売られた。
 - 3c. 拾った/時計が/まだ/新しかったので/祖母は/交番に/向かった。
 - 3d. 拾った/祖母が/お金に/困っていたので/時計は/質屋に/売られた。
-
- 4a. 試着した/洋服が/通常の/半額だった/お婆さんは/2着も/買い込んだ。
 - 4b. 試着した/お婆さんが/かなり/太っていた/洋服は/ボタンが/取れた。
 - 4c. 試着した/洋服が/通常の/半額だったので/お婆さんは/2着も/買い込んだ。
 - 4d. 試着した/お婆さんが/かなり/太っていたので/洋服は/ボタンが/取れた。
-
- 5a. 採点した/テストが/全員/百点だった/先生は/機嫌が/良かった。
 - 5b. 採点した/先生が/とても/寛大だった/テストは/全員が/合格した。
 - 5c. 採点した/テストが/全員/百点だったために/先生は/機嫌が/良かった。
 - 5d. 採点した/先生が/とても/寛大だったために/テストは/全員が/合格した。
-
- 6a. 盗んだ/お金が/全部/偽札だった/強盗は/言葉を/失った。
 - 6b. 盗んだ/強盗が/とても/慎重だった/お金は/2年間/使われなかった。
 - 6c. 盗んだ/お金が/全部/偽札だったために/強盗は/言葉を/失った。
 - 6d. 盗んだ/強盗が/とても/慎重だったために/お金は/2年間/使われなかった。
-
- 7a. 建てた/病院が/地震で/壊れた/医者は/がっくり/うなだれた。
 - 7b. 建てた/医者が/交通事故で/死んだ/病院は/息子が/引き継いだ。
 - 7c. 建てた/病院が/地震で/壊れたために/医者は/がっくり/うなだれた。
 - 7d. 建てた/医者が/交通事故で/死んだために/病院は/息子が/引き継いだ。

- 8a. 運転した/自動車が/路上で/故障した/営業マンは/商談を/のがした。
 8b. 運転した/営業マンが/疲れて/居眠りした/自動車は/電柱に/ぶつかった。
 8c. 運転した/自動車が/路上で/故障したために/営業マンは/商談を/のがした。
 8d. 運転した/営業マンが/疲れて/居眠りしたために/自動車は/電柱に/ぶつかった。
- 9a. 経営した/会社が/不況で/倒産した/社長は/一年後/自殺した。
 9b. 経営した/社長が/収賄で/捕まった/会社は/一年後/倒産した。
 9c. 経営した/会社が/不況で/倒産したために/社長は/一年後/自殺した。
 9d. 経営した/社長が/収賄で/捕まったために/会社は/一年後/倒産した。
- 10a. なくした/財布が/次の日/見つかった/小学生は/担任に/知らせた。
 10b. なくした/小学生が/次の日/名乗り出た/財布は/担任が/返した。
 10c. なくした/財布が/次の日/見つかったために/小学生は/担任に/知らせた。
 10d. なくした/小学生が/次の日/名乗り出たために/財布は/担任が/返した。
- 11a. 開いた/会議が/予定より/長引いた/支店長は/機嫌が/悪かった。
 11b. 開いた/支店長が/急用で/帰宅した/会議は/すぐに/終わった。
 11c. 開いた/会議が/予定より/長引いたために/支店長は/機嫌が/悪かった。
 11d. 開いた/支店長が/急用で/帰宅したために/会議は/すぐに/終わった。
- 12a. 観戦した/試合が/大雨で/中断した/観客は/ぬれながら/座っていた。
 12b. 観戦した/観客が/接戦で/興奮した/試合は/2回も/中断した。
 12c. 観戦した/試合が/大雨で/中断したために/観客は/ぬれながら/座っていた。
 12d. 観戦した/観客が/接戦で/興奮したために/試合は/2回も/中断した。
- 13a. 演じた/芝居が/シェークスピアの/喜劇だった/役者は/イギリスに/旅行した。
 13b. 演じた/役者が/売れっ子の/タレントだった/芝居は/前売り券が/完売した。
 13c. 演じた/芝居が/シェークスピアの/喜劇だったので/役者は/イギリスに/旅行した。
 13d. 演じた/役者が/売れっ子の/タレントだったので/芝居は/前売り券が/完売した。
- 14a. 試飲した/健康茶が/ダイエットに/効いた/女子大生は/友達に/おしえた。
 14b. 試飲した/女子大生が/ダイエットに/成功した/健康茶は/学生に/広まった。
 14c. 試飲した/健康茶が/ダイエットに/効いたので/女子大生は/友達に/おしえた。
 14d. 試飲した/女子大生が/ダイエットに/成功したので/健康茶は/学生に/広まった。
- 15a. 演奏した/セレナーデが/ショパンの/難曲だった/ピアニストは/みんなが/注目した。
 15b. 演奏した/ピアニストが/天才音楽家の/娘だった/セレナーデは/みんなが/注目した。
 15c. 演奏した/セレナーデが/ショパンの/難曲だったので/ピアニストは/みんなが/注目した。
 15d. 演奏した/ピアニストが/天才音楽家の/娘だったので/セレナーデは/みんなが/注目した。
- 16a. 操縦した/飛行機が/エンジンから/発火した/機長は/管制塔に/連絡した。
 16b. 操縦した/機長が/心臓発作で/倒れた/飛行機は/空港に/引き返した。
 16c. 操縦した/飛行機が/エンジンから/発火したために/機長は/管制塔に/連絡した。
 16d. 操縦した/機長が/心臓発作で/倒れたために/飛行機は/空港に/引き返した。

- 17a. 発見した/化石が/恐竜の/骨だった/おじさんは/博物館に/電話した。
 17b. 発見した/おじさんが/恐竜に/詳しくった/化石は/博物館に/届けられた。
 17c. 発見した/化石が/恐竜の/骨だったので/おじさんは/博物館に/電話した。
 17d. 発見した/おじさんが/恐竜に/詳しくったので/化石は/博物館に/届けられた。
- 18a. 捜査した/事件が/予想以上に/複雑だった/刑事は/捜査員を/増やした。
 18b. 捜査した/刑事が/経験豊富な/ベテランだった/事件は/一週間で/解決した。
 18c. 捜査した/事件が/予想以上に/複雑だったので/刑事は/捜査員を/増やした。
 18d. 捜査した/刑事が/経験豊富な/ベテランだったので/事件は/一週間で/解決した。
- 19a. 買った/豪邸が/空き巣に/入られた/芸能人は/警備会社を/訴えた。
 19b. 買った/芸能人が/先月/離婚した/豪邸は/売りに/出された。
 19c. 買った/豪邸が/空き巣に/入られたために/芸能人は/警備会社を/訴えた。
 19d. 買った/芸能人が/先月/離婚したために/豪邸は/売りに/出された。
- 20a. 購入した/絵画が/ピカソの/作品だった/美術館長は/展示会を/計画した。
 20b. 購入した/美術館長が/ピカソの/ファンだった/絵画は/抽象画が/ほとんどだ。
 20c. 購入した/絵画が/ピカソの/作品だったので/美術館長は/展示会を/計画した。
 20d. 購入した/美術館長が/ピカソの/ファンだったので/絵画は/抽象画が/ほとんどだ。
- 21a. 発表した/論文が/初めて/本になった/教授は/みんなに/自慢した。
 21b. 発表した/教授が/とても/堂々としていた/論文は/みんなが/納得した。
 21c. 発表した/論文が/初めて/本になったので/教授は/みんなに/自慢した。
 21d. 発表した/教授が/とても/堂々としていたので/論文は/みんなが/納得した。
- 22a. 計画した/事業が/予算不足で/中止になった/部長は/ショックで/寝込んだ。
 22b. 計画した/部長が/セクハラで/クビになった/事業は/途中で/中止になった。
 22c. 計画した/事業が/予算不足で/中止になったために/部長は/ショックで/寝込んだ。
 22d. 計画した/部長が/セクハラで/クビになったために/事業は/途中で/中止になった。
- 23a. 製作した/映画が/日米の/合作だった/監督は/西海岸を/行き来した。
 23b. 製作した/監督が/広島出身だった/映画は/被爆シーンが/生々しかった。
 23c. 製作した/映画が/日米の/合作だったので/監督は/西海岸を/行き来した。
 23d. 製作した/監督が/広島出身だったので/映画は/被爆シーンが/生々しかった。
- 24a. 書いた/エッセーが/10万冊も/売れた/女性議員は/テレビ出演が/増えた。
 24b. 書いた/女性議員が/東大文学部を/卒業した/エッセーは/読みごたえが/あった。
 24c. 書いた/エッセーが/10万冊も/売れたので/女性議員は/テレビ出演が/増えた。
 24d. 書いた/女性議員が/東大文学部を/卒業したので/エッセーは/読みごたえが/あった。

APPENDIX H

TEST SENTENCES FOR EXPERIMENT 5

The following are the conditions for each set.

- a. Strong bias with distant filler involving a subject gap
 - b. Strong bias with distant filler involving an object gap
 - c. Mild bias with distant filler involving a subject gap
 - d. Mild bias with distant filler involving an object gap
 - e. Null bias with distant filler involving a subject gap
 - f. Null bias with distant filler involving an object gap
-
- 1a. 予約した/席が/喫煙席の/隣にあった/客は/他の席に/変えさせた。
 - 1b. 予約した/客が/時間に/遅れた/席は/他の客に/まわされた。
 - 1c. 呼んだ/店員が/とても/失礼だった/客は/店長に/抗議した。
 - 1d. 呼んだ/客が/とても/失礼だった/店員は/店長に/報告した。
 - 1e. 呼んだ/妻が/テレビを/見ていた/夫は/庭に/出た。
 - 1f. 呼んだ/夫が/テレビを/見ていた/妻は/庭に/出た。
-
- 2a. 注文した/料理が/和牛の/ステーキだった/男性は/赤ワインを/追加した。
 - 2b. 注文した/男性が/店の/常連だった/料理は/盛りが/よかった。
 - 2c. 誘った/女性が/明るい/性格だった/男性は/機嫌よく/帰宅した。
 - 2d. 誘った/男性が/明るい/性格だった/女性は/機嫌よく/帰宅した。
 - 2e. 誘った/建築家が/明るい/性格だった/設計士は/機嫌よく/帰宅した。
 - 2f. 誘った/設計士が/明るい/性格だった/建築家は/機嫌よく/帰宅した。
-
- 3a. 拾った/時計が/まだ/新しかった/老人は/交番に/向かった。
 - 3b. 拾った/老人が/お金に/困っていた/時計は/質屋に/売られた。
 - 3c. 雇った/家政婦が/タイガースを/けなした/老人は/とても/驚いた。
 - 3d. 雇った/老人が/タイガースを/けなした/家政婦は/とても/驚いた。
 - 3e. 雇った/アメリカ人が/ビートルズを/けなした/イギリス人は/とても/驚いた。
 - 3f. 雇った/イギリス人が/ビートルズを/けなした/アメリカ人は/とても/驚いた。
-
- 4a. 試着した/洋服が/通常の/半額だった/おばさんは/2着も/買い込んだ。
 - 4b. 試着した/おばさんが/かなり/太っていた/洋服は/ボタンが/取れた。
 - 4c. にらんだ/子供が/独り言を/言っていた/おばさんは/店を/出た。
 - 4d. にらんだ/おばさんが/独り言を/言っていた/子供は/店を/出た。
 - 4e. にらんだ/姑が/独り言を/言っていた/嫁は/買い物に/行った。
 - 4f. にらんだ/嫁が/独り言を/言っていた/姑は/買い物に/行った。
-
- 5a. 採点した/テストが/全員/百点だった/先生は/機嫌が/良かった。
 - 5b. 採点した/先生が/とても/寛大だった/テストは/全員が/合格した。
 - 5c. 見送った/卒業生が/校門に/立っていた/先生は/手を/ふった。
 - 5d. 見送った/先生が/校門に/立っていた/卒業生は/手を/ふった。

- 5e. 見送った/会社員が/駐車場に/立っていた/同僚は/手を/ふった。
 5f. 見送った/同僚が/駐車場に/立っていた/会社員は/手を/ふった。
- 6a. 盗んだ/お金が/全部/偽札だった/強盗は/言葉を/失った。
 6b. 盗んだ/強盗が/とても/慎重だった/お金は/2年間/使われなかった。
 6c. 襲った/OLが/自転車で/逃げた/強盗は/仲間に/電話した。
 6d. 襲った/強盗が/自転車で/逃げた/OLは/友人に/電話した。
 6e. 襲った/チンピラが/自転車で/逃げた/不良少年は/仲間に/電話した。
 6f. 襲った/不良少年が/自転車で/逃げた/チンピラは/仲間に/電話した。
- 7a. 建てた/病院が/地震で/壊れた/医者は/がっくり/うなだれた。
 7b. 建てた/医者が/交通事故で/死んだ/病院は/息子が/引き継いだ。
 7c. 説得した/患者が/とても/頑固だった/医者は/病院長に/相談した。
 7d. 説得した/医者が/とても/頑固だった/患者は/家族に/相談した。
 7e. 説得した/神父が/とても/頑固だった/牧師は/知人に/相談した。
 7f. 説得した/牧師が/とても/頑固だった/神父は/知人に/相談した。
- 8a. 運転した/自動車が/路上で/故障した/営業マンは/商談を/のがした。
 8b. 運転した/営業マンが/疲れて/居眠りした/自動車が/電柱に/ぶつかった。
 8c. 無視した/後輩が/北海道の/出身だった/営業マンは/同僚に/確かめた。
 8d. 無視した/営業マンが/北海道の/出身だった/後輩は/同僚に/確かめた。
 8e. 無視した/弁護士が/北海道の/出身だった/検事は/同僚に/確かめた。
 8f. 無視した/検事が/北海道の/出身だった/弁護士は/同僚に/確かめた。
- 9a. 経営した/会社が/不況で/倒産した/社長は/一年後/自殺した。
 9b. 経営した/社長が/収賄で/捕まった/会社は/一年後/倒産した。
 9c. からかった/秘書が/とても/のんきだった/社長は/専務に/話した。
 9d. からかった/社長が/とても/のんきだった/秘書は/家族に/話した。
 9e. からかった/会計士が/とても/のんきだった/税理士は/主任に/話した。
 9f. からかった/税理士が/とても/のんきだった/会計士は/主任に/話した。
- 10a. なくした/財布が/次の日/見つかった/中学生は/担任に/知らせた。
 10b. なくした/中学生が/次の日/名乗り出た/財布は/担任が/返した。
 10c. いじめた/転入生が/近所を/歩いていた/中学生は/驚いて/隠れた。
 10d. いじめた/中学生が/近所を/歩いていた/転入生は/驚いて/隠れた。
 10e. いじめた/看護婦が/近所を/歩いていた/薬剤師は/驚いて/隠れた。
 10f. いじめた/薬剤師が/近所を/歩いていた/看護婦は/驚いて/隠れた。
- 11a. 開いた/会議が/予定より/長引いた/支店長は/機嫌が/悪かった。
 11b. 開いた/支店長が/途中で/帰宅した/会議は/すぐに/終わった。
 11c. もてなした/国会議員が/急用で/帰宅した/支店長は/機嫌が/悪かった。
 11d. もてなした/支店長が/急用で/帰宅した/国会議員は/機嫌が/悪かった。
 11e. もてなした/首相が/急用で/帰国した/大統領は/機嫌が/悪かった。
 11f. もてなした/大統領が/急用で/帰国した/首相は/機嫌が/悪かった。

- 12a. 観戦した/試合が/大雨で/中断した/観客は/文句を/言い始めた。
 12b. 観戦した/観客が/接戦で/興奮した/試合は/2回も/中断した。
 12c. 応援した/投手が/審判を/ばかにした/観客は/呆れて/見ていた。
 12d. 応援した/観客が/審判を/ばかにした/投手は/呆れて/見ていた。
 12e. 応援した/空手部員が/審判を/ばかにした/柔道部員は/呆れて/見ていた。
 12f. 応援した/柔道部員が/審判を/ばかにした/空手部員は/呆れて/見ていた。
- 13a. 演じた/芝居が/シェークスピアの/喜劇だった/役者は/イギリスに/旅行した。
 13b. 演じた/役者が/売れっ子の/タレントだった/芝居は/前売り券が/完売した。
 13c. 励ました/子役が/真剣に/稽古していた/役者は/とても/感心した。
 13d. 励ました/役者が/真剣に/稽古していた/子役は/とても/感心した。
 13e. 励ました/女優が/真剣に/稽古していた/俳優は/とても/感心した。
 13f. 励ました/俳優が/真剣に/稽古していた/女優は/とても/感心した。
- 14a. 試飲した/健康茶が/ダイエットに/効いた/女子大生は/友達に/おしえた。
 14b. 試飲した/女子大生が/ダイエットに/成功した/健康茶は/学生に/広まった。
 14c. 訪問した/恩師が/昔と/変わっていた/女子大生は/ちょっと/戸惑った。
 14d. 訪問した/女子大生が/昔と/変わっていた/恩師は/ちょっと/戸惑った。
 14e. 訪問した/市長が/仕事で/疲れていた/知事は/休暇を/すすめた。
 14f. 訪問した/知事が/仕事で/疲れていた/市長は/休暇を/すすめた。
- 15a. 演奏した/セレナーデが/ショパンの/難曲だった/ピアニストは/注目を/集めた。
 15b. 演奏した/ピアニストが/天才音楽家の/娘だった/セレナーデは/注目を/集めた。
 15c. ほめた/少女が/コンクールに/来ていた/ピアニストは/にっこり/微笑んだ。
 15d. ほめた/ピアニストが/コンクールに/来ていた/少女は/にっこり/微笑んだ。
 15e. ほめた/写真家が/展示会に/来ていた/画家は/にっこり/微笑んだ。
 15f. ほめた/画家が/展示会に/来ていた/写真家は/にっこり/微笑んだ。
- 16a. 操縦した/飛行機が/エンジンから/発火した/機長は/管制塔に/連絡した。
 16b. 操縦した/機長が/心臓発作で/倒れた/飛行機は/空港に/引き返した。
 16c. 注意した/訓練生が/飛行中/黙っていた/機長は/ラジオを/つけた。
 16d. 注意した/機長が/飛行中/黙っていた/訓練生は/ラジオを/つけた。
 16e. 注意した/サーファーが/ビーチで/寝ていた/ダイバーは/横を/通り過ぎた。
 16f. 注意した/ダイバーが/ビーチで/寝ていた/サーファーは/横を/通り過ぎた。
- 17a. 発見した/化石が/恐竜の/骨だった/おじさんは/博物館に/電話した。
 17b. 発見した/おじさんが/恐竜に/詳しく/化石は/博物館に/届けられた。
 17c. 押した/女の子が/石に/つまづいた/おじさんは/大声で/笑った。
 17d. 押した/おじさんが/石に/つまづいた/女の子は/大声で/笑った。
 17e. 押した/横綱が/一瞬/わき見した/大関は/うわてを/かけた。
 17f. 押した/大関が/一瞬/わき見した/横綱は/うわてを/かけた。
- 18a. 捜査した/事件が/予想以上に/複雑だった/刑事は/捜査員を/増やした。
 18b. 捜査した/刑事が/とても/辛抱強かった/事件は/ようやく/解決した。
 18c. 追いかけた/犯人が/けん銃を/持っていた/刑事は/冷静に/考えた。

- 18d. 追いかけた/刑事が/けん銃を/持っていた/犯人は/冷静に/考えた。
 18e. 追いかけた/双子の兄が/花びんを/壊した/双子の弟は/ほうきを/取ってきた。
 18f. 追いかけた/双子の弟が/花びんを/壊した/双子の兄は/ほうきを/取ってきた。
- 19a. 買った/豪邸が/時価/十億円した/芸能人は/笑顔で/会見した。
 19b. 買った/芸能人が/先月/離婚した/豪邸は/売りに/出された。
 19c. 招いた/レポーターが/ベンツに/乗っていた/芸能人は/中を/のぞいた。
 19d. 招いた/芸能人が/ベンツに/乗っていた/レポーターは/中を/のぞいた。
 19e. 招いた/ロシア大使が/ベンツに/乗っていた/ドイツ大使は/中を/のぞいた。
 19f. 招いた/ドイツ大使が/ベンツに/乗っていた/ロシア大使は/中を/のぞいた。
- 20a. 購入した/絵画が/ピカソの/作品だった/美術館長は/展示会を/計画した。
 20b. 購入した/美術館長が/ピカソの/ファンだった/絵画は/抽象画が/ほとんどだ。
 20c. 案内した/来賓が/ピカソの/ファンだった/美術館長は/夕食に/招いた。
 20d. 案内した/美術館長が/ピカソの/ファンだった/来賓は/夕食に/招いた。
 20e. 案内した/博物館長が/ピカソの/ファンだった/美術館長は/夕食に/招いた。
 20f. 案内した/美術館長が/ピカソの/ファンだった/博物館長は/夕食に/招いた。
- 21a. 発表した/論文が/初めて/本になった/教授は/みんなに/自慢した。
 21b. 発表した/教授が/とても/早口だった/論文は/みんな/分からなかった。
 21c. 推薦した/学生が/あまり/やる気のない/教授は/気にも/とめなかった。
 21d. 推薦した/教授が/あまり/やる気のない/学生は/気にも/とめなかった。
 21e. 推薦した/総務課長が/あまり/やる気のない/経理課長は/気にも/とめなかった。
 21f. 推薦した/経理課長が/あまり/やる気のない/総務課長は/気にも/とめなかった。
- 22a. 計画した/事業が/予算不足で/中止になった/部長は/ショックで/寝込んだ。
 22b. 計画した/部長が/セクハラで/クビになった/事業は/途中で/中止になった。
 22c. 責めた/部下が/ミーティングに/出席した/部長は/何だか/気になった。
 22d. 責めた/部長が/ミーティングに/出席した/部下は/何だか/気になった。
 22e. 責めた/小児科医が/ミーティングに/出席した/内科医は/何だか/気になった。
 22f. 責めた/内科医が/ミーティングに/出席した/小児科医は/何だか/気になった。
- 23a. 製作した/映画が/日米の/合作だった/監督は/西海岸を/行き来した。
 23b. 製作した/監督が/広島の/出身だった/映画は/被爆シーンが/生々しかった。
 23c. 殴った/選手が/試合後も/怒っていた/監督は/さっさと/帰った。
 23d. 殴った/監督が/試合後も/怒っていた/選手は/さっさと/帰った。
 23e. 殴った/自民党員が/ロビーに/入ってきた/社会党員は/部屋を/出た。
 23f. 殴った/社会党員が/ロビーに/入ってきた/自民党員は/部屋を/出た。
- 24a. 書いた/エッセーが/10万冊も/売れた/女性議員は/テレビ出演が/増えた。
 24b. 書いた/女性議員が/東大文学部を/卒業した/エッセーは/読みごたえが/あった。
 24c. 見舞った/被災者が/雨の中/働いていた/女性議員は/カサを/さし出した。
 24d. 見舞った/女性議員が/雨の中/働いていた/被災者は/カサを/さし出した。
 24e. 見舞った/作家が/とても/お喋りだった/編集長は/黙って/聞いていた。
 24f. 見舞った/編集長が/とても/お喋りだった/作家は/黙って/聞いていた。

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