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RESOLVING REANALYSIS AMBIGUITY IN JAPANESE RELATIVE CLAUSES

by

Yuki Hirose

A dissertation submitted to the Graduate Faculty in Linguistics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1999

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Abstract

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First-pass processing of a sequence of NPs in a Japanese sentence has been observed to favor analysis of them as clausemates if possible. In a relative clause (RC) construction, subsequent appearance of the head noun (HN) may force a reanalysis which breaks up this hypothesized single clause. However, the grammar often leaves open a choice between alternative reanalyses, differing in the position of the relative clause ‘gap’. This dissertation focuses on reanalysis ambiguity between two types of argument-gap RC, one named “Subject Reanalysis (SR)” and the other “Subject Object Reanalysis (SOR)”. We argue against the widely assumed view that SOR is difficult to process due to structural biases. Two non-structural factors are proposed to be more influential in determining the reanalysis preference between SR and SOR.

First, we consider thematic compatibility: the plausibility of a HN as filling one of the thematic roles the RC verb assigns. Results of three experiments are reported. When thematic compatibility did not uniquely select one analysis, a heavier processing cost occurred at the thematically ambiguous HN. We argue that when thematic information is available, it is utilized at the very beginning of the reanalysis ambiguity

resolution process in Japanese, preempting any structure-based preference strategies.

Constituent length also influences the SR/SOR ambiguity resolution preference, as shown by the outcomes of two experiments with long and short subject phrases. Data from a production experiment indicate that this same length manipulation controls the prosodic pattern when these RC constructions are read aloud. We ascribe this length effect to the influence of implicit prosody computed during first-pass syntactic processing in silent reading. We propose that the reanalysis process takes into consideration the implicitly assigned prosodic pattern as if it were part of the input, and selects the structure that is consistent with that prosodic pattern.

The grammar of Japanese rarely provides any syntactic cue that establishes the correct analysis of an RC. The reported findings indicate that what takes the place of syntactic information is not primarily syntactic biases (structural preference strategies) but the cues provided by non-structural factors including thematic compatibility and (implicit) prosody. Implications for Modularity and parsing universals are considered.

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CHAPTER 1

INTRODUCTION

1.1 Background: Structural ambiguity in sentence processing research

Research on the human sentence processing mechanism (HSPM, or “the parser”) explores the means by which humans comprehend sentences that they read or hear. Although this process may seem simply automatic, there are numerous constituent subprocesses involved. In the reading process, after individual characters are recognized and individual words are identified, the information is forwarded to the syntactic processing level where these words are grouped together to form appropriate phrasal units and the structural relationships between the phrases are figured out. Semantic interpretation processes must then apply to determine the meaning of the sentence. All of these processes have been shown to occur extremely rapidly (within approximately a few hundred milliseconds of receiving the relevant stimulus) and generally without error.

The task of the syntactic processing mechanism, which this dissertation investigates, begins when the input has been identified as a sequence of words. The parser assigns a grammatical structure to the input string by reference to its knowledge of the grammar of the language. Let us call this process “first-pass syntactic parsing”. It is incremental, occurring while the input is being received. The mental processes involved in syntactic parsing cannot be directly observed; it is possible, however, to examine such

processing operations *indirectly*, by feeding precisely-designed input stimuli to human perceivers and examining how the system responds to them.

Structural ambiguity is one of the most useful phenomena that can be employed to understand what is easy and what is difficult for the processing routines. Structural ambiguity occurs when a string of words happens to be compatible with more than one syntactic structure (and hence more than one meaning). In some cases, a whole sentence is ambiguous (global ambiguity). Ambiguity may also occur temporarily in a sentence in which it is resolved by later words. Ambiguous linguistic input presents a choice of syntactic structures to the parser, which must make certain decisions about the structure. Different models of the HSPM make different predictions about the exact timing and the type of decision that the parser makes about an ambiguous syntactic structure. We start by considering assumptions made within the framework of serial processing models (*garden path* models). In later chapters alternative parsing models are discussed as well.

In serial models, the parser adopts one syntactic analysis over other possible alternatives. What choice the parser makes can be established by seeing whether or not it has problems with the remainder of the sentence. If its guess happens to be correct for the sentence, the processing proceeds smoothly; but if the guessed structure which is currently being parsed is grammatically incompatible with a word that follows, this will show up in what is called a *garden path effect*. That is, an extra processing cost (to be revealed by experimental methods, or sometimes apparent to intuition) occurs as the parser detects the incompatibility and reanalyzes the initial incorrect analysis.

Extensive investigation of various types of ambiguity and their resolution patterns in English and related languages has made it possible to extract some very general

principles employed by the human processing routines. The most central of these are Minimal Attachment, Late Closure, and the Minimal Chain Principle. These decide the parser's preferred choice based on the syntactic configuration of the alternative analyses. Also, efforts are made to understand what kinds of non-syntactic information are used to select an analysis. Factors such as lexical frequency, semantic information, plausibility, pragmatic information, discourse information, knowledge of the world, and prosodic information (if the input is spoken sentences) have been shown to be influential to greater or lesser extent in the first-pass structure building process.

1.2 Japanese relative clauses and reanalysis ambiguity

Research to date on the processing of English and more recently other Indo-European languages has been very productive. However, much work remains to further our understanding of the mental mechanisms that underlie language use. It is important to confirm that a model of HSPM based on data from a certain language or group of languages is not just parochial but is compatible with all human languages. The empirical basis must be supplemented by data from typologically different languages, which are unlike English in many important structural respects.

Japanese is a head-final language in which the verb is located at the very end of its clause, following all of its objects and other complements, so the important information about clause structure provided by the verb is encountered at a later point. This can become problematic in a sentence with more than one clause, since the parser needs to determine which of the phrases in the sentence should be associated with which verbs.

Additional problems are due to the fact that, unlike English, arguments do not have to be overtly expressed, and the word order among arguments and adjuncts is relatively free. As a result, there are many points of ambiguity in a Japanese sentence, many of which are multiple ambiguities (with more than two alternative analyses). This creates frequent opportunities for misanalysis, requiring the parser subsequently to back up and revise the incorrect structure. These facts make it quite difficult to explain how Japanese is actually processed on-line.

The relevant syntactic characteristics of Japanese and the potential problems of comprehension that are created by the poverty of morpho-syntactic marking of phrase structure will be discussed in Chapter 2. On-line processing, and the particular problems of first-pass parsing and reanalysis will be discussed in Chapter 3. Throughout, the focus will be on relative clause constructions, and ambiguities concerning the position of the relative clause ‘gap’.

Testing existing parsing models against the facts of Japanese is only one part of this research project. At the center of this dissertation is an examination of a phenomenon that is common in Japanese: the phenomenon of “reanalysis ambiguity”. This refers to the recurrence of ambiguity during the reanalysis stage, where the parser is faced with a number of alternative ways of revising the incorrect structure. Thus, wrong choices may be made also in reanalysis, inducing more garden paths and demanding yet more reanalysis.

Reanalysis ambiguity has been noted by researchers including Inoue (1991), Mazuka & Itoh (1995), and Sturt & Crocker (1996). However, very few experimental data have been reported (Hirose, 1995). This may partly be due to the infrequency of

reanalysis ambiguity in English (but see Sturt & Crocker, 1996). In English a garden path is usually disambiguated by a syntactic cue, which very often allows only one way of revising the structure. Reanalysis is sometimes still unsuccessful, but it is typically because the uniquely required analysis is too difficult for the parser to deduce or to carry out. Japanese is very different. We will demonstrate that in Japanese, at the point at which reanalysis is necessitated, there is often no syntactic cue to pin down the correct reanalysis.

The constructions that will provide our test materials are two types of relative clause structures, one dubbed “Subject Reanalysis” (SR) and the other “Subject and Object Reanalysis” (SOR), as introduced in Chapter 3. Relative clause structures in Japanese are commonly misparsed initially as a single matrix clause, because there is no clear syntactic marking to help the parser recognize that the current clause is a relative or any other type of embedded clause. Relative clause status is signaled by a head noun following the clause. However, a further ambiguity is often present at that point, between two or more types of relative clause structure. The SR and SOR structures differ in terms of the role of the relative clause gap coindexed with the head noun, and the position of the left edge of the relative clause. The syntax of Japanese does not provide useful or timely evidence to reveal which of these structures is the correct analysis. Sometimes there is none at all, and the sentence is globally ambiguous. Sometimes there is syntactic disambiguation but not until the very end of the sentence. This makes it more or less unavoidable that for Japanese relatives the parser must rely on some non-syntactic information source, such as prosody or meaning, to guide ambiguity resolution between different relative clause analyses.

In spoken Japanese, SR and SOR structures are typically uttered with distinct prosodic patterns. A longer pause and a reset of a pitch range are commonly observed at the beginning of a relative clause. However, in the processing of written sentences, on which this dissertation centers its attention, perceivers do not have access to such potentially disambiguating information from pitch and timing.

Our goal is to uncover how the SR/SOR ambiguity is resolved, in the sense of what mental operations of information processing lead to the parser's decision on-line, and then perhaps its subsequent revision. An important first step toward this explanatory goal is to discover how the ambiguity is resolved in the sense of which analysis is the preferred one. It is widely assumed, on the basis of discussion by Mazuka & Itoh (1995), that there is a clear preference for SR, and that the reasons for the preference concern syntactic processing, such as the type or amount of structural change that must be made to the initial simple clause analysis. However, our suspicion is that the relative preference for one analysis or the other is more variable than this implies, and that the processing cost associated with each type of analysis depends on the influence of other factors besides purely structural ones.

In the experimental research reported here we raise the following questions: (i) whether there is a constant difference in processing cost between the two structures, in particular, whether SR is always easier than SOR; (ii), if so, why, and if not, under what circumstances SOR is easier (or SR is harder). New answers to these questions are motivated by the discovery of two interesting contrasts, one semantic and one prosodic.

The first concerns an effect of the semantic content of the head noun. This will be discussed in Chapter 4. When the head noun content is compatible with the thematic role

required for an SOR structure but not with the thematic role required for an SR structure, an SOR becomes notably easier to process, compared to when the head noun content is compatible with either structure. In other words, the SOR analysis is not difficult when it is the only plausible choice. Based on this observation, we further extend the research question concerning the exact nature of the role played by this “thematic compatibility information”.

Another new finding is an effect of constituent length on SR/SOR ambiguity resolution. Preference toward SR increases when the subject NP consists of two nouns conjoined compared with when it is a single noun. When the subject NP is a single word, no systematic preference toward either SR or SOR is observed. This is reported in Chapter 5. In Chapter 6 we propose that this length effect (reminiscent of others that have been reported for English) is in fact an effect of prosodic phrasing. This explanation crucially relies on the assumption that prosody plays a role not only in the processing of spoken materials but also in the processing of written materials in silent reading, where the prosodic contour must be projected onto the sentence by the reader.

Chapter 6 moves toward this account step by step. First we establish the relationship between constituent length and the prosodic phrasing of relative clauses in speech (reading aloud). Then we review studies reporting evidence of an influence of prosodic phrasing on ambiguity resolution of relative clauses in perception of spoken stimuli. Finally, we integrate these facts in a ‘silent prosody’ account of relative clause preference in reading. We suggest that the HSPM computes not only syntactic structure but also prosodic structure, based on the input perceived via silent reading. We further propose that in resolving a reanalysis ambiguity, a reader treats the implicitly assigned

(first-pass) prosodic pattern as if it were part of the input, and chooses whichever syntactic analysis (SR or SOR) is consistent with that prosodic pattern.

How the human parser deals with ambiguity within reanalysis, what kinds of non-syntactic information are used, and how they are deployed in making reanalysis decisions, are questions raised here specifically for Japanese relative clause processing. The answers offered here are necessarily tentative in part, but it is hoped that they will contribute to the understanding of broader issues in human sentence processing research.

CHAPTER 2

STRUCTURE OF JAPANESE RELATIVE CLAUSES

In order to correctly interpret a Japanese relative clause, a perceiver needs to know, first of all, that it is a relative clause construction, in which a head noun is modified by a clause. It is also necessary to determine at which point of the sentence the clause starts, and what grammatical and/or thematic role the head noun is associated with within the relative clause. Any person with native knowledge of Japanese can apparently establish these facts with reasonable accuracy and speed; otherwise everyday communication could not be as successful as it appears to be. In fact, it may go unnoticed that in everyday communication there are a number of information sources which contribute to make it look like an easy process, e.g., semantic facts, world knowledge and/or discourse information to signal what can be a possible or plausible role for a head noun to play, and prosodic information to signal where the clause boundary is. The Japanese language, and relative clause constructions in particular, pose an enormous number of problems for any purely syntactic processor operating 'left-to-right' on-line.

In the current chapter and the next chapter, we outline the problems that derive from the syntactic/morphological characteristics of Japanese. In this chapter we limit our attention to the problem of the lack of syntactic information to identify the role of the head noun within the relative clause. This results in ambiguities between more than one

possible relative clause structure, even when the boundaries delimiting the relative clause are evident. The next chapter discusses how the ambiguity concerning the identity of the role of the head noun may interact with further ambiguity concerning the position of the clause boundary, making it obscure where the relative clause starts.

In what follows in this chapter we present syntactic characteristics of Japanese relative clause constructions. Section 2.1 introduces basic assumptions about the syntactic configuration of relative clauses. Section 2.2 discusses the ambiguity problems that result from these syntactic facts; specifically, we emphasize how uninformative syntactic/morphological information is, in identifying the intended structure of a relative clause.

As has often been noted in the literature, Japanese has three major typological properties which conspire to create ambiguity (Inoue, 1991; Yamashita, 1994; Mazuka & Itoh, 1995).

First, Japanese is a head final language: within a constituent, the position of the head is fixed at the end of the constituent, as illustrated in examples below.

- (1) Onna-ga kicchin-de John-no ootoo-o kusugutta .
 woman-Nom kitchen-Loc -Gen brother-Acc tickled
 "The woman tickled John's brother in the kitchen. "

The verb head "kusugutta" (tickled) is located at the final position of the VP, and thus at the end of the sentence. Within a postpositional phrase (PP) such as "kicchin-de" (in the kitchen), the postposition follows the noun phrase (NP) and within an NP "John-no imooto" (John's sister), the head noun "imooto" follows the PP modifier "John-no".

Head finality within the NP and the complementizer phrase (CP) is especially relevant in the next section, in relation to the relative clause construction.

Second, we must also note the flexible word order which characterizes Japanese: the surface word order of arguments and adjuncts is free within a clause.¹ Therefore, sentence (1) can also surface as (2) or (3), for example.²

(2) kicchin-de onna-ga John-no imooto-o kusugutta .
 kitchen-Loc woman-Nom John-Gen sister-Acc tickled
 "The woman tickled John's sister in the kitchen. "

(3) John-no imooto-o onna-ga kicchin-de kusugutta .
 John-Gen sister-Acc woman-Nom kitchen-Loc tickled
 "The woman tickled John's sister in the kitchen. "

Finally, Japanese allows null pronouns: any argument, whether in a matrix or embedded clause, can be phonologically unrealized if its referent is recoverable from the discourse, i.e., if the null pronoun is bound to a referent within the sentence or in the prior discourse. Therefore, (4) and (5) are both well-formed sentences, and fully acceptable as long as the referent of a null pronoun (*pro*) is understood. For example, (4) can be an answer to a question such as "What did you do?", in which case the *pro* in the answer refers to the speaker. Likewise, (5) can be used to answer a question such as "Who did you say tickled that man? ", in which case the *pro* refers to the man.

¹ Typically the word order employed may be influenced by factors such as the discourse structure or constituents weight, but other than this, there is still no definitive answer to the question of why a certain word order is chosen over others (see recent proposals by Hawkins, 1994; Yamashita, in press).

² Japanese also allows long distance scrambling where the object NP in an embedded clause can be moved out of the clause, as extensively discussed by Saito (1985). Here we do not consider long-distance scrambling.

- (4) *pro* otoko-o kusugutta .
 man-Acc tickled
 "*pro* tickled the man. "
- (5) onna-ga *pro* kusugutta .
 woman-Nom tickled
 "The woman tickled *pro*. "

In this dissertation, the head-final property of Japanese is most relevant to sections 2.1 and 2.2, scrambling is relevant to Chapter 3, and null pronouns will be discussed in section 2.2.

2.1 Syntactic configuration of Japanese relative clauses

As noted, Japanese is a strict head final language. Without exception the verb follows all of its complements (arguments and adjuncts) in a clause (IP).³ Overt argument and adjunct noun phrases are marked with a case marker or postposition which indicates the grammatical role of the phrase, but case markings may be phonologically null in some circumstances or the meaning (thematic roles) of them may be ambiguous (e.g., a *ni*-marked NP can express GOAL, SOURCE, LOCATION, TIME, etc.). Within an NP, the noun follows all of its modifiers such as adjective phrases (AP) and relative clauses. Relative clauses are assumed to be of category CP.⁴ Within the CP, the

³ In colloquial Japanese, one might encounter a case in which an argument or an adjunct follows the verb as expressing an afterthought, but this is a very marked construction (see Shibatani, 1990).

⁴ The category of a relative clause is standardly assumed to be CP, though it is sometimes analyzed as IP (Murasugi, 1991). For concreteness, we adopt the CP analysis in this dissertation.

complementizer (COMP) follows the IP (clause). However, in a relative clause the COMP is phonologically null. (6) shows schematically the configuration of a Japanese relative clause construction.

(6) ... [[[..... V_{IP}] COMP_{CP}] N_{NP}] V.

Japanese relative clauses have no overt relative pronoun, either in situ or moved to the COMP position (as in English). Syntactic analyses of the relative clause "gap" differ with respect to whether the gap is the trace of a moved null operator or is an empty pronoun. In the analysis we adopt here, the COMP position is assumed to contain a null operator (Op), which binds an empty category (variable) within the relative clause. The operator is also linked to the head noun. Thus, the relative clause gap is bound to the head noun via the null operator in COMP. This is shown in (7).

(7) ... [[[..... e_i V_{IP}] Op_i_{CP}] N_i_{NP}] V.

Others argue that the relative clause gap is a base-generated *pro* (Mihara, 1992) or empty resumptive pronoun (for some types of adjunct relative clauses, Murasugi, 1991, or for all adjunct relative clauses, Kaplan & Whitman, 1995).⁵ What is relevant for the purpose of

⁵ Analyses of adjunct relatives vary with respect to whether and/or to what extent relative clause operator movement should be assumed and even whether or not a relative clause gap should be assumed. Saito (1985) proposed a distinction between two types of PPs: PPs expressing reason and manner (e.g., (11)) are identified as "pure" adjunct PPs, and those of time and place (e.g., (12)) as "quasi" adjuncts. Based on this proposal, Murasugi (1991) argued that the relative clause gap for "quasi" adjunct PPs as in (12) is an empty resumptive pronoun, rather than the trace of an operator. (This is because the gaps for "quasi"-type adjuncts may appear in a subjacency-violating environment while others may not.)

this dissertation and what seems to be in agreement among different proposals is that there is a phonologically null item in the relative clause and it is coindexed with the head noun. We call this empty item just "the relative clause gap" and represent it as "e" for convenience. For simplicity in what follows we will express the relative clause structure as follows, in which only the relevant details are represented (thus the CP brackets are not shown).

(8) ... [[..... e_i V_{IP}] N_i NP] V.

The head noun assumes the grammatical role of the gap in the relative clause but this role is not morpho-phonologically marked in the sentence. A case marker or postposition attached to the head noun shows the noun's role in the matrix clause but not the role in the relative clause. Case-marking particles are bound morphemes in Japanese; therefore, the case marker or postposition of a relativized NP or PP is not allowed to be stranded without an overt host at the empty category position in the relative clause, or pied-piped with the null operator to the COMP position.

A relative clause gap can be in an argument position or adjunct position in the clause.

Kaplan & Whitman (1995) argue that no adjunct relative clause can involve operator movement, to maintain consistency with the recoverability condition motivated for the English facts: a null operator originating in the relative clause as a PP is disallowed. It is assumed that a PP null operator cannot exist because it will never be categorically identical to the relative head.

Kaplan & Whitman adopt Murasugi's proposal that the "quasi" adjunct PP relative clause gaps are null resumptive pronouns. For "pure" adjunct PPs, they argue that there is no gap in the relative clause, just like so-called "gapless" relative clauses (to be introduced below).

- (9) [NP [IP e_i otoko-o kusugutta] onna_i]
 man-Acc tickled woman
 "the woman who tickled the man"
- (10) [NP [IP onna-ga e_i kusugutta] otoko_i]
 woman-Nom tickled man
 "the man whom the woman tickled"
- (11) [NP [IP onna-ga e_i otoko-o kusugutta] hoohoo_i]
 woman-Nom man-Acc tickled method
 "the method by which the woman tickled the man"
- (12) [NP [IP onna-ga e_i otoko-o kusugutta] heya_i]
 woman-Nom man-Acc tickled room
 "the room in which the woman tickled the man"

Examples (9) and (10) exemplify typical argument (NP)-gap relative clauses. The relativized argument is a nominative subject NP in (9) and an accusative object NP in (10). Examples (11) and (12) show adjunct relative clauses, in which the gap corresponds to a PP. An instrumental PP, "hoohoo-de" (method-Inst), is relativized in (11). In (12) a locative PP, "heya-de" (room-Loc), is relativized.

Some head nouns such as (13) and (14) refer to a consequence of some action described in the relative clause, but there is no formal syntactic link between the relative clause and the head noun. These are called "gapless" relative clauses (Kitagawa, 1982) because there is not even a potential gap in the relative clause for the head noun to be associated with.

- (13) [NP [IP onna-ga otoko-o kusugutta] monooto]
 woman-Nom man-Acc tickled sound
 (Lit.) "the sound that the woman tickled the man"
 "the sound from the woman's tickling of the man"

- (14) [NP [IP onna-ga otoko-o kusugutta] mukui]
 woman-Nom man-Acc tickled retribution
 "the retribution owing from the woman's tickling of the man"

The relationship between the content of the relative clause and its head noun in such a case is semantic or pragmatic in nature. Consequently the interpretation depends on the speaker/hearer's ability to establish a plausible connection. Acceptability of this construction is constrained by an *Aboutness condition* (Kuno, 1976; Kitagawa, 1982): "a relative clause must be a statement about its head noun" (Kuno, 1976). Exactly what semantic relationships can satisfy this condition is difficult to state, and will not be discussed further here.

In what follows, we discuss problems in the interpretation of relative clauses in Japanese. Specifically, we focus on relative clauses with a gap, and discuss the potential problem of identifying the position of the relative clause gap within the relative clause.

2.2 Poverty of syntactic/morphological information

In this chapter we focus on describing problems involving global ambiguity, while deferring until Chapter 3 the discussion of how perceivers react to the ambiguity and some possible on-line guessing strategies. An ambiguity is global if two or more analyses are compatible with the entire word string. From this point of view, there is no ambiguity in Japanese with respect to whether a relative clause construction is present in a sentence. This is because the right edge of a relative clause is unambiguously

syntactically marked by a noun following a verb (possibly with an adjective or other modifier of the noun between them). By contrast, there can be global ambiguity with respect to where a relative clause starts. This is because the left edge of a relative clause, or in fact any embedded clause, is very often obscure because the head final property of the language allows no syntactic marking for it; thus it is often unclear which (or how many) of the NPs/PPs preceding the verb are complements in the relative clause. This contributes to the difficulty of knowing what constituent is ‘missing’ from the clause due to the relativization. This left-edge ambiguity is often (though not always) only temporary, and is resolved when relevant syntactic information about the matrix clause appears later in the sentence. Note that there is an interdependence between the contents of the two clauses: roughly, a phrase that is in the relative clause is not in the matrix clause, and vice versa. Therefore, matrix clause facts can disambiguate the left edge of the relative clause. We will defer further discussion of this matter until Chapter 3.

What will be discussed in this section concerns how the position of the gap associated with the head noun is identified. Even if the left edge of the relative clause is somehow known (e.g., from the intonation contour), there can still be ambiguity concerning the gap position.

Here we show that the grammatical position or role of the gap within a Japanese relative clause cannot be uniquely identified by reference to the syntactic or morphological information available in the entire word string for the relative clause. This is due mainly to two facts: (a) that Japanese lacks potentially informative syntactic/morphological markers such as an overt relative pronoun, and (b) that some other properties of the language such as a discourse-bound null pronoun make the

available syntactic/morphological facts less informative. These points will be demonstrated in comparison with English, which typologically contrasts with Japanese in both (a) and (b).

In English, argument relative clauses often contain an overt relative pronoun. English relative pronouns are morphologically distinguished as animate/inanimate (*who*, *which*). They may also be morphologically marked for case, which can be useful in identifying the grammatical role of the relative clause gap. In example (15) the relative pronoun *whom* is marked for accusative case and by contrast the *who* in (16) may be taken to be nominative. Accordingly the role of the gap is evident.

(15) [NP the man_i [CP whom_i [IP the woman tickled e_i]]]

(16) [NP the woman_i [CP who_i [IP e_i tickled the man]]]

However, the *who/whom* distinction is not often maintained in modern American English. Thus, case marking on the relative pronoun is morphologically ambiguous or neutralized. There is also no overt case distinction for inanimate relative pronouns, as shown in (17) and (19). And for both animates and inanimates, it can even be that an uninflected *that* is present in place of the relative pronoun, as in (18) and (20), or that no morphological marker is present in COMP at all, as in (21). We will discuss later what keeps the interpretation of (17) - (21) non-problematic nevertheless.

(17) [NP the puppy_i [CP which_i [IP e_i scared the cat]]]

(18) [NP the puppy_i [CP that_i [IP e_i scared the cat]]]

(19) [NP the cat_i [CP which_i [IP the puppy scared e_i]]]

(20) [NP the cat_i [CP that_i [IP the puppy scared e_i]]]

(21) [NP the cat_i [CP Op_i [IP the puppy scared e_i]]]

As (22b) and (23b) below show, adjunct relatives in English may be introduced by a *wh*-word, which has a distinct morphological form for a specific adjunct role; e.g., *where* for locative adjuncts and *when* for temporal adjuncts, and less commonly *why* for reason adjuncts. Alternatively, prepositional phrase structure may be evident: there may be a "normal" relative pronoun and a preposition.

(22)

a. [NP the box_i [CP which_i [IP the boy was hiding e_i]]] (argument)

b. [NP the box_i [CP where_i [IP the boy was hiding e_i]]] (adjunct)

c. [NP the box_i [CP in which_i [IP the boy was hiding e_i]]] (adjunct)

d. [NP the box_i [CP which_i [IP the boy was hiding in e_i]]] (adjunct)

(23)

a. [NP the date_i [CP which_i [IP the boy remembered e_i]]] (argument)

b. [NP the date_i [CP when_i [IP the boy remembered e_i]]] (adjunct)

c. [NP the date_i [CP on which_i [IP the boy remembered e_i]]] (adjunct)

The preposition may be pied-piped into initial position with the relative pronoun as in (22c) and (23c), or it may remain in the gap position as in (22d), though in-situ

prepositions are generally less acceptable for adjunct relatives than for argument relatives. Either way, the preposition clarifies the position or role of the gap.⁶

Now, let us turn to the case of Japanese. As noted above, Japanese lacks overt relative pronouns (see section 2.1), and allows no stranded case marker (for argument relatives) or stranded postposition (for adjunct relatives). Lack of these morphological/syntactic markings can disguise the role of the relative clause gap. This is illustrated in example (24)-(26). (*pro* = something/someone possibly discourse identified)

(24) hikooki-o mituketa reedaa
plane-Acc found radar

a. [*e_i* hikooki-o mitsuketa] reedaa_i
"the radar that found the plane"

b. [*pro e_i* hikooki-o mitsuketa] reedaa_i
"the radar with which *pro* found the plane"

(25) Taro-ga sagasimawatta kyoositsu
Taro-Nom searched around classroom

a. [Taro-ga *e_i* sagasimawatta] kyoositsu_i
"the classroom which Taro searched around for"

b. [Taro-ga *e_i* *pro* sagasimawatta] kyoositsu_i
"the classroom in which Taro searched around for *pro*"

(26) mituketa otoko
found man

⁶ In some cases the preposition may be absent, as in (i); see Klein (1990) for details.

(i) [_{NP} the place_i [_{CP} [_{IP} we stayed *e_i*]]] (adjunct)

- a. [e_i *pro* mituketa] otoko_i
 " the man that found *pro*"
- b. [*pro* e_i mituketa] otoko_i
 " the man that *pro* found "

In the structurally ambiguous word string in (24), the head noun "reedaa" (rader) can be associated with a subject gap as in (24a), or with an adjunct gap (most naturally an instrumental adjunct) as in (24b). The subject NP in (24b) is realized as a null pronoun (*pro*) referring to some entity in the discourse or in the higher clause. In (25a) the phonologically empty but syntactically obligatory object NP (e_i) is the relative clause gap, which is bound to the head noun "kyoositsu" (classroom). In (25b) the object NP is realized as a *pro* and the relative clause gap (e_i) is in the locative adjunct position. There would be no such ambiguity if an overt relative pronoun morphologically marked for case or adjunct type (locative, etc.) were present in the COMP position, or if a case marker were retained in the gap position.

The examples in (24) and (25) show an argument/adjunct ambiguity. The examples in (26) illustrate ambiguity between two types of argument relative clauses. The object of the relative clause could be a null pronoun (*pro*) bound to an antecedent in the discourse while the relative clause gap is in the subject position, as in (26a).⁷ Another

⁷ Some verbs are optionally transitive, so the ambiguity between subject/object argument relative clauses need not involve a *pro* object.

- (i) [e_j jimansita] musuko_j
 boasted son
 "the son that boasted"
- (ii) [*pro* e_j jimansita] musuko_j
 boasted son
 "the son that *pro* boasted about"

possibility is that a null pronoun is in the subject position and the relative clause gap is in the object position, as in (26b). If overt case marking of a relative pronoun or relative clause gap were possible, the structure could have been unambiguous between (26a) and (26b), but again, such options do not exist in Japanese.

One might imagine there is some contrast in the grammatical status of these examples in accord with accessibility of relative clause formation proposed by Keenan & Comrie (1977). According to this, argument gaps as in (24a) and (25a) may be less marked than adjunct gaps as in (24b) and (25b), and among argument gaps, subject gaps as in (26a) are less marked than object as in (26b). However, both readings of each pair are almost equally accessible to native speakers as long as the antecedent of *pro* is recoverable from appropriate discourse information (this may be difficult to judge by comparing the above examples in isolation). There is sometimes misunderstanding among native speakers, typically between the two readings presented in (26), when the discourse does not select one reading over the other.

Note that in the comparisons above, the position of the left boundary of the relative clause is constant in relation to the word string. What we have been focusing on in the above examples are ambiguities between different NP-internal structures when the extent of the NP is known. In such a case, if the ambiguity is not resolved within the relative clause, no syntactic information outside of the relative clause can disambiguate it. (As noted above, ambiguity concerning the clause boundary position can be disambiguated by the properties of the matrix clause, such as its argument structure requirement; see Chapter 3.)

Note that the presence of null pronouns in Japanese is a contributing factor in these ambiguities. It undermines the disambiguating effect of argument structure information. Such information is usually available in English. In English, a relative clause gap is often evident from the fact that an overt NP is missing from the position in which one must occur. For example, in (17) and (18) there is no overt NP in the subject position of “scared” and in (19) and (21) there is no overt NP in the object position though “scared” as a verb is obligatorily transitive. Since English does not allow phonologically empty discourse-bound pronouns (less strictly so in matrix clauses in colloquial style, but strictly disallowed in embedded clauses), the absence of an obligatory argument in the relative clause flags the presence of a relative clause gap. Therefore these vacant subject in (17) and (18), object in (19)-(21), and prepositional object positions in (22) will be identified as relative clause gaps.

Even in English, however, there can be ambiguity, because many English verbs (e.g., “read”, “knit”, “know”) are optionally transitive, and thus the absence of an overt object is not a clear indicator of a gap.⁸ Prepositions may also be ambiguously transitive (e.g., “look up”, “fall down”). Thus, the absence of an overt argument does not always make the relative clause structure unambiguous, but in combination with other cues (such as the form of the relative pronoun), the chance of a globally ambiguous relative clause is quite small. The fact that empty pronouns are not allowed in the subject position eliminates any ambiguity between subject vs. object argument relative clauses.

⁸ Perceivers may have expectations about these “doubtful” gaps (Fodor, 1978), based on the relative frequency of occurrence of the transitive and intransitive forms, but these are not decisive. There has been considerable research on the guessing strategies for such gaps in English, but we will not review this work here.

In contrast, Japanese does permit phonologically null, discourse-bound pronouns, both for the subject and the object. So the fact that an argument is not overtly realized does not mean it is "missing", and does not constitute evidence that the relative clause gap must fill that position. The position may already be filled by a *pro*, and the gap may be linked to a different argument position or to an adjunct position. (In left-to-right parsing, it may be ambiguous even whether or not an argument is "missing" until the verb is encountered, because of the possibility of scrambled word order: see Chapter 3.) Note that potential adjunct positions are abundant in most types of clauses, so this is a multiple ambiguity.

In addition, in Japanese unlike English, there is ambiguity between gapped and gapless relative clauses. This is illustrated in (27). Note that "rokuon suru" (to record) is optionally transitive: a transitive reading is required for (27a) and an intransitive reading for (27b).

- (27) rokuon suru oto
 record sound
- a. [*pro* e_i rokuon suru] oto_i
 "the sound which pro records"
- b. [*pro* rokuon suru] oto
 "the sound resulting from the recording"

As discussed earlier, a gapless relative clause is a common construction, but it is limited by the aboutness condition. In some cases it does not induce ambiguity but in some cases the possibility of gapless relatives increases the number of (potential) syntactic analyses of any relative clause construction.

In examples (24)-(26), there is no way to make syntactically explicit the role or structural position of the gap, and hence the semantic role of the head noun within the relative clause. In some cases, however, the semantic content of the head noun constrains the plausible interpretations, sometimes to uniqueness. Compare (28)-(30) with (24)-(26) above. The symbol "!" signifies a sentence that is syntactically well-formed but semantically or pragmatically unusual.

(28) hikooki-o mitsuketa kyaputen
plane-Acc found captain

a. [e_i hikooki-o mitsuketa] kyaputen_i
"the captain that found the plane"

b. ! [*pro* e_i hikooki-o mitsuketa] kyaputen_i
"the captain with(instrumental) which/whom *pro* found the plane"⁹

(29) Taro-ga sagasimawatta hon
Taro-Nom searched around book

a. [Taro-ga e_i sagasimawatta] hon_i
"the book which Taro searched around for"

b. ! [Taro-ga e_i *pro* sagasimawatta] hon_i
"the book in which Taro searched around for *pro*"

(30) mituketa hon
found book

⁹ English "with" can signal an instrument or something/someone accompanying. On the latter interpretation, "the captain with whom *pro* found the plane" is possible. In Japanese, such a reading of (28) is almost impossible to get, without support of a phrase such as "isshoni (together) ", as in (i).

(i) [*pro* e_i isshoni hikooki-o mitsuketa] kyaputen_i
together plane-Acc found captain
"the captain together with whom *pro* found the plane"

- a. ! [*e_i pro* mituketa] hon_i
 "the book that found *pro*"
- b. [*pro e_i* mituketa] hon_i
 "the book that *pro* found"

The comparison between (24)-(26) and (28)-(30) shows that the semantic content of the head noun, which restricts the thematic roles that can plausibly be assigned to it, can be quite informative in identifying the internal structure of the relative clause when syntactic or morphological features do not clarify it. Without such semantic constraints, any Japanese relative clause is many ways ambiguous. Such information is also available in English, but is often redundant with other cues. If they clash, the semantic cue is always overridden. However, in Japanese, where there are no syntactic or morphological cues to the gap position, semantic cues may take on a more significant role.

In sum: A Japanese relative clause contains no reliable syntactic or morphological cues as to the position of the gap. Many relative clauses may be multiply ambiguous, at least in principle, between argument gap, adjunct gap, and no-gap analyses. In the presence of so much ambiguity, it is not clear how Japanese relative clauses can be assigned only one clear interpretation, except on the basis of information other than syntactic or morphological cues. It appears that perceivers must rely to a large extent on semantic information about the head noun in relation to the clause meaning, in deciding between possible analyses.

In Chapter 3, we consider the additional ambiguity of the left edge of a relative clause, and we note that there are more problems for the parsing mechanism in

interpreting Japanese relative clauses on-line, if we take into account not only global ambiguities but also temporary ambiguities which occur in left-to-right processing.

CHAPTER 3

AMBIGUITY IN PROCESSING JAPANESE RELATIVE CLAUSES

In the previous chapter, it was demonstrated that relative clause constructions in Japanese lack much of the overt syntactic marking which in other languages indicates the position and role of the relative clause gap. In left-to-right on-line processing, there are further ambiguities that the parser has to cope with.

Section 3.1 presents the temporary ambiguity problems that the parser would encounter in left-to-right processing. In many relative clause structures, there is ambiguity as to whether the input word string will end as a single clause, or will split into a main clause and an embedded clause. Even when the head noun confirms that a relative clause structure is present, there is still ambiguity as to what kind of relative clause it is, because of the lack of syntactic information discussed in Chapter 2. Section 3.2 reviews three ways in which the human parser might process temporarily ambiguous input: serial processing with reanalysis when needed, limited or ranked parallel processing, and delay processing. We will discuss how the initial single versus embedded clause ambiguity is handled on each of these approaches.

In the remainder of this dissertation we focus on the ambiguity between the two types of argument relative clause structures discussed by Mazuka & Itoh (1995), one

referred to as “subject reanalysis” and the other as “subject and object reanalysis.” These constructions will be introduced in section 3.3. Mazuka & Itoh observed that the latter type is more difficult to process than the former. We will examine whether and how each of the models considered here can explain this reported difference in processing difficulty.

3.1 Ambiguity in the first-pass parse

As we have seen in section 2.1, there is no overt syntactic marker at the left edge of a clause in Japanese. Embedded clauses are marked only by an item following the verb of that clause; e.g., a complement clause is immediately followed by a complementizer, and a relative clause by a head noun.

In fact, ambiguity as to the clausal construction of a sentence begins as soon as the first word is encountered. When the parser encounters a word string such as (1), it is natural to guess that the three NPs all belong to one clause, as in (1a), but there might be at least one clause boundary intervening in the string, as in (1b-c).

(1)	Bob-ga -Nom	Mary-ni -Dat	ringo-o ... apple-Acc
a.	[_{IP} Bob-ga -Nom	Mary-ni -Dat	ringo-o ... apple-Acc
b.	[_{IP} Bob-ga -Nom	[_{IP} Mary-ni -Dat	ringo-o ... apple-Acc
c.	[_{IP} Bob-ga -Nom	Mary-ni -Dat	[_{IP} ringo-o ... apple-Acc

Sometimes a case marker attached to a noun can provide a hint as to where the word string breaks into two clauses. For example, in (2), the second occurrence of the nominative NP “Mary-ga” (Mary-Nom) most likely signals the presence of two clauses, each of which has one nominative-marked subject such as in (2a).¹

- (2) Bob-ga Mary-ga ringo-o ...
 -Nom -Nom apple -Acc
- a. [_{IP} Bob-ga [_{IP} Mary-ga ringo-o ...
 -Nom -Nom apple -Acc

However, although the second occurrence of a nominative NP can signal that there is a clause boundary between the first and the second NP-ga, the possibility of scrambling can still obscure the exact position of the clause boundary in cases like (3). That is, the intervening dative NP “Mary-ni” (Mary-Dat) may be a matrix constituent in a canonical

¹ Japanese allows two nominative-marked NPs within a clause in some special cases, such as a *ga*-marked object for certain verbs, as in (i),

- (i) [_{IP} John-ga Mary-ga sukidesu .]
 -Nom -Nom like
 "John likes Mary."

and in the major subject construction (Kuroda, 1986; Saito, 1985) as in (ii), in which the first NP-ga derives from a non-argument NP, in this case, NP-no.

- (ii) [_{IP} nihon-ga [_{IP} dansei-ga tanmei desu .]]
 Japan-Nom male-Nom short life span Copula
 "It is in Japan that men have a short life span. "
 (= [_{IP} nihon-no dansei-ga tanmei desu .])
 -Gen

In (2), the occurrence of an *o*-marked NP ("ringo-o", apple-Acc) eliminates the possibility that "Mary-ga" is an object in the same clause as "John-ga" and "ringo-o". Also, a major subject interpretation of "Bob-ga" in (2) is not possible: "John-ga" should have been able to be replaced by "John-no".

word order as in (3a), or it may be an embedded constituent scrambled to the top of the embedded clause, as in (3b).

- (3) Bob-ga Mary-ni ringo-ga...
 -Nom -Dat apple-Nom
- a. [_{IP} Bob-ga Mary-ni [_{IP} ringo-ga...
 -Nom -Dat apple -Nom
- b. [_{IP} Bob-ga [_{IP} Mary-ni; ringo-ga e_i...
 -Nom -Dat apple-Nom

In addition, the presence of an embedded clause may also be evident as early as the first encountered verb (Inoue, 1991; Yamashita, 1994). Consider the following example from Inoue (1991).

- (4) Bob-ga Mary-ni ringo-o tabeta ...
 -Nom -Dat apple-Acc ate

Since “tabeta” (ate) does not take a dative NP as its argument, it provides a syntactic cue that “Mary-ni” and “tabeta” do not belong to the same clause, and thus the word string breaks into at least two clauses.

By contrast, consider the following string of NPs with a following verb, in which the NPs preceding the verb perfectly match the argument structure requirement of the verb.

- (5) Bob-ga Mary-ni ringo-o ageta ...
 -Nom -Dat apple-Acc gave

When the verb is read, the parser has no clear information regarding whether or not the current clause is a main or a subordinate clause, as has been discussed in the literature (Yamashita, 1994; Mazuka & Itoh, 1995). The analysis of the string is ambiguous as to (i) whether there is only one clause or more: a higher clause and one (or more) embedded clause(s), (ii) if it involves an embedded clause, what type of clause that is: a sentential complement, a relative clause, or an adverbial clause, (iii) and where it breaks, if it does break.

The word string (5) could end at the verb to form a simple sentence (i.e., with a single main clause only) as in (6).

- (6) [Bob-ga Mary-ni ringo-o ageta .]
 -Nom -Dat apple-Acc gave
 "Bob gave Mary an apple."

Alternatively it could continue after the verb, as in the examples (7)-(13):

- (7) [Bob-ga e_i Mary-ni ringo-o ageta] koosaten_i-ga koko da .
 -Nom -Dat apple-Acc gave intersection-Nom here Copula
 "The intersection where Bob gave Mary an apple is here."
- (8) [Bob-ga Mary-ni ringo-o ageta] to minna-ga itta .
 -Nom -Dat apple-Acc gave that everyone-Nom said
 "Everyone said that Bob gave Mary an apple."
- (9) *pro* [Bob-ga Mary-ni ringo-o ageta] to itta .
 -Nom -Dat apple-Acc gave that said
 "*pro* said that Bob gave Mary an apple."

(10) Bob-ga [e_i Mary-ni ringo-o ageta] onnanoko_i-o sikatta .
 -Nom -Dat apple-Acc gave girl-Acc scolded
 "Bob scolded the girl who gave Mary an apple."

(11) Bob_j-ga [pro_{j/k} Mary-ni ringo-o ageta] to itta .
 -Nom -Dat apple-Acc gave that said
 "Bob said that *pro*/(he) gave Mary an apple."

(12) Bob_j-ga Mary-ni [pro_{j/k} e_i ringo-o ageta] onnanoko_i-o shookaisita .
 -Nom -Dat apple-Acc gave girl-Acc introduced
 "Bob introduced to Mary the girl who *pro*/(he) gave an apple to."

(13) Bob_j-ga Mary-ni [pro_{j/k} pro ringo-o ageta] to itta .
 -Nom -Dat apple-Acc gave that said
 "Bob said to Mary that *pro*/(he) gave *pro* an apple."

The string up to the first verb may indeed form a single clause embedded in a higher clause, as in (7) and (8), and (9) or it may split into a higher (main) clause and a lower (embedded) clause, between the first and the second NP, as in (10) and (11), or between the second and the third, as in (12) and (13).^{2, 3} The embedded clause may be a relative

² One might think the head noun plus the preceding relative clause "ringo-o ageta onnanoko" also allows the internal structure as in (i) and (ii).

(i) Bob_j-ga Mary-ni [e_i pro_j ringo-o ageta] onnanoko_i-o shookaisita .
 -Nom -Dat apple-Acc gave girl-Dat introduced
 "Bob introduced to Mary the girl who gave *pro*(him) an apple."

(ii) Bob_j-ga Mary_k-ni [e_i pro_k ringo-o ageta] onnanoko_i-o shookaisita .
 -Nom -Dat apple-Acc gave girl-Dat introduced
 "Bob introduced to Mary the girl who gave *pro*(her) an apple."

However, for (i) and (ii), the embedded verb must be replaced with "kureta" (gave) or a ditransitive verb specifically marked by "kureta", such as "misete-kureta" (showed), which means that the action denoted by the verb was performed for the benefit of the speaker, or the subject of the main clause, in this case, "Bob", or possibly the object "Mary". Thus these potential analyses are grammatically ruled out. However, the

clause as in (7), (10), and (12), or a complement clause as in (8), (9), (11), and (13).

Thus, the ambiguities stated in (i) and (ii) above (whether or not there is an embedded clause, and if so, what type it is) can be resolved by the input item immediately following the verb (by the complementizer "to" in (8), (9), (11) and (13), and by the head noun "koosaten" (intersection) and "onnanoko" (girl) in (7), and (10) and (12), respectively).

Ambiguity (iii) (where the clause boundary falls) may not be resolved at this point, as shown by the contrast between (10), and (12), or between (11) and (13). Note that for relative clause constructions such as (7), (10), and (12), the position of the gap varies along with variation in the position of the clause boundary. The two ambiguities go hand in hand. As noted in Chapter 2, the semantic content of the head noun can sometimes disambiguate the gap position. Therefore it can also sometimes disambiguate the position of the clause boundary. For example, a relative clause with a following locative noun as its head could have its left clause boundary before "Bob-ga" in (7), but a relative clause with an animate head noun would (have to) have its left clause boundary following "Bob-ga" as in (10). Later in this chapter, and in subsequent chapters, we will

acceptability of (i) and (ii) without *-kureta* improves when the verb denotes some action which causes some damage to the person to whom that action is done, e.g., "nagetuketa" (threw at).

³ A relative clause structure with the clause boundary following the third NP is not totally impossible, as in (i), although the acceptability is marginal, so it is not considered here.

(i) ? Bob_j-ga Mary-ni ringo_k-o [*pro*_j e_i *pro*_k ageta] onnanoko_i-no kyooryoku-de okutta .
 -Nom -Dat apple-Acc gave girl-Gen help-with sent
 "Bob sent the apples to Mary with the help of the girl to whom he (previously) had given the apples."

A complement clause structure in which the clause boundary is between the third NP and the verb is not an option, as there is no matrix verb which takes -Nom, -Dat, and -Acc NPs plus a complement clause.

make use of the interdependence between matrix constituents and gap position in the relative clause, in order to disambiguate the gap position.

For some relative clauses, the case marker attached to the head noun may help disambiguate, as may the semantic content of the head noun. For example, a word string such as (14) is temporarily ambiguous between (10) and (12). If, however, the same head noun were marked by a dative marker as in (15), the likelihood of one analysis compared with the other analysis with respect to the position of the clause boundary, as illustrated in (15a-b), would become very large because it is not possible to have more than one NP with the same thematic role in a clause. However, NP-ni can receive different thematic roles (GOAL, LOCATION, SOURCE, PASSIVE AGENT, CAUSEE, etc.), so more than one NP-ni per clause is actually possible, and (15) is therefore not a definitive disambiguation.

(14) Bob-ga Mary-ni ringo-o ageta onnanoko-o ...
 -Nom -Dat apple-Acc gave girl-Acc

(15) Bob-ga Mary-ni ringo-o ageta onnanoko-ni ...
 -Nom -Dat apple-Acc gave girl-Dat

a. [_{IP} Bob-ga [_{IP} Mary-ni ringo-o ageta] onnanoko-ni ...
 -Nom -Dat apple-Acc gave girl-Dat

b. [_{IP} Bob -ga Mary-ni [_{IP} ringo-o ageta] onnanoko-ni ...
 -Nom -Dat apple-Acc gave girl-Dat

In (14) however, when the parser has processed the accusative-marked head noun “onnanoko”, there is no way to tell where the split between the matrix clause and the

relative clause is. The resolution of this ambiguity will be discussed in more detail later in this chapter.

In section 3.2, we will consider how the parser copes with the temporary ambiguities associated with input such as (5). In particular, we will look at whether the word string is analyzed as forming a single clause or breaking into two or more clauses. We will also consider how the parser reacts to the ambiguity that remains even after the head noun of a relative clause is processed, i.e., the ambiguity concerning where the first-pass clause is divided into a matrix and a relative clause. However, detailed discussion of the latter problem will be deferred until section 3.3.

3.2 Theories of how the parser copes with first-pass ambiguities

In this section we review three classes of parsing models which differ in the proposals they make about the way temporary ambiguity is handled. In particular, they differ with respect to how a relative clause analysis is derived. Our first concern is cases like (10) and (12), in which the words up to the verb can form a single clause but the next word (noun) signals that the verb heads a relative clause which cannot include the whole word string, thus requiring the string to be split into two clauses.⁴ We will discuss experimental data from Hirose (1995) comparing two types of sentences, one in which

⁴ The relative clause could include the whole word string if the gap were in an adjunct position, assigned an adjunct role such as locative, temporal, reason, or manner, etc. (or if the relative clause were gapless), but the meaning of the head noun makes this very unlikely or impossible in the examples that will be considered here.

the initial sequence of NPs is compatible with a single clause analysis prior to the head noun, as in the cases of (10) and (12), and the other type with a simple transitive (monotransitive) verb whose argument slot cannot accommodate all of the preceding NPs, as in (4). The data indicated some extra processing cost upon receiving the input word which first falsifies the single clause analysis. We will discuss whether and/or how each type of parsing model can explain these data.

3.2.1 Serial (garden-path) models

A serial parser, as proposed in the garden path model (Kimball, 1973; Frazier, 1978; and many subsequent works), computes only one analysis at a time for an ambiguous string. At the onset of the ambiguity, or at any point at which two or more structural analyses are possible, the parser opts for one structural analysis. It is not always the case that the parser's initial guess is correct. The analysis may be shown to be wrong by later input which is not grammatically compatible with the current analysis, in which case the parser's reaction to the unexpected and incompatible input causes a temporary disruption in processing. This is called a *garden path* effect. The meaning of the term "garden path" varies across models. It may refer to a severe disruptive effect that can be consciously detected and hard to recover from (the sense adopted by researchers such as Pritchett, 1991, 1992; Gibson, 1991; Gorrell, 1995a). Or the term may refer both to such severe effects and also to a subtle disruption of parsing, not consciously noticed. In so-called garden path models, the latter meaning of the term is

usually intended. For example, Inoue & Fodor (1995) refer to “mild garden paths” and “severe garden paths.” Even when a garden path is experienced, parsing can often continue after appropriate reanalysis of the incorrect first-pass structure. So a serial parser must be equipped with a reanalysis mechanism; otherwise, since ambiguities abound in natural languages, a high proportion of sentences would be unparsable garden paths.

The standard garden-path model assumes that the parser’s choice of an analysis for an ambiguous string is not random. The parser has a systematic tendency to choose a particular syntactic analysis over its alternatives. The parser abides by general preference principles such as Minimal Attachment (Frazier & Fodor, 1978), Late Closure (Frazier, 1978), and the Minimal Chain Principle (de Vincenzi, 1992).

(16) They knew the girl at the bakeshop ...

For example, in the word string shown in (16), the attachment site of “the girl” is ambiguous between the direct object position of “knew” and the subject position of a complement clause. Minimal Attachment predicts that “the girl” would be initially processed as the direct object of the verb “knew”, because that structure requires less nodes than the sentential complement analysis.

Minimal Attachment: Attach incoming material into the phrase marker being constructed using the fewest nodes consistent with the well-formedness rules of the language. (Frazier, 1978)

If the subsequent input happens to be “was”, which is incompatible with the direct object analysis of “the girl”, this signals that the correct analysis should have “the girl” as part of the sentential complement of the verb “knew”. The model predicts a minor disruption of processing, or a garden path, as the parser reacts to the disambiguating input “was” . In this case (though not in all) the garden path is mild, and recovery of the correct structure is possible without necessarily causing a conscious difficulty.

In the processing of the string in (5), Minimal Attachment predicts an initial preference for the single clause analysis over any bi-clausal analysis. Assuming the word string is processed left-to-right incrementally, word by word, without delay, an expectation for a single clause analysis will be established before the head noun, or possibly before even the first verb is received in sentences such as (7), (10) and (12).

This prediction is confirmed by empirical studies showing that the parser’s initial preference is to analyze a word string such as (5) as a single clause. More generally, all of the NPs prior to a verb are preferentially taken to be constituents of a clause headed by the verb if possible (Yamashita, 1994; Inoue, 1991; Inoue & Fodor, 1995). Inoue (1991) and Inoue & Fodor (1995) gave intuitive evidence that the parser integrates each NP and PP into the structure currently being processed on-line (the current partial phrase marker, CPPM) before a verb is encountered, in accord with Minimal Attachment. Yamashita (1994), Hirose (1995) and Kamide (1998) provided experimental data to show that a sequence of NPs is analyzed as arguments of a single verb until any conflicting information is encountered (e.g., a verb with a mismatching argument structure,

Yamashita, 1994; Hirose, 1995, or an occurrence of a second nominative NP, Kamide, 1998).

Now consider example (4) above. The argument structure of the verb signals that the single clause analysis is not possible. This is the point at which the serial model predicts a garden path effect, assuming that a single clause analysis is postulated prior to the verb. This contrasts with (5), in which the string is compatible with the single clause analysis up through the verb. In the latter case, it is assumed that the parser creates a single clause which is the matrix root clause (Yamashita, 1994; Inoue & Fodor, 1995), and it is the appearance of the head noun that signals an error, inducing a garden path effect.

As noted, shifting from the single clause analysis to a relative clause analysis is indeed a reanalysis process. It may be achieved by reparsing the relevant part of the word string (Inoue & Fodor, 1995). Or it may be achieved by altering structure that was built during the first-pass parse. For example, Inoue (1991) characterizes the structural changes as “expelling” elements on the left and reattaching them to the CPPM as constituents of a higher clause. The SOAR model of Lewis (1993) would entail a similar process of “snipping” and reattaching. Frazier & Clifton (1998) seem to assume the same kind of repair routine (see more discussion below in section 3.4.1). The predicted cost of reanalysis varies among cases. It may depend on the number of constituents that are affected by such operations (Inoue, 1991; Frazier & Clifton, 1998), or on other factors. This will be discussed in section 3.4.1 below.

Let us consider some experimental data reported by Hirose (1995), which appear to illustrate just this picture of garden paths discussed above. In a "bunsetsu-by-bunsetsu" self-paced reading experiment, subjects read sentences presented on a computer screen one bunsetsu at a time, at their own pace, and reading time was recorded for each frame of the display. (A *bunsetsu* consists of either one content word, or a combination of a content word plus one or more function words.) The two kinds of sentences shown in (17a-b) were tested. In (17a) the initial three NPs and the following verb "okutta" (sent) are compatible with a single clause analysis, as in (5). In (17b), however, the verb "yabutta" (tore) does not take a dative NP argument. The verb shows that the word string does not constitute a single clause, just as in (4). In (17a) the head noun "tomodachi" (friend) reveals the relative clause construction (though it does not uniquely select a gap position). In (17b) the head noun confirms the two-clause analysis already signaled by the verb.

(17)

- a. Michiko_j-ga itoko-ni [*pro*_j e_i tegami-o okutta]
 -Nom cousin-Dat letter-Acc sent
- tomodachi_i-no koinu-o hisokani ageta .
 friend-Gen puppy-Acc secretly gave
- "Michiko secretly gave the cousin the puppy of the friend who she sent the letter "
- b. Michiko-ga itoko-ni [e_i tegami-o yabutta]
 -Nom cousin-Dat letter-Acc tore
- tomodachi_i-no koinu-o hisokani ageta .
 friend-Gen puppy-Acc secretly gave
- "Michiko secretly gave the cousin the puppy of the friend who tore the letter."

Increased processing costs were observed at the head noun in (17a) and at the embedded verb in (17b). That is, reading time for the head noun with case marker (e.g., “tomodachi-no”, friend-Gen) was longer in (17a) than in (17b), and reading time for the embedded verb was greater in sentences like (17b) (e.g., “yabutta”, tore) than in sentences like (17a) (e.g., “okutta”, sent). The final matrix verb demands “itoko-ni” in the matrix clause and disambiguates the entire structure.

Hirose (1995) took this result as evidence for the parser’s early commitment to the single clause analysis in which the three NPs would be clausemates of the first encountered verb. For both sentence types, the parser has to revise its first single-clause analysis at the disambiguation point, i.e., the point where the structure that the parser has been building turns out to be grammatically incompatible with the subsequent input. In (17b), that initial analysis is suggested as incorrect by the appearance of the monotransitive verb, because it does not take the dative NP as its argument. The garden path effect is reflected in the rise of reading time. In (17a), the parser retains its preferred single-clause analysis (since this appears to be confirmed by the ditransitive verb), and it is only at the head noun that the initial analysis needs to be reanalyzed. In (17b), the single clause analysis is falsified before the head noun is encountered, so encountering a noun following the monotransitive verb is less surprising. Of course, the parser may have already committed to some other subordinate clause structure, and in this case the head noun may strike the parser as input that is incompatible with that analysis. In *bunsetsu-by-bunsetsu* presentation this it is less likely, because a complementizer is usually

expected to appear as part of the same *bunsetsu* as the embedded verb. However, to be clear, all that the contrast in reading time between the two types of sentences at the head noun indicates is that the parser was more prepared for a relative clause analysis in (17b) than in (17a). This is explained on the assumption that the parser analyzes a string as a single clause as long as that analysis is viable (alternative interpretations by different models will be discussed below).

Note in addition that even though reanalysis to a relative clause structure is signaled by the head noun, there is still ambiguity as to where the clause boundary falls, and where the relative clause gap is, as shown in (7), (10), and (12). We assume that the noun attaches to the clause headed by the verb (see the *Attach Anyway* principle of Fodor & Inoue, 1998). This could already yield a grammatical analysis without further reanalysis if the semantics were compatible with a gapless relative or an adjunct relative, for which all the constituents in the CPPM can remain in the original clause. For an adjunct relative in which an adjunct gap is inserted without displacing any current item in the clause (provided that the head noun can allow the locative, temporal, or reason reading), all that would be needed is the creation of an empty category coindexed with the head noun (see Sturt & Crocker, 1996). However, those analyses are not always an option because the head noun content does not necessarily support an adjunct reading or license the aboutness link to the relative clause. Let us restrict attention to cases in which the adjunct reading of the head noun is not possible, and no link between the head noun and the content of the clause can be established by aboutness. In sentences such as (10) the parser must insert an empty category into an argument position. Since all of the

argument positions are occupied by NPs, this necessitates the removal of one NP from the clause. In (10) the gap postulated for the head noun “onnanoko” (girl) requires the displacement of at least one argument, in this case at least the leftmost “Bob-ga” (Bob-Nom) from the relative clause. “Bob-ga” then becomes the subject of a higher clause. In a sentence like (12), the original clause must lose two of its arguments, to allow the gap to be inserted into object position.

Assuming the characteristics of the serial model hold for the reanalysis stage, just as for the first-pass parsing, the parser would select one relative clause structure based on some general economy principle such as Minimal Attachment, or some reanalysis principle. There may also be some strategy for guessing the location of a relative clause gap; or some economy principle which finds one type of relative clause analysis more economical than others. There is a good chance that the preferred relative clause analysis again will turn out to be incorrect in relation to later input. As a result, there may be some contrast in overall processing difficulty among different types of relative clauses, depending on what the parser’s initial choice tends to be. In 3.3 we will discuss an intuitive contrast in the processing difficulty observed for the relative clause structures with argument gaps exemplified in (10) and (12), both of which are ambiguous up to the head noun. In 3.4 we will discuss different proposals in the literature as to what exactly the parser’s decision-making strategy is when there is ambiguity among relative clause structures. First, however, we review alternatives to the garden path model of the HSPM.

3.2.2 Parallel models

Another way to cope with temporary ambiguity is not to commit to one analysis until the disambiguating information is received. A parallel parser avoids commitment by computing multiple analyses simultaneously.

In the strictest version of parallelism, the parser would build all the syntactic structures that are possible for the word string at the onset of any ambiguity and pursues them as long as they are compatible with the input. Since it computes all possible analyses, it cannot miss the correct one. Hence no garden path should occur. However, when there are many potential analyses, as in the case of Japanese, pure parallel parsing would consume vast processing resources. Therefore, full parallel parsing is unrealistic as a model of the human sentence processing mechanism. On the assumption that the parser's operating characteristics are innate, if full parallel parsing is implausible for Japanese, it cannot be correct for any language. A reasonable parallel model needs some mechanism that controls the amount of resources consumed by allowing the parser to select a feasible number of analyses to pursue. In such a model, many potential analyses are left uncomputed.

Given a limitation on computational resources when the parser builds alternative structures in parallel, many parallel models assume some evaluative mechanism to rank the alternatives (Gibson, 1991; Kurzman, 1985; Gorrell, 1987; Crain & Steedman, 1985). The highest ranked analysis will eventually be assigned to the sentence, unless it is excluded by the input, in which case the next highest ranked one would be dominant.

Low-ranked analyses are most likely to be abandoned. For example, Gibson (1991, 1998) proposes a limited parallel model in which a structure is “pruned” from the parser’s consideration when the cost associated with that structure (evaluated by a specific metric based on memory resources, to be described below) exceeds a certain threshold (either relatively or absolutely).

3.2.2.1 Memory-based ranked parallel model (Gibson, 1991)

Gibson (1991) proposes an implementation of this kind of system in his ranked parallel parsing model. Here, alternative analyses are evaluated and ranked in terms of memory cost. At each point in the incremental parse (i.e., as each new input word is received) a cost is calculated for each analysis, and this provides the basis for a ranking. Any analysis with a memory cost much higher than its competitor, or with a memory cost which exceeds an absolute limit on computability, is pruned. Even the sole analysis for an unambiguous sentence would not be computed if the cost associated with it exceeded the absolute limit.

The cost of maintaining a particular analysis is evaluated based on the number of violations of certain general constraints. The severity of violations is measured in terms of “Processing Load Units” (PLUs). These are defined in terms of cognitive resources and grammatical concepts based on Government and Binding (GB) theory (Chomsky, 1981, 1986). The former gives rise to a recency preference, and the latter to constraints related to the Theta Criterion and Projection Principle. Here, we focus on the latter

notions as they are the most relevant to the Japanese cases under discussion. The following definitions are from Gibson (1991).

The property of Thematic Reception (PTR): (p. 97)

Associate a load of x_{TR} PLUs to each C-node (confirmed node) constituent that is in a position that can receive a thematic role in some co-existing structure, but whose theta-assignor is not unambiguously identifiable in the structure in question.

The property of Lexical Requirement (PLR): (p. 97)

Associate a load of x_{LR} PLUs to each lexical requirement that is obligatory in some co-existing structure, but is satisfied by an H-node (hypothesized node) constituent containing no thematic elements in the structure in question.

Gibson notes that x_{TR} and x_{LR} are approximately equal, so both can be referred to as x_{int} , where 'int' stands for 'interpretation'.

Multiple analyses are maintained in parallel unless an analysis evaluated in terms of the number of PLU penalties is much more costly than its competitors. Specifically, when one of the possible analyses of a word string is associated with two more PLUs than its best competitor, or simply exceeds 5 PLUs which is the absolute memory limit, it is considered too costly for the parser to maintain, and the structure is rejected or "pruned". If the rejected analysis later turns out to be the correct analysis, it cannot be recovered as part of the regular processing routine (though it may be retrieved by deliberate problem solving).

Let us look at the example (16) repeated below. The PLU cost relevant to this example is the one associated with an NP that has not received a thematic role from its theta role assigner (PTR).

(16) They knew the girl at the bakeshop ...

At the point that “the girl” is encountered, no PLU is associated with any of the preceding material in the direct object analysis as there are no NPs in theta positions without an identified theta assigner, or elements with unsatisfied lexical requirements. In the sentential complement analysis, since “the girl” is in a theta position but its theta assigner is not yet encountered, there is $l_{x_{TR}}$, thus l_{int} PLU. However, a processing load only $l_{x_{int}}$ more than the preferred (direct object) structure is not sufficient for it to be pruned, and thus the unpreferred sentential complement structure can be maintained without exceeding resource limits. Thus the fact that the complement clause continuation of (16) is not very difficult is explained.

In (18), a single clause analysis of the entire word string as in (18a) is possible, and it carries no PLU at the point of processing “the dog”. However, (18) could have the structure (18b) and could turn out to continue as in (19), which is observed to cause severe processing difficulty.

(18) John gave the boy the dog ...

a. John [gave [the boy] [the dog]]

b. John [gave [[the boy [the dog ...]]]]

(19) John gave the boy the dog bit a dollar.

For this analysis (John gave [the boy the dog bit] [a dollar]), at the point of processing “the dog”, the cost is $3x_{\text{int}}$ PLU, because the thematic role (THEME) associated with the verb “give” is not assigned, the empty operator in the SPEC position of the CP modifying “boy” is not assigned a thematic role, and the NP “the dog” is in a thematic position without a thematic role yet. This is a difference of $3x_{\text{int}}$ PLUs from (18a), which is big enough (exceeding 2 PLUs) for the parser to abandon the correct structure for (19). Therefore, a severe garden path effect is expected at the disambiguation point (“bit”), because the correct structure is available only by a presumably very costly conscious reanalysis.

This model may be able to explain the Hirose (1995) results, but only if it is assumed that there is some cost or time associated with dropping the initially preferred analysis and/or re-ranking other remaining possible analyses. (Strictly speaking, this parser does not adjust its PLU assignments for the less preferred analyses when the preferred analysis is eliminated. However, it is possible that there is effort associated with focusing on the new preferred analysis, which controls the meaning the perceiver is aware of.) The model would predict that the single clause analysis of the initial sequence of NPs “Michiko-ga itoko-ni tegami-o” would be the highest-ranked analysis. The monotransitive verb “yabutta” in (17b) eliminates the single clause analysis. At this point, the analysis for which the memory cost is the lowest (hence ranked highest) would be one in which only “tegami-o” is an argument of “yabutta”. This analysis, which is the correct one, carries $2x_{\text{int}}$ PLUs associated with the first two NPs, for which the theta-

assigning verb has not been encountered, but this analysis is not pruned because there is no better competitor. The longer reading time found at the monotransitive verb in (17b) compared to the ditransitive verb in (17a), might be ascribed to the cost of discarding the initially preferred single clause analysis.

In (17a), the single clause analysis (as well as bi-clausal analyses in which all the NPs preceding the first verb are within the same single clause) would have no x_{int} PLUs at the first verb, because thematic roles will be assigned to all the three preceding NPs. Note that the target structure is predicted to be pruned, because the first two NPs are matrix clause constituents in the target, and the two x_{int} PLUs associated with them remain undischarged at the first verb. So it is pruned because it is two PLUs worse than the single clause analysis. There is still a relative clause analysis available, however (though it is incorrect): It is an analysis in which only the first NP is outside of the relative. This analysis survives because its cost at the verb was not great enough for it to be pruned. When the head noun “tomodachi” is encountered, the single clause analysis must be eliminated. Therefore, the longer reading time found at the head noun in (17a) compared to the same position in (17b) may be due to the cost of discarding the initially preferred single clause analysis at the head noun position. At this point, the relative clause analysis in which only “Michiko-ga” is the matrix constituent remains alive, and is now the highest ranked analysis.

Thus the reading time differences of Hirose (1995) could be accounted for on these assumptions. Of course, the parser’s analysis of (17a) is wrong. The correct structure is the one in which both “Michiko-ga” and “itoko-ni” are matrix constituents,

because the sentence-final matrix verb requires a dative NP. At the point of processing the head noun, this target analysis is still alive in (17b), since nothing has required it to be pruned, (and it will remain alive until the matrix verb), but not in (17a). This will cause a greater problem at the final matrix verb in (17a). Reading time data for the matrix verb position in the materials of Hirose (1995) were not collected. However, based on intuitive judgments it seems that there is a potential problem here. It is predicted that analyses such as (17a) would be associated with severe processing difficulty at the matrix verb, because this analysis had been pruned at an earlier point. When it turns out subsequently that such an analysis is in fact the only one possible, it is too late to recover, at least by the parser's routine processing operations. It is predicted, therefore, that sentences like (17a) are impossible to process (except by deliberate problem solving). It seems intuitively dubious, however, that these sentences are really so difficult as to be unprocessable. We will come back to the discussion of this issue in section 3.4.2 later. In Chapter 4, based on the outcome of a series of experiments, we will argue that this prediction is not correct.

3.2.3 Delay models

In the case of ambiguity, a delay parser postpones the computation of structural analyses until disambiguating information is encountered. A strict delay parser does not make any commitment to an analysis on the basis of insufficient information. Therefore no garden path would ever occur and hence no reanalysis is ever needed. Instead, extra

processing cost is predicted at the disambiguating point, since all the computations involved in structuring the preceding word string are done at this point. (The processing load for the simpler or preferred analyses might nevertheless be somewhat smaller than that for other analyses.) Furthermore it is only at this point that any semantic interpretation is assigned. On the assumption that unstructured and uninterpreted materials cause a strain on memory, it is important for a realistic parser that delays due to ambiguity be few and short.

A full-delay parser is particularly unrealistic for languages like Japanese in which frequent temporary ambiguities are inevitable at different points in a sentence, and important information such as the argument structure of the verb is not obtained until late in the clause. A full-delay system would predict that no semantic interpretation can be established on line prior to the end of the sentence for many sentences and that no interpretation is possible at all for globally ambiguous sentences. A full-delay parser would thus predict that in processing (17a) and (17b), given the possibility of different kinds of embedded or relative clause endings, no structure building should occur until the very end of the sentence. Thus this approach cannot account for the sentence-medial pattern of reading times reported in Hirose (1995).

A reasonable delay parser therefore needs to have a limited delay mechanism, in terms of how long decisions can be delayed, or in terms of what kinds of processing decision can be delayed.

3.2.3.1 Look ahead (Marcus, 1980)

Marcus (1980) proposes a limited delay model in which the parser can look ahead a limited number of additional constituents following the input word.

For example, he discusses the following imperative versus yes-no question ambiguity in English, as shown in (20-22).

(20) Have [all of the eggs] [broken]?

(21) Have [all of the eggs broken]!

(22) Have [the student who missed the exam take it today]!

In reading the sentence initial “have” in (20) and (21), the parser needs to determine if it is an auxiliary verb in a yes-no question or a tenseless verb in an imperative sentence, in order to determine what syntactic structure to assign to the following input words. It is observed that (21) causes a noticeable garden path at the disambiguating punctuation mark. Presumably, then, the default preference is for the question analysis rather than the imperative analysis. Such difficulty does not arise in (22), in which the singular “student” which follows the ambiguous “have” eliminates the yes-no question reading at an earlier point. Considering the above contrast as well as some severe garden path examples, Marcus proposes that the HSPM has a look-ahead capacity, provided by an input buffer that holds three constituents of any size. The material that is held in the buffer provides the parser with information as to how the current input word is to be

analyzed, though for these buffered constituents, only a shallow parsing may be done, e.g., packaging NP constituents. The decisions are strictly deterministic: Once an element is attached to another one, the decision becomes indelible. In (21), there is no information resolving the ambiguity between the question analysis and the imperative analysis of “have” within the three constituents (“have”, “all the eggs”, and “broken”) and the parser guesses that the sentence is a yes-no question. This decision is indelible, and thus cannot be revised even if some relevant information becomes available (in this case, punctuation) later in the sentence.

Let us apply this to the Hirose (1995) data. It is not absolutely clear what to count as a constituent for purposes of Marcus’s buffer store, but we assume that “Michiko-ga,” “itoko-ni,” and “tegami-o” in (17) each initially occupies one buffer unit. When the decision has to be made about how to attach NP-ni in relation to NP-ga, the 3-constituent buffer should allow the parser to see only as far as the first verb in (17a) and (17b), counting from NP-ni. In (17b) the monotransitive verb indicates that NP-ni cannot be in the same clause as the verb, so it would be attached as a clausemate of NP-ga in the matrix clause. In (17a) the ditransitive verb would suggest that NP-ga and NP-ni are clausemates. The same correct attachment of NP-ni would thus be made in both cases. However, the observed difference in reading times at this first verb might be explained as due to the cost of building the two-clause structure associated with (17b) but not (17a); but see below. When NP-o is to be attached, the buffer will include the head noun in both cases, so a relative clause structure will be created. NP-ga and NP-ni will have to be in the matrix clause in both cases. The NP-o might, in principle, be either in the matrix

clause or in the relative clause, so this is another ambiguity that needs resolving, but it is not relevant here.⁵ Assuming the two-clause structure was previously anticipated in (17b), but needs to be created now in (17a), this could account for the observed reading time difference at the head noun, and the predicted distribution of processing costs would be compatible with the data of Hirose (1995). However, there is in fact no reason why the Marcus parser should build the lower clause structure while attaching NP-ni (while looking ahead to the first verb) in (17b); and there is good reason for it not to do so because it could not tell at this stage what type of subordinate clause was present. In this case, both (17a) and (17b) would incur a processing cost at the head noun, and not at the preceding verb, and the experimental data would be unexplained. Note that it is predicted in any case that if there were additional constituents intervening between NP-ni and the first verb and head noun, these would block the parser's ability to look ahead to that information and this would cause additional errors.

3.2.3.2 Head-driven parser (Pritchett, 1991)

Pritchett (1991) proposes a limited delay model in which the projection of a node is deferred until its head appears. Thus the delay (or look ahead) is determined by head position rather than being based on an absolute number of constituents. For the Japanese

⁵ Relative clause attachment of NP-o seems natural, since the noun is compatible with the relative clause verb. Also, in (17) the complex NP is case-marked with *-o*, and this could not be a clause-mate of another NP-o, so the relative clause attachment of NP-o is strongly favored (see Inoue, 1991, on such considerations). But the Marcus parser could see the case marking on the complex NP at this point only if the head noun and the following noun ("tomodachi-no" and "koinu-o") had been combined together by a pre-processing routine so that they now occupy a single buffer cell.

cases, it is when the verb is encountered that the syntactic structure of the clause headed by that verb is built. Let us examine whether this proposal is consistent with the Hirose (1995) data.

In this model, the observed cost difference would be explained not as a garden path effect, but as the structure building cost once the disambiguating information allows the parser to assign a syntactic analysis to the preceding input string. In (17a), when the verb is encountered, the decision about the clause headed by that verb is initiated. Since the preceding NPs fit the argument slots required by the verb, a single clause analysis may be chosen (which will be found to be wrong at the subsequent head noun position) and the parser starts building the syntactic structure for the single clause analysis. In (17b), the verb would also signal the necessity of projection of a clausal node; however, since the dative NP cannot be an argument of the verb that has currently been processed, that dative NP and the preceding nominative NP would have to be left unattached. In a head-driven model, the higher clausal node in which these two NPs are the arguments would not be projected at this point, since the head of that clause (the matrix verb) has not been encountered yet. This may or may not be consistent with the reading time difference at the relative clause verb. Recall that the first verb in (17a) was read faster than the first verb in (17b). The structure building cost for the clause headed by the first verb should apply to both, but there is one difference. In (17b) not all of the constituents can fit into that clause: the subject position of the clause is empty, and the two preceding NPs have to be held in memory. Therefore, it might be possible to interpret this difference as the cause of the longer reading time since more memory is presumably

required. Then at the head noun, the NP node is projected to dominate the preceding clause as a relative clause modifying that noun. Faster reading of the head noun in (17b) than in (17a) may then be explained, because the parser cannot find a position for a relative clause gap in (17a). On the other hand, in (17b) the empty subject position in the embedded clause can immediately accommodate the relative clause gap, thus processing may be more smooth.

So, the head-driven parsing model may be able to provide an interpretation of the Hirose (1995) data. In fact, however, the experimental results reported in Chapter 4 will provide evidence against head-driven parsing: they will show that a decision about the higher clausal structure is made prior to the matrix verb.

3.2.4 Structural Determinism

Another way of delaying certain decisions in order to avoid making a commitment to a wrong structure, but at the same time allowing some interpretation along the way of processing input, is to set a limit on how many details the parser makes a decision about on-line (Weinberg, 1993; Gorrell, 1995a; Sturt & Crocker, 1996). This approach assumes an incremental processing of the input, like serial models, rather than delaying all operations on the input string. However, it also has an aspect of delay parsing because the full representation of the analysis is not obtained until there is no ambiguity. Meanwhile (or if the sentence is globally ambiguous) a default structure and

interpretation can be hypothesized, consisting of the minimal well-formed extension of the underspecified representation.

Description Theory (D-theory) proposed by Marcus, Hindle, & Fleck (1983) allows analysis trees to be described in terms of dominance (instead of immediate dominance) relations between nodes. At any given point in the parse the parser commits itself, not to one particular analysis, but to a set of analyses that are all compatible with the tree description constructed so far for the word string. The parse starts with a minimal analysis, no more than is warranted by its input, and more details are added to the description as the parse proceeds. The more specifications that are added, the smaller the set of analyses becomes. The parse fails only when the set of possible analyses is reduced to zero, i.e., when a new word cannot be integrated into the tree description without falsifying a previous description.

Adapting D-theory, Gorrell (1995a) and Sturt & Crocker (1996) assume that the parser is subject to Structural Determinism.

Structural Determinism: the domain of determinism is limited to the primary structural relations, dominance and precedence.

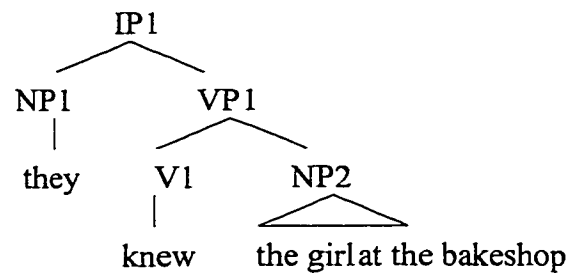
The primary structural relations, dominance and precedence (although not immediate dominance and precedence) are strictly deterministic and cannot be erased. Structural relations such as government and thematic role assignment are considered secondary relations and can be altered during the course of processing.

In this system a new description is added only when there is evidence for it. The only additions consistent with Structural Determinism are those equivalent to “inserting

one tree inside another at an intermediate point on the right frontier” (Sturt and Crocker, 1996, p.451). For example, when (16, repeated below) is processed, the following description of primary relations can be made, as shown in (23).

(16) They knew the girl at the bakeshop ...

(23)



dominate (d)

d (IP1 NP1)

d (IP1 VP1)

d (VP1 V1)

d (VP1 NP2)

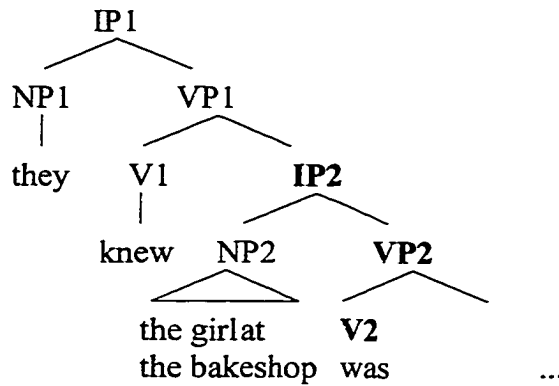
precede (p)

p (NP1 VP1)

p (V1 NP2)

If the sentence ends here, all the dominance descriptions will be interpreted as immediate dominance relations by default. Or, if subsequent input follows which initiates the addition of the descriptions marked in boldface in (24), this amounts to *lowering* NP2 into a subordinate clause.

(24)



dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- d (VP1 V1)
- d (VP1 NP2)
- d (VP1 IP2)**
- d (IP2 NP2)**
- d (IP2 VP2)**
- d (VP2 V2)**

precede (p)

- p (NP1 VP1)
- p (V1 NP2)
- p (V1 IP2)**
- p (NP2 VP2)**

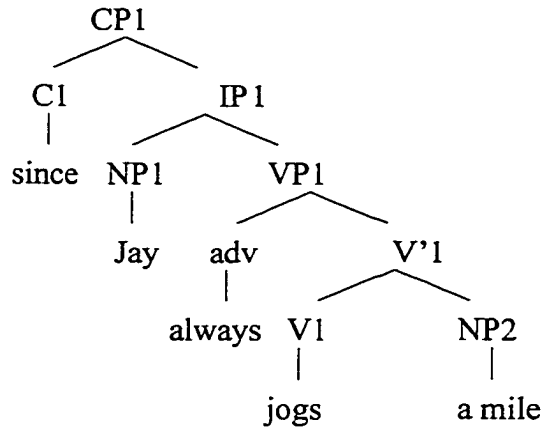
All the previously stated descriptions still remain true, so this structural change is legitimate.

Let us now turn to a case in which Structural Determinism is violated. (25) is reported to involve a severe garden path which is hard to recover from. When "a mile" is

received, it is assumed to be within the VP headed by the verb “jogs”.⁶ The relations shown in (26) are computed.

(25) Since Jay always jogs a mile seems like a short distance for him.

(26)



dominate (d)

d (CP1 C1)
 d (CP1 IP1)
 d (IP1 NP1)
 d (IP1 VP1)
 d (VP1 V1)
 d (VP1 NP2)

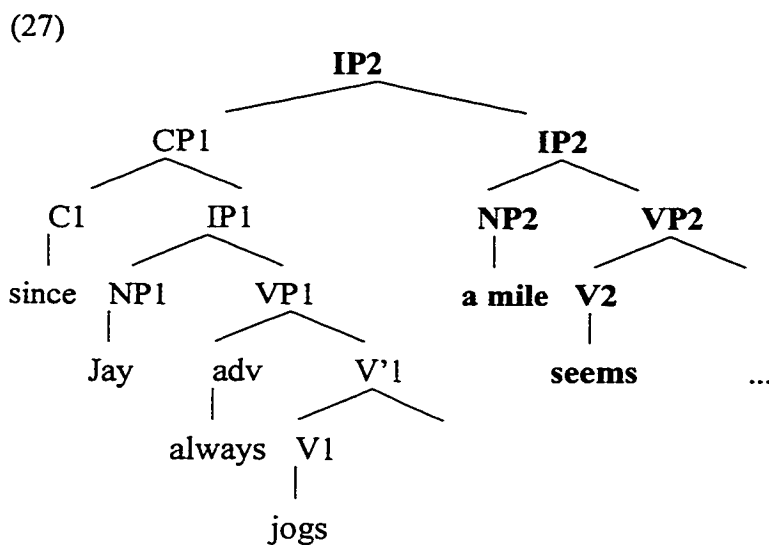
precede (p)

p (C1 IP1)
 p (NP1 VP1)
 p (V1 NP2)

When “seems” is encountered, a new IP is added, within which “a mile” now has to be the subject. But in order to obtain the appropriate structure, the relation between VP1

⁶ The NP “a mile” could have been attached instead as the beginning of the matrix clause which dominates the “since” clause. We assume that in this model its preferred attachment site is the direct object position of “jogs” because of Late Closure.

(headed by “jogs”) and NP2 (“a mile”) has to be destroyed, as illustrated in (27). Thus this is a structure which is impossible for the parser to compute.



dominate (d)

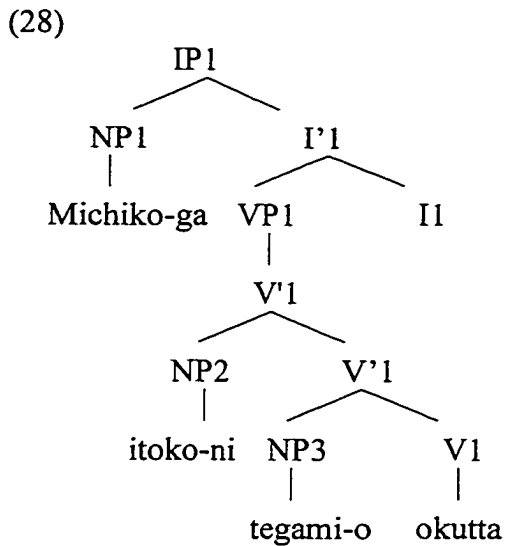
d (CP1 C1)
 d (CP1 IP1)
 d (IP1 NP1)
 d (IP1 VP1)
 d (VP1 V1)
 ~d (VP1 NP2)
 d (IP2 NP2)
 d (IP2 VP2)
 d (VP2 V2)

precede (p)

p (CP1 IP2)
 p (C1 IP1)
 p (NP1 VP1)
 p (V1 NP2)
 p (NP2 VP2)

Let's consider (17a) and (17b) again. The operation by which (17a) is obtained in this model is as follows. Given a string up to the first verb in (17a), no relative clause structure is assumed since there is as yet no evidence for it. The parser computes the structurally simplest analysis, just as a serial parser abiding by Minimal Attachment does. This minimal commitment strategy would account for the initial preference for the single clause analysis, as shown in (28). (In this discussion, only the description of the dominance relations is directly relevant; precedence relations will not be shown.)

(17a) Michiko-ga itoko-ni tegami-o okutta ...
 -Nom cousin-Dat letter-Acc sent

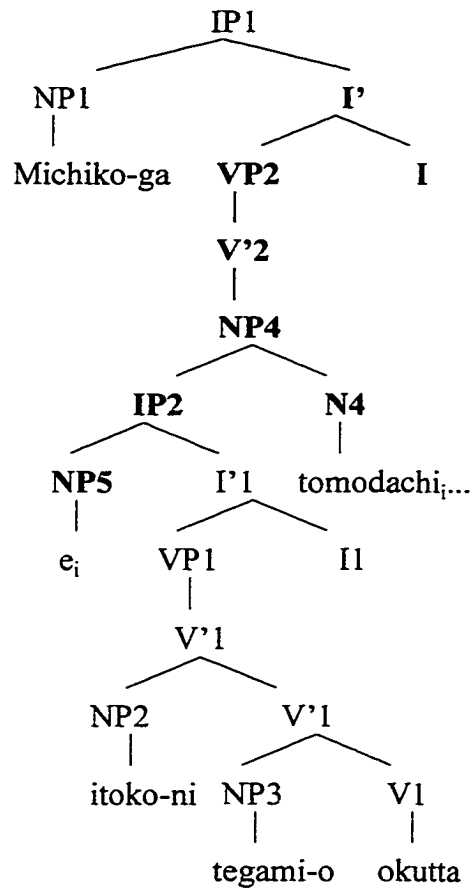


dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- d (VP1 V1)
- d (VP1 NP2)
- d (VP1 NP3)
- d (VP1 V1)

On receiving the head noun “tomodachi” (friend) in (17a), the parser would attempt to attach it by establishing new dominance and/or precedence relations between some of the current nodes and the new noun node without deleting any previously established dominance or precedence relations. It could do this by adding all the new nodes above the IP1. But this analysis would be rejected because it is incompatible with the meaning of the head noun. Instead, the parser could obtain a possible relative clause analysis without violating Structural Determinism by creating a new IP node (IP2) and an NP node that dominates IP2 and the noun and inserting these beneath the current IP1 but above VP1, as shown in (29). This is a subject-gap analysis of the relative clause. It is not the correct analysis for (17a), but in this model it is the best analysis that is plausible at this point; see section 3.4.3.2 for discussion of which analyses are preferred. This way all the previous dominance and precedence relations are maintained, but “Michiko-ga” is above the relative clause as a result of the original VP having been ‘lowered’ into a new clause.

(29)



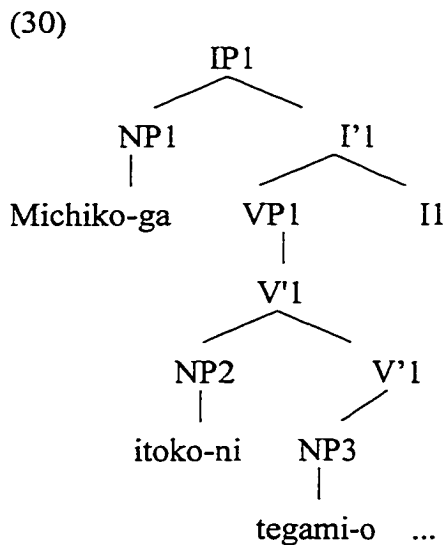
dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- d (VP1 V1)
- d (VP1 NP2)
- d (VP1 NP3)
- d (VP1 V1)
- d (IP1 VP2)**
- d (VP2 NP4)**
- d (NP4 IP2)**
- d (NP4 N4)**
- d (IP2 NP5)**
- d (IP2 VP1)**

No severe processing cost is predicted at the head noun in (17a) as Structural Determinism is not violated here. The Hirose (1995) data in fact showed some cost at the head noun position in (17a) when the argument structure of the embedded verb that preceded the head noun was compatible with the sequence of all of the sentence-initial NPs. This might be ascribed to the cost of adding new nodes into the CPPM to dominate the extra clause (although it is not explicitly assumed in the Structural Determinism literature that adding nodes by itself leads to a measurable cost), or to some cost associated with the process of deciding where in the CPPM to add the new structure. On this assumption, the data for (17a) are compatible with the model.

Let us turn to (17b). First, the parser assumes that the first three NPs are clausemates, as in (30).

(17b) Michiko-ga itoko-ni tegami-o yabutta ...
 -Nom cousin-Dat letter-Acc tore

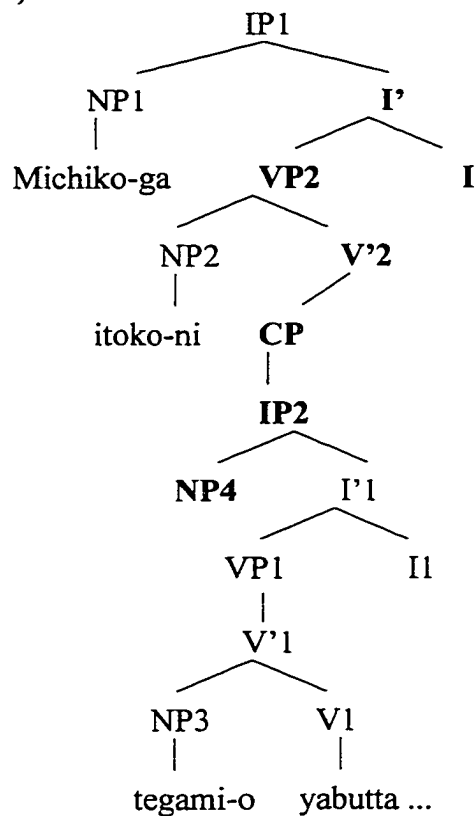


dominate (d)

d (IP1 NP1)
 d (IP1 VP1)
 d (VP1 NP2)
 d (VP1 NP3)

It then encounters the monotransitive verb, which forces a two-clause structure. So this is the point at which new nodes have to be added, in order to split the clause: see (31).

(31)



dominate (d)

d (IP1 NP1)
 d (IP1 VP1)
 ~d (VP1 NP2)
 d (VP1 NP3)
d (IP1 VP2)
d (IP2 NP4)

d (IP2 VP1)
d (VP1 V1)
d (VP2 IP2)

In doing this, one of the previously established dominance relations, namely [d (VP1 NP2)] has to be broken, at least in Gorrell's version of the theory (Gorrell, 1995a, 1995b); see below on Sturt & Crocker's version. This is predicted to lead to a severe garden path, because building a structure which violates Structural Determinism cannot be performed by the normal processing routines. The reading time rise at the verb in (17b) might be attributed to this processing breakdown, although intuitively the difficulty is not as severe as this would suggest.

In fact, Gorrell and Sturt & Crocker's theories differ with respect to whether (17b) is predicted to violate Structural Determinism. Gorrell assumes that lowering is applied to a node above VP1. (As noted by Sturt & Crocker, 1996, Gorrell assumes that I is a sister of VP and lowering is applied to the entire I', as he assumes verb movement to the INFL.) Thus for Gorrell it is inevitable that the VP1 and NP2 must be split apart, as we have seen above. Sturt & Crocker, on the other hand, propose that just the V' or the V can be lowered. If the lowering is performed on the intermediate V' node which only dominates "tegami-o" but not "itoko-ni", then no determinism violation occurs and no severe difficulty is predicted. The reading time rise at the verb in (17b) would then have to be accounted for as a minor cost of adding nodes to the structure. Hence, the prediction of Structural Determinism for Japanese relative clause processing depends partly on the assumption about the exact point in the tree at which the structure adding

operation applies, which in turn depends on what specific syntactic theory is assumed. We will come back to this point in section 3.4.3.1.

How does this model decide in cases of ambiguity between the different types of relative clause structures? The ambiguity concerns what kind of structure is to be added and at what point in the CPPM it should be added. Sturt & Crocker make a specific proposal concerning the strategy that the parser employs. The parser's preference is based on the height of the node in the syntactic structure at which structure insertion is performed; for Japanese, higher insertion is preferred over lower insertion. An analysis that is not preferred can be obtained only after the preferred structure has been tried and fails on structural or semantic grounds. Therefore, the proposal entails that there are contrasts in processing difficulty between the different types of relative clauses shown in (8)-(12). This will be discussed in detail in 3.4.3.2, and Sturt & Crocker's specific proposal will be evaluated in Chapter 4.

3.2.5 Summary: Single clause vs. relative clause

In the preceding sections, we have discussed how the human parser copes with the single clause versus embedded (relative) clause ambiguity.

We have seen that the different models of HSPM all agree that the single clause analysis is preferred over the relative clause or other bi-clausal analyses. We have presented several alternative interpretations of the experimental data reported by Hirose (1995), which were originally taken to support the serial processing model. The data

showed a processing cost increase at the point at which the single clause analysis turns out to be incompatible with the input. We have considered explanations of this fact within the frameworks of a ranked parallel model proposed by Gibson (1991), a head-driven model proposed by Pritchett (1991), look-ahead model by Marcus (1980), and Structural Determinism models proposed by Gorrell (1995a) and Sturt & Crocker (1996). Their explanations for the nature of the cost increase are completely different, and succeed to different degrees.

Note we focus on the stage at which the preferred single clause analysis has turned out not to be an option any more, so that a relative clause analysis is the only possibility. As noted, there can be further ambiguity at this point, between different relative clause structures. We call this *reanalysis ambiguity*, on the assumption that the parser first postulates a single clause analysis if possible, and then reanalyzes that structure when subsequent input signals a relative clause structure. (Terminological note: at this point, we are still considering some models for which on-line reanalysis is not assumed to be part of the normal parsing routine, so for these models the term “reanalysis ambiguity” is not fully appropriate. Nevertheless, we retain the term for convenience. Eventually we will argue that a serial model with on-line reanalysis is the most consistent with our experimental data.)

The question we ask in the following section is how and at what point reanalysis ambiguities are resolved in these parsing models, and whether there is any processing preference between different relative clause structures. Are all relative clause structures

equally processable, or processable at all? The different processing models considered above make different predictions.

3.3 Ambiguity between subject gap and object gap

Our concern is the contrast exemplified by (32) versus (33). This was originally discussed by Mazuka and Itoh (1995). It parallels the contrast between (10) and (12) above.

(32) Yoko-ga [e_i kodomo-o koosaten-de mikaketa] onnanoko_i-ni koe-o kaketa .
 -Nom child-Acc intersection-Loc saw girl-Dat called (to)
 "Yoko called (to) the girl who saw the child at the intersection."

(33) Yoko_i-ga kodomo-o [e_i e_j koosaten-de mikaketa] takusii_j-ni noseta .
 -Nom child-Acc intersection-Loc saw taxi-Dat put on
 "Yoko put the child into the taxi she saw at the intersection."

In both of these sentences, the relative clause must contain an empty category in an argument position co-indexed with the head noun. The adjunct argument clause reading is not an option here: the locative position is already filled by "koosaten-de" so that a gap cannot be postulated at this position. Other types of adjunct such as time, location, reason, and manner are not compatible with the head noun. Accompaniment or benefactive readings are not common, and though they are not impossible for animate nouns, they are not a possible choice for the gap position here, so we set them aside. This leaves subject and object gaps as the likely candidates. In (32) the gap is in the subject

position of the relative clause, and in (33) the gap is in the object position. The subject empty category of the relative clause in (33) is a *pro* most likely bound by the matrix subject.

Suppose a parser had initially favored a single clause analysis. Since all of the argument positions in these examples are filled with NPs in the first-pass single clause analysis, the parser has to make room for the gap by removing an NP (when the head noun is encountered). As discussed in Chapter 2, there is no syntactic cue signaling the exact position or the role of the relative clause gap in Japanese. So the parser would have to guess the best position for the gap. The guess might subsequently prove to be correct or not depending on how the matrix clause ends, or the matrix clause might be ambiguous so that any guess the parser makes will be viable even if not as the speaker or writer intended.

Appealing to native intuition, Mazuka & Itoh propose that relative clause structures such as (32) involve non-costly reanalysis, in contrast to (33) which they claim involves costly reanalysis. The latter, they suggest, leaves an "impression of conscious reanalysis" (p.305). They suppose that reanalysis is not costly in (32) because only the subject NP "must be taken out of the lower clause" (p. 307) while reanalysis in (33) is costly because "both the subject and the object NPs need to be taken out of the lower clause" (p. 307). Based on Mazuka & Itoh's characterization, we will henceforth refer to structures such as (32) as "Subject Reanalysis" (or SR) structures and to structures such as (33) as "Subject and Object Reanalysis" (or SOR) structures. This terminology is convenient, although such terms imply movement of the subject and object out of the original clause. For

some theories (see below) this may not accurately describe the process by which a relative clause structure is established.

Examples (32) and (33) are both temporarily ambiguous at the head noun. That is, the appearance of the head noun signals that a relative clause of some kind must be built, but it is only at the sentence-final matrix verb that it becomes clear what kind of relative clause it must be, i.e., an SR structure for (32), and an SOR structure for (33). At the head noun, (32) temporarily allows the SOR structure, (“the girl *pro* saw at the intersection”) as well as the eventually correct SR structure, because “onnanoko” (girl) can be interpreted as a THEME object of the verb “mikaketa” (saw). Conversely, (33) also temporarily allows the SR structure (“the taxi which saw the child at the intersection”) as well as the eventually correct SOR structure, because “takusii” (taxi) can metaphorically mean taxi driver and hence can be interpreted as an EXPERIENCER subject of “mikaketa.” (Native speakers consulted find the EXPERIENCER reading quite natural.) Subsequently, the SR interpretation will be falsified by the argument structure of the main clause. Because “noseta” would require an accusative object, “kodomo-o” will have to end up as the matrix object

This raises an important question concerning Mazuka & Itoh’s proposal. Suppose the SR structure is always chosen at an ambiguous head noun (as their claim seems to imply, since it is the SR that is non-costly). Then the relative clause structure first assigned at “takusii” in (33) will later have to be revised to the SOR structure at the matrix verb “noseta” (put on). This latter process (the *revision* of a reanalysis) might give an impression of conscious reanalysis. Alternatively, the difficulty associated with

SOR in (33) may reflect not a garden path, but an additional structure-building cost for that structure when the parser has opted to build it. Mazuka & Itoh's discussion does not mention the thematic ambiguity of "takusii", and thereby suggests that the parser immediately assumes an object gap.

This distinction is an important one which runs through all of sentence processing theory. For a garden path model, a very small difference in the attractiveness of two competing analyses can result in a considerable difference in processing difficulty, since a dispreferred structure will not be computed during the ambiguous region. In comparable constructions that are unambiguous, however, that same structure (dispreferred in ambiguity) may be quite easy to compute. Three empirical questions are therefore relevant. (i) First, is a systematic preference observed when both SR and SOR structures are possible at the head noun? (ii) Second, how great is the cost of computing an SOR structure when only the SOR analysis is possible at the head noun? (iii) Finally, if the answer to (i) is SR, how great is the cost when the SOR structure turns out to be the correct structure at the matrix verb? Before investigating these matters, we review theoretical predictions.

3.4 Predicted difficulty of SR and SOR analyses

This section considers what specific predictions the different parsing models discussed in section 3.2 make concerning the comparative difficulty of SR and SOR relative clauses. When there is ambiguity at the head noun so that both SR and SOR are

allowed, how would the parser resolve the ambiguity? Further, is SOR predicted to be difficult even when there is *no* ambiguity? We focus on sentences such as (33) and (34), which are identical except for the matrix verb. The head noun “takusii”, as we have argued, is compatible with either SR or SOR relative clause because it can serve as THEME or (metaphorically) as EXPERIENCER. The matrix verb “donatta” (yelled at) disambiguates toward SR in (34), and the matrix verb “noseta” disambiguates toward SOR in (33) (repeated below).

(33) Yoko_i-ga kodomo-o [e_i e_j koosaten-de mikaketa] takusii_j-ni noseta .
 -Nom child-Acc intersection-Loc saw taxi-Dat put on
 "Yoko put the child into the taxi she saw at the intersection."

(34) Yoko-ga [e_i kodomo-o koosaten-de mikaketa] takusii_i-ni donatta .
 -Nom child-Acc intersection-Loc saw girl-Dat yelled at
 "Yoko yelled at the taxi (= taxi driver) who saw the child at the intersection."

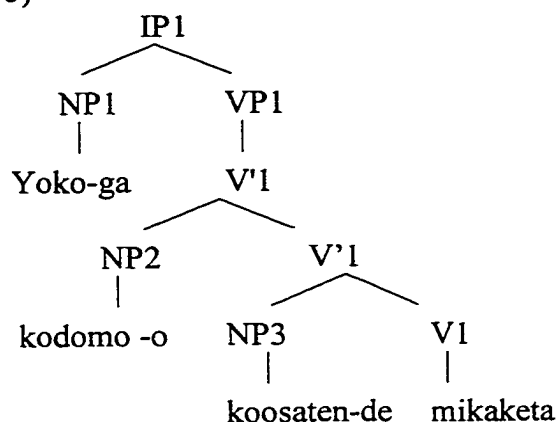
In the discussion that follows we will be concerned with predicted processing costs at the head noun and at the matrix verb which is the point of disambiguation.

3.4.1 Serial models and head-driven models

In a serial parsing model the shift from the initial single clause analysis to a relative clause analysis is a reanalysis process. Head-driven models share this aspect for the examples under discussion. Commitment to a single clause analysis is made at the first verb, prior to the head noun (see (35)), so reanalysis is needed to arrive at the

appropriate relative clause structure. We will discuss proposals in these two frameworks together in this section.

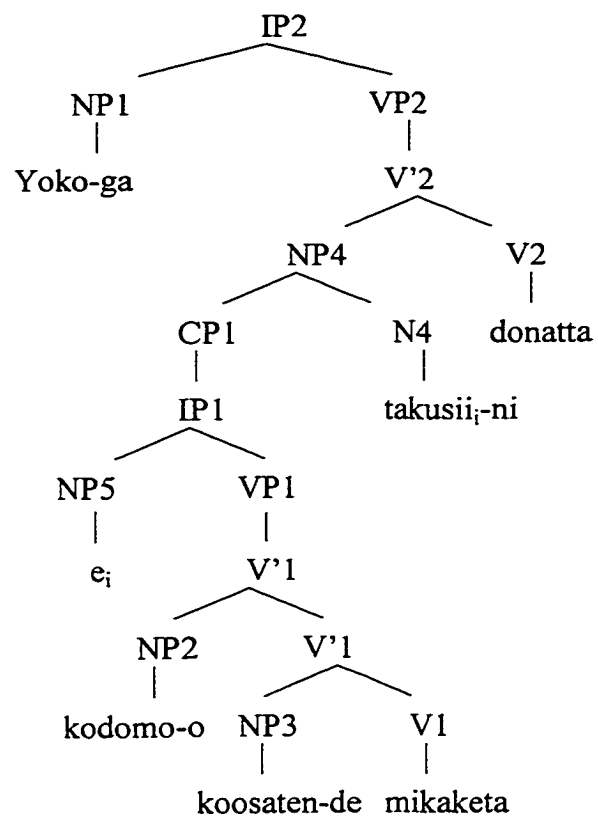
(35)



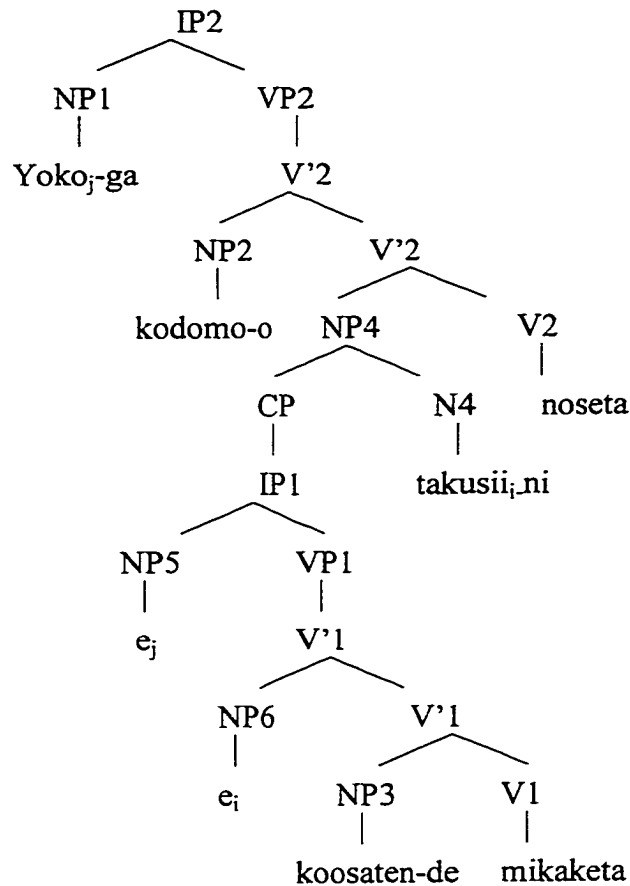
3.4.1.1 Minimal Expulsion (Inoue, 1991)

Inoue (1991) would predict a preference for SR over SOR relative at the ambiguous head noun by the Minimal Expulsion strategy, which requires expulsion of the least number of arguments so that the resulting complex NP is well-formed (p.138). Inoue's claim is that this follows from the parser's general preference for minimal revision: the parser avoids unnecessary effort by not re-processing any part of a sentence unless necessary. SR revision is predicted to be preferred over SOR revision because SR requires fewer items to be expelled than SOR. In SR, only the subject NP is expelled (see (36)) whereas in SOR the subject NP and the object NP are both expelled (see (37)).

(36)



(37)



After later input reveals that SOR is in fact the correct structure, the object would then be expelled and the coindexing of the gaps would be revised.

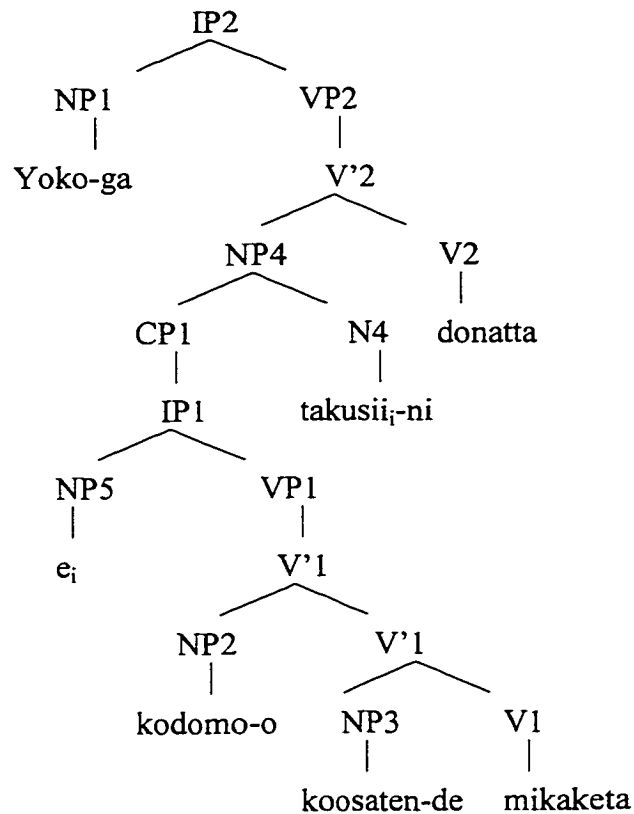
Minimal Expulsion predicts a preference only when there are two or more analyses to choose from. It makes no prediction about how much more effort is involved in computing the SOR analysis than the SR analysis when there is no ambiguity. The difference might be negligible or substantial.

3.4.1.2 Minimal Revisions (Frazier & Clifton, 1998)

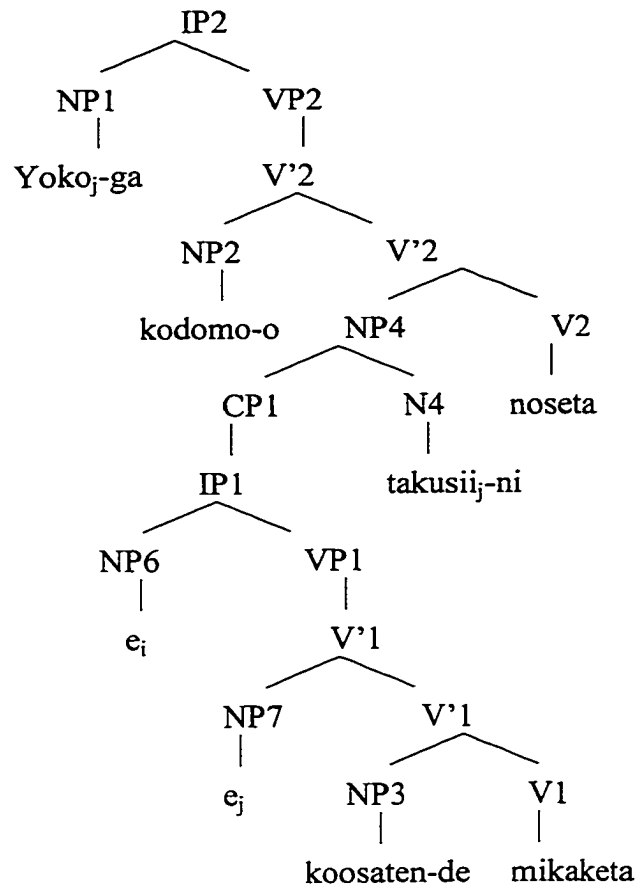
Frazier & Clifton (1998) argue that an SR preference follows from a principle which they call “Minimal Revisions” (originally in Frazier, 1991).

Minimal Revisions: Don't make an unnecessary revision. When revision is necessary, make the minimal revision consistent with the error signal, maintaining as much of the already assigned structure and interpretation possible. (p. 155)

(38)



(39)



According to this principle, revision to the SR structure is preferred because it is more minimal than revision to the SOR structure in terms of both the number of new nodes that are added and the number of lexical phrases that are reanalyzed. In the SR revision, one new node for the subject gap of the relative clause is added and the original subject NP “Yoko-ga” is raised, as shown in (38). In the SOR revision, two new nodes for the empty subject and the object gap of the relative clause have to be added and both the subject NP “Yoko-ga” and the object NP “kodomo-o” have to be raised, as illustrated in (39). Hence SR is predicted to be preferred over SOR.

Frazier & Clifton appear to assume also that the number of new nodes to be added and lexical phrases to be reanalyzed not only decides between the two possible reanalyses but also determines the difficulty of the reanalysis process independently of any competing reanalysis. If this is the case, the Minimal Revisions Principle is compatible with the possibility that structure building alone makes parsing more difficult for an SOR than for an SR. Nevertheless, the size of the difference is possibly negligible so that no clear prediction is made on this point.

At the matrix verb, revision to the SOR structure from the preferred SR structure would be predicted to be about as easy as SR revision at the head noun. In (33) the matrix verb “noseta” requires the SOR analysis and hence re-revision from the SR reanalysis adopted at the head noun, to SOR. For this re-revision only one new node would need to be added for the object gap and only the object NP would need to be raised because the subject NP is already in the higher clause. Therefore the number of items affected in this revision would be the same as that for the SR revision at the head noun, except for the empty category in the subject position inside of the relative clause would need to be re-indexed.

3.4.1.3 Cue-based repair models

The class of theories which may be referred to as *cue-based* models proposes that the cost of repair is not determined by the amount of work that is done or by the manner in which the incorrect structure is deformed. No inherent cost for different kinds of

revision operation is assumed. Rather, the cost is determined by how difficult it is for the parser to spot the right revision. We discuss Lewis (1993) and Fodor & Inoue (1994, 1998). These two models have much in common, e.g., when the parser encounters input which is not compatible with the CPPM, it attaches that input to the CPPM although the resulting structure is not well-formed. The structure then has to be revised and the ease or difficulty of repair depends on whether the needed repair can be successfully recognized by the parser. With respect to this, Lewis (1993) is concerned with whether the necessary revision is within the some locality domain as the same node whose temporary inconsistency indicates that revision has to performed. Fodor & Inoue (1994) argue that the success of revision depends on whether the conflicting input allows the parser to easily deduce what revision will be needed to eliminate the conflict.

3.4.1.3.1 Locality constraint on the Snip operator (Lewis, 1993)

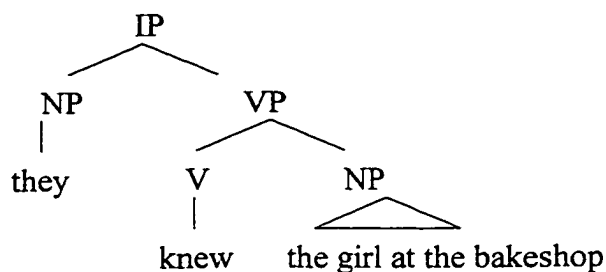
Lewis (1993) argues for *limited repair parsing*, in which parsing consists of “Link” and “Snip” operations. In the initial parse, he assumes a head-driven parser which establishes structural relation between nodes. This node-creation process is called the Link operation. When an input word is not compatible with the structure initially built, the Link operator attempts to attach it to the CPPM even though it temporarily creates an illegitimate syntactic structure. To resolve such grammatical inconsistency in the parse tree, Lewis proposes an on-line repair operation called Snip that detaches from the tree

the existing node which is inconsistent with the newly linked input. To examine this process, let us consider the nonproblematic repair in (16), repeated here.

(16) They knew the girl at the bakeshop ...

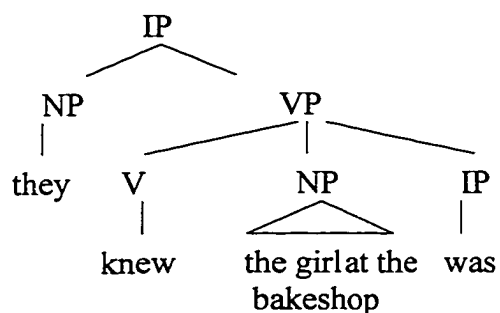
The material up to “the girl at the bakeshop” is attached within an IP by the Link operator to make a well-formed clause as shown in (40).

(40)



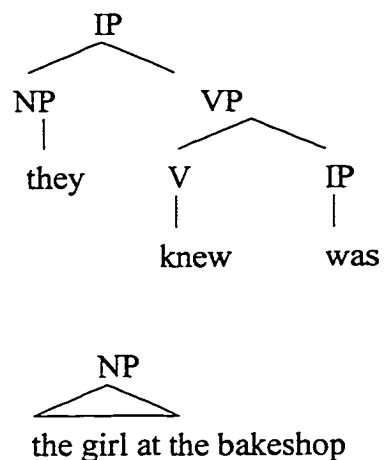
When “was” is encountered, it will be linked to a new IP node which is linked to the existing VP node, although this does not result in a well-formed tree ((41)).

(41)



The local grammatical inconsistency is detected within the VP, and thus a repair by Snip is proposed. The Snip operator attempts to dissolve the local inconsistency by breaking the link between the VP headed by the verb “knew” and [_{NP} the girl] ((42)).

(42)

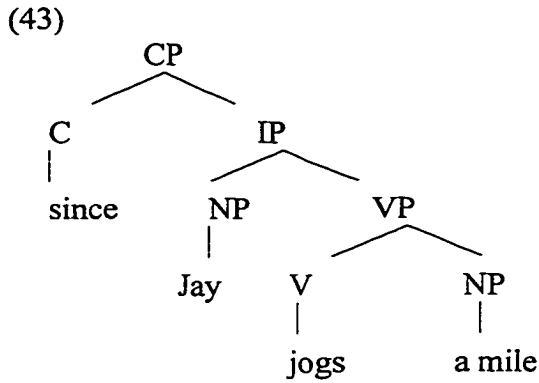


The parser then re-attaches “the girl” to the subject position of the embedded IP, again by the Link operation. This is a nonproblematic repair and no severe difficulty is predicted.

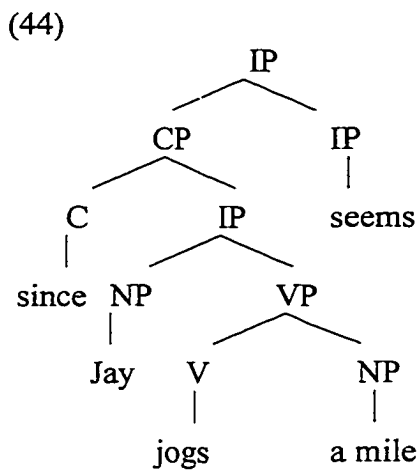
To avoid the computational explosion of unlimited potential repairs, the Snip operator is subject to a constraint: it can be initiated only locally, i.e., within the minimal maximal projection containing the inconsistency. In (16), the Snip operator is successfully generated for “the girl” because it is within the VP, local to the detected grammatical inconsistency.

Example (25), repeated below, illustrates a case for which repair is not successful.

(25) Since Jay always jogs a mile seems like a short distance for him.

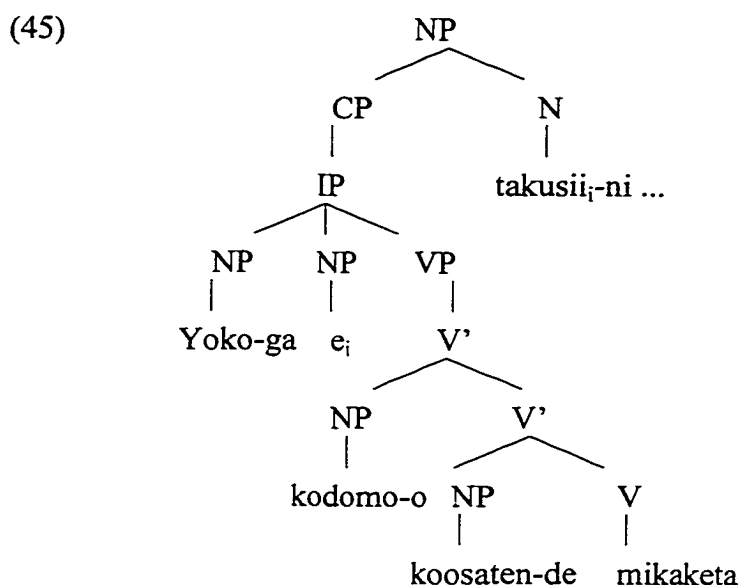


As (43) shows, “a mile” is initially linked to the direct object position of the VP headed by “jogs.” When “seems” is encountered, the structure in (44) is created. There is a grammatical inconsistency because “seems” is missing its obligatory subject. The correct repair operation would be to dissociate “a mile” from the current position and re-link it to the subject position for the new IP. However, the Snip operation cannot be initiated because the position at which the grammatical inconsistency is detected is not local to the position at which Snip would have to be applied.



Does this predict a contrast in preference between SR and SOR in Japanese?

Lewis claims that his model predicts that SR can be processed without difficulty. Parsing presumably proceeds as follows. When “takusii” is encountered in (34) after the creation of the single clause analysis, a relative clause analysis is required, so the parser creates a higher NP node and attaches “takusii” to the appropriate head noun position ((45)).

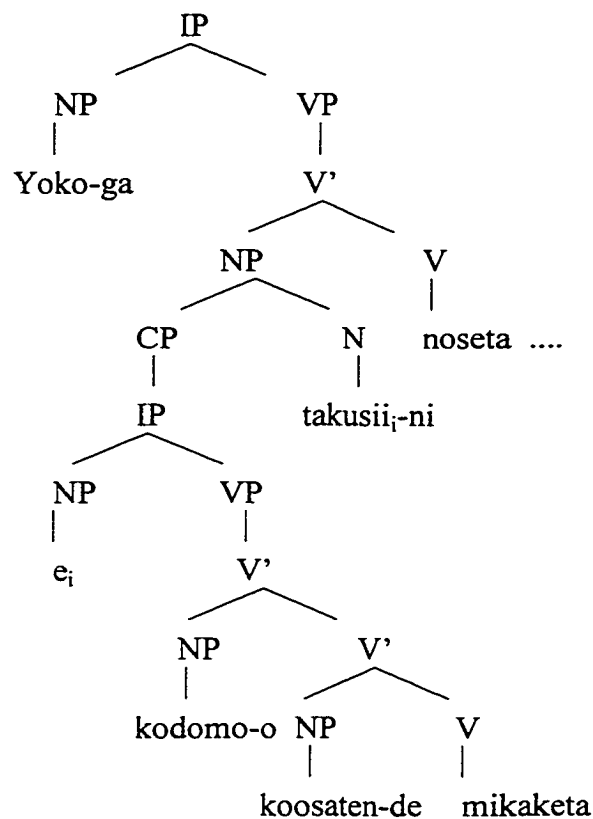


A grammatical inconsistency arises within the embedded IP: an overt NP “Yoko-ga” and the relative clause gap are competing for the subject position. The Snip operator can be applied to “Yoko-ga”, because it is local to the detected inconsistency (within the IP). “Yoko-ga” will then be re-linked to the subject position of the higher IP which will be projected once the matrix verb “donatta” (yelled at) is processed.

Let us now consider how an SOR structure can be computed. Parsing presumably proceeds as follows. The relative clause gap should be in the object position of the relative clause, but when “takusii” is attached to the head noun position there is no way to

know whether the gap should be coindexed with the subject or the object in the relative clause. We can suppose that the gap is first assumed to be in the subject position so an SR relative clause is constructed first. This triggers snipping of “Yoko-ga” which is left stranded until the higher clause is built. When the matrix verb “noseta” is encountered, the head-driven parser builds the matrix structure (46).

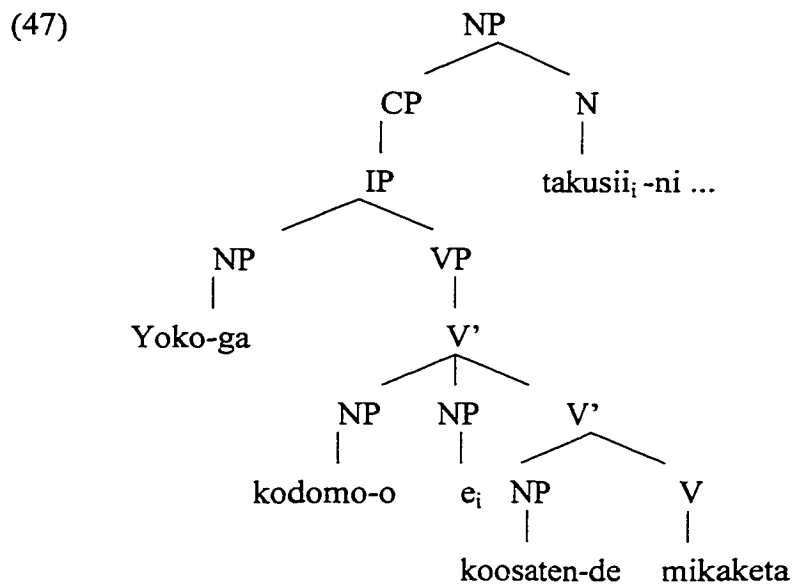
(46)



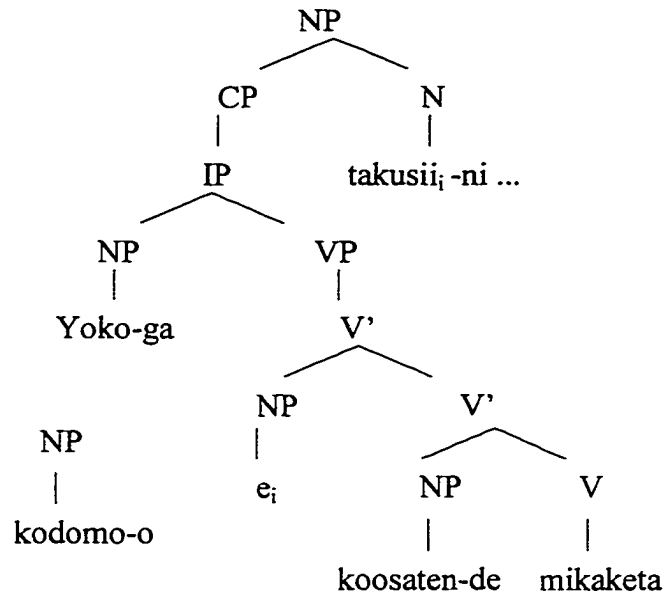
A grammatical inconsistency local to the matrix IP arises at this point because “noseta” is missing its direct object. In order to compute the correct target SOR analysis, “kodomo-o” would have to be snipped and re-linked to the object position of the higher IP.

However, since “kodomo-o” in its current position is not local to the detected grammatical inconsistency, repair is not successfully triggered and processing fails.

Alternatively, Lewis’s discussion is not clear about how the choice between SR and SOR is made in case of ambiguity, so we might assume that under some circumstance (see later discussion on unambiguous SOR sentences) when the head noun is encountered, the parser decides immediately that it should link the gap to the object position of the relative clause, rather than to the subject position (see (47)).



(48)



The grammatical inconsistency in this case is indeed local to “kodomo-o”, so “kodomo-o” can be snipped, as is necessary, as in (48). However, there is nowhere else for “kodomo-o” to re-link to. For the correct SOR structure, “Yoko-ga” would also have to be snipped, so that later it and “kodomo-o” can re-link to the tree in the matrix clause. But it appears as if no local grammatical inconsistency is present to trigger snipping of “Yoko-ga” at this point.

Lewis has suggested (personal communication) that there *is* a grammatical inconsistency in the relative clause in (48) that could generate a snip operator to detach the subject “Yoko-ga”. Once the object “kodomo-o” has been snipped, and is unable to re-link legitimately to the CPPM, the two constituents forming the relative clause IP violate a general constraint requiring that elements can be adjacent in the tree if and only if they are adjacent in the input word string. After snipping of “kodomo-o”, the subject

and the I' predicate of the relative clause are now adjacent in the tree structure though not in the word string. So one of them must be snipped. Since the I' heads the IP, it is the subject that must be snipped. Then both “Yoko-ga” and “kodomo-o” can be re-linked in the matrix clause. Thus the SOR structure can be achieved.

3.4.1.3.2 Diagnosis Model (Fodor & Inoue, 1994, 1998)

Fodor & Inoue (1994) assume a full-attachment incremental parser, which attaches the input to the CPPM without delay. This is formulated as *Attach* in Fodor & Inoue (1998).

Attach: On receiving a word of the input sentence, connect it to the current partial phrase marker (CPPM) for the sentence in such a way that the resulting CPPM is syntactically well-formed though possibly incomplete at its right edge. (Fodor & Inoue, 1998, p. 103)

When the parser encounters input material for which no appropriate attachment site is available in the CPPM, the parser makes the least unacceptable attachment it can find and then tries to adjust earlier parts of the tree to fit, as dictated by the grammar. This is the *Attach Anyway* principle of Fodor & Inoue (1998).

Attach Anyway: Having established that there is no legitimate attachment site in the CPPM for the current input word, attach the input word into the CPPM wherever it least severely violates the grammar, and subject to the usual preference principles that govern *Attach*. (Fodor & Inoue, 1998, p. 105)

Attach Anyway causes temporary ill-formedness within the CPPM. This has to be resolved by *Adjust* right away.

Adjust: When a grammatical conflict has been created between two nodes or features X and Y in the CPPM, by either *Attach Anyway* or *Adjust*, eliminate the problem by altering minimally (i.e., no more than is necessary for conflict resolution) whichever of X and Y was less recently acted on, without regard for grammatical conflicts thereby created between that node and other elements in the CPPM (Fodor & Inoue, 1998, p. 106)

There may be a claim of adjustments to be made, leading from the perceived conflict back to the original error. The parser resolves each in turn. Revision is difficult in case the parser cannot easily deduce at each step what the nature of the conflict is and how to cure it.

(16) They knew the girl at the bakeshop was hungry .

(49) Susan put the book that she had been reading all afternoon in the library .

(16) is an example of an easy revision. A diagnosis model explains this is because the right revision is easy to deduce. The symptom here is *overt* . The word “was” must be attached into the CPPM. It cannot do so grammatically. But the parser can attach it as a VP associated with the NP “the girl at the bakeshop”, though at the cost of incorrect case for that NP, and a violation of the selection feature presently assumed for “knew”. However, both these problems are clearly recognizable and can be put right, so “knew” takes a complement clause, and “girl” is nominative, and the CPPM is correct.

(49) is an example of a difficult revision. In (49), "in the library " is initially misanalyzed as a constituent of the lower clause (as predicted by Late Closure). The repair requires removing "in the library " from the lower clause and re-attaching it as an argument in the higher clause. However, the initial analysis is revealed to be ill-formed only when the parser realizes that the sentence ends without any locative phrase to satisfy the lexical need of "put". There is no lexical item that is attached into the tree to create a conflict which will set *Adjust* to work. Thus, a *null* symptom as in this example does not help the parser work back to the source of the error.

Even when a repair is signaled by an overt symptom, it can still be difficult. Fodor & Inoue (1998) note that *Adjust* entails that repairs are constrained by the *Grammatical Dependency Principle (GDP)* formulated below.

Grammatical Dependency Principle (GDP): When a grammar violation has been created in the CPPM by an action on node *n* in accord with *Attach Anyway* or *Adjust*, attempt to eliminate the problem by acting on a node that is grammatically incompatible with *n*. (Fodor & Inoue, 1998, p. 109).

In (25), "seems" is an overt symptom requiring a subject, but reanalysis is not easy.

(25) Since Jay always jogs a mile seems like a short distance for him.

This is explained by the GDP. There is no grammatical dependency that links the matrix subject position where the grammatical problem is, to the object position in the embedded clause where the repair has to be performed. Hence, if revision occurs here it will lack

guidance by the GDP and will be more difficult. (Fodor & Inoue suggest that a superficial and not very accurate kind of stealing of “a mile” may occur instead.)

According to the Diagnosis Model, (34) should be a nonproblematic repair. When the head noun "takusii" is encountered, it is attached to the clause that has been built. This is unacceptable because (unless a gapless relative were possible) there must be an associated gap in the relative clause. So the adjustment system inserts a gap. Assuming it favors a subject gap, it must remove “Yoko-ga” from the subject position, and then re-attach it to the matrix clause. The relationships involved are all grammatical relationships in accord with the GDP. The adjustment system can see at each step what needs to be done next.

In order for (33) to be correctly processed, the parser must be able to detect what the necessary repair is, i.e., to detach "Yoko-ga" and "kodomo-o" from the relative clause and reattach them to the subject and the object position, respectively in the higher clause. Consider first what happens if the gap is initially postulated in the subject position. An SR structure is created at the head noun, just as in (34). Later, the SR must be reanalyzed as an SOR. The symptom for this would be the ditransitive matrix verb, which requires an object. This is an overt symptom which is supposed to be a helpful cue. However, a verb has grammatical dependency links to its own arguments, but not to those in another clause. So the matrix verb cannot reach down and steal the object from the relative clause. This is similar to the case of (25). The repair (stealing) is difficult, because it is not guided by the GDP.

Suppose, instead, that the parser postulated the gap in the object position in the first place, i.e., on encountering the head noun. The gap will displace “kodomo-o”, which then needs to be reattached to the CPPM. But there is a problem in this process of adjustment. The reattachment of “kodomo-o” is blocked because “Yoko-ga” occupies the subject position of the relative clause; “kodomo-o” cannot reattach into the relative clause, and “Yoko-ga” prevents it from attaching into the matrix clause, as it ought to. This repair can proceed no further, unless perhaps it is facilitated by the matrix verb. However, the matrix verb’s need for a subject and an object should be no more effective than the need of “seems” in (25). So it appears that SOR must be difficult in the Diagnosis Model.

Summary for cue-based models: The models proposed by Lewis (1993) and Fodor & Inoue (1994, 1998) have much in common. Both predict that SR is a non-problematic reanalysis. The difficulty of SOR depends on (i) whether the relative clause gap is initially linked to the subject position or the object position, since the former would entail revising SR to SOR, rather than a single clause to SOR, and (ii) whether there is any legitimate cue to trigger revising of NP-ga.

3.4.1.4 On-Line Locality Constraint (OLLC): (Pritchett, 1992)

As part of the head-driven parsing model proposed in Pritchett (1991), Pritchett (1992) formulates a condition on (automatic, non-conscious, “normal”) reanalysis called

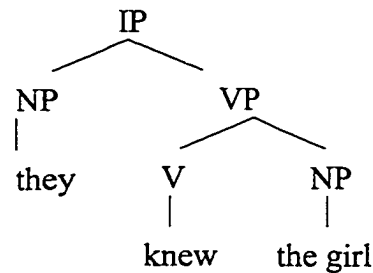
the On-Line Locality Constraint, which distinguishes difficulties of garden paths in terms of government and domination relations.

On-Line Locality Constraint (OLLC): Upon reanalysis, the target position (if any) assumed by a constituent must be governed or dominated by its source position.

Consider (16) repeated here. The head-driven parser constructs a single clause analysis in which “the girl” is the direct object of the verb, as in (50).

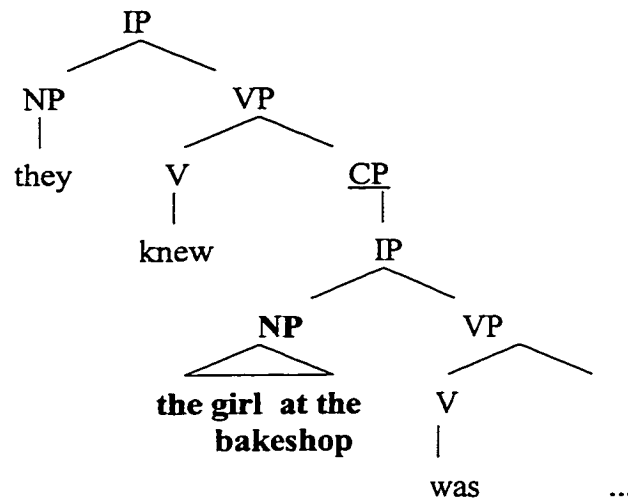
(16) They knew the girl at the bakeshop...

(50)



When “was” is encountered, the original structure must be reanalyzed so that the verb takes a sentential complement within which “the girl” is the subject. The initial analysis made at the verb position must be altered, but OLLC predicts that this does not cause difficulty: the target position (marked in bold) is dominated by its source position (underlined) which is now replaced by the CP, as in (51).

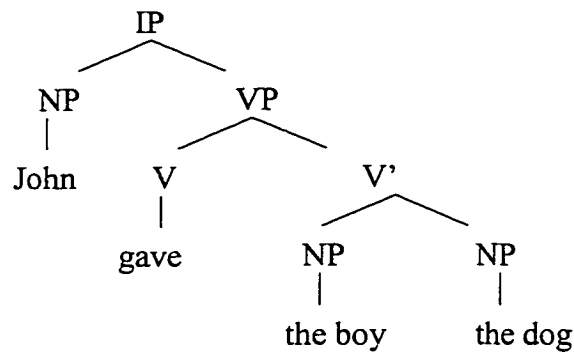
(51)



This contrasts with a severe garden path such as in (19), repeated below.

(19) John gave the boy the dog bit a dollar.

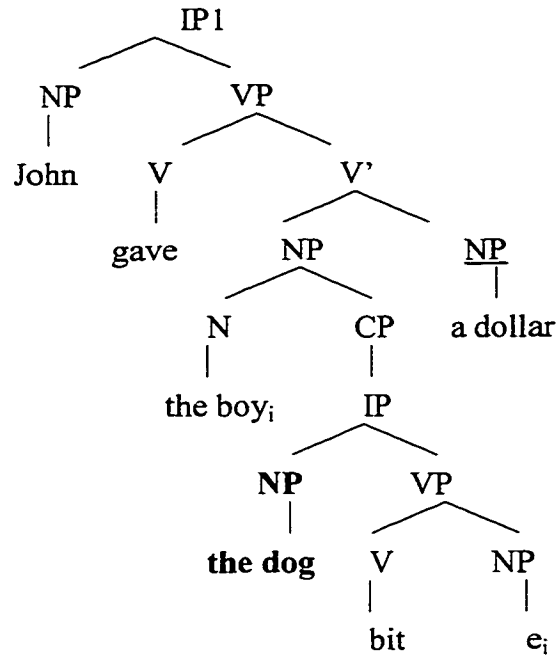
(52)



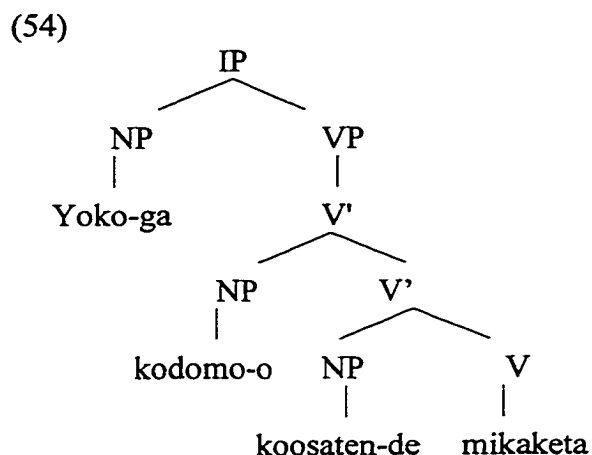
Assuming “the dog” is initially analyzed as a direct object of “gave”, as in (52), OLLC is violated in the target structure (53) below: the target position of “the dog” (bold) is not

governed (because of the intervening CP barrier) or dominated by its source position (underlined).

(53)



Let us now examine what OLLC predicts about the Japanese argument relative clauses under discussion. The head-driven parser would construct a single clause analysis once the first verb is encountered, as in (54), which can take all the preceding NPs as its arguments.



Pritchett views reanalysis as a combination of *detachment* and *reattachment*, which are separate operations. An SR structure can be processed by first detaching “Yoko-ga” from the original clause. Note that there is no target position for “Yoko-ga” to be reattached to, because the higher IP is not postulated by this head-driven parser until the final matrix verb is encountered. As a result, “Yoko-ga” is left unattached. So far, no violation of OLLC occurs because there is no target position. When the final matrix verb is processed, “Yoko-ga” is reattached to its subject position. Building on a suggestion by Pritchett (1992), one might suppose that this reattachment operation does not cause an OLLC violation because at this point “Yoko-ga” does not have a source position in the current parse tree. The reanalysis operations needed for SR are therefore unproblematic.

The difficulty of SOR depends on whether the parser initially detaches both the subject and object (“Yoko-ga” and “kodomo-o”) when the head noun is encountered. Detachment of two items *per se* does not make the process any more difficult than detachment of only one item because no OLLC violation occurs. Reattachment of “Yoko-ga” to the matrix subject position and “kodomo-o” to the matrix object position

will not cause any problem either, for the same reason as the SR case above. SOR will be a problem if only “Yoko-ga” is detached on the first attempt at reanalysis, leaving the object “kodomo-o” in the original position. When the ditransitive matrix verb is encountered, “kodomo-o” is forced to be detached from the original clause. Since the higher matrix IP is already postulated at this point, “kodomo-o” must reattach to the matrix object position right away. This is a bad move because the target position exists but is not governed by the original position, and thus results in an OLLC violation.

As long as SR is the initially preferred reanalysis and thus first pursued at the head noun, OLLC has to predict that SOR will not be processed without causing conscious difficulty. SOR can be processed without any problem as long as both the subject and object are correctly removed from the original clause at the head noun position. But it is not clear how this could reliably occur if the head noun is fully ambiguous between subject and object roles in the relative clause.

3.4.2 Ranked parallel model (Gibson, 1991)

As we have already seen in section 3.2.2.1, Gibson (1991) predicts that a heavier processing load is associated with an SOR compared to an SR. In fact this model predicts that the SOR relative is never successfully computed by the normal parsing routines regardless of whether there is an SR/SOR ambiguity, as long as the single clause analysis was an option at the point the first verb is encountered. At the verb, crucially, the PLUs associated with the single clause analysis are discharged while there are $2x_{int}$ PLUs

remaining associated with the SOR. This makes the SOR so much worse than the best competitor that it must be pruned. Therefore, the SOR structure would not be obtained (except by conscious problem solving, not as part of normal processing) even when the head noun disallows an SR relative and/or even when the matrix verb unambiguously requires an SOR relative.

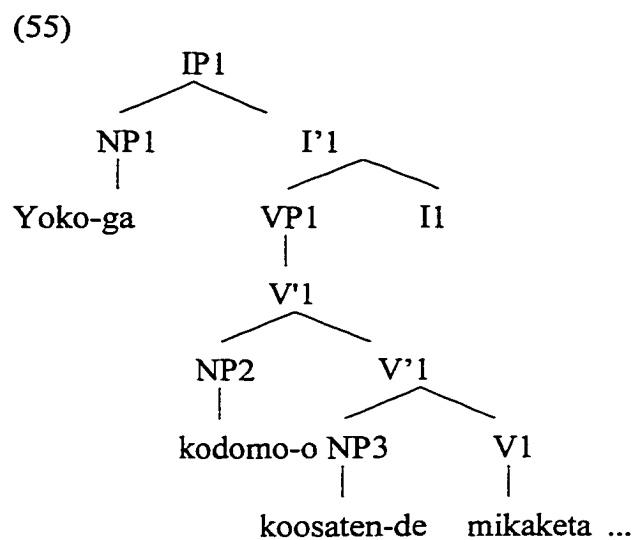
Notice that this prediction is based on the assumption that an analysis is pruned when it is costlier than its best competitor by two PLUs. By changing this assumption about the size of the allowable PLU difference, this model could be made to incorporate the SOR structure as a computable analysis. For example, if a three or four PLU difference were allowed, then the SOR analysis could be maintained at a head noun that allows the SOR interpretation, and would thus be available at a matrix verb that disambiguates for SOR. These unambiguous SOR relatives would be predicted to be as easy as the SR relative. The SR preference over SOR at a head noun which does not disambiguate between SR and SOR (e.g., “takusii”) would still be predicted by the difference in ranking between the two analyses: SR is ranked higher than SOR because it carries fewer PLUs. However, though a larger allowable PLU difference would accommodate these examples, to alter this parameter of the model would have extensive consequences for preferences and garden path severity, and it would not be compatible with parsing preferences in English. It might nevertheless be appropriate for Japanese, if the criterion for pruning can vary across languages, but it is not known at present whether such a difference is reflected in other constructions in Japanese.

3.4.3 Structural Determinism

In D-theoretic parsing models, trees are described in terms of dominance and precedence relations, and such descriptors can only be added but never be deleted. The relative clause revision process, to the extent that it is possible for the human sentence processing mechanism, must therefore be an addition of such relations to the set of previous descriptions.

3.4.3.1 Structural Determinism (Gorrell, 1995a)

As we have seen in an earlier section (3.2.4), Gorrell's model predicts a severe processing difficulty for an SOR, regardless of whether the previous stage of the parse was one that corresponds to a single clause analysis or to an SR structure. This is because it is specifically assumed that lowering can be applied only above the original VP (because of the assumption that the verb moves to an INFL position). The single clause analysis is shown in (55).

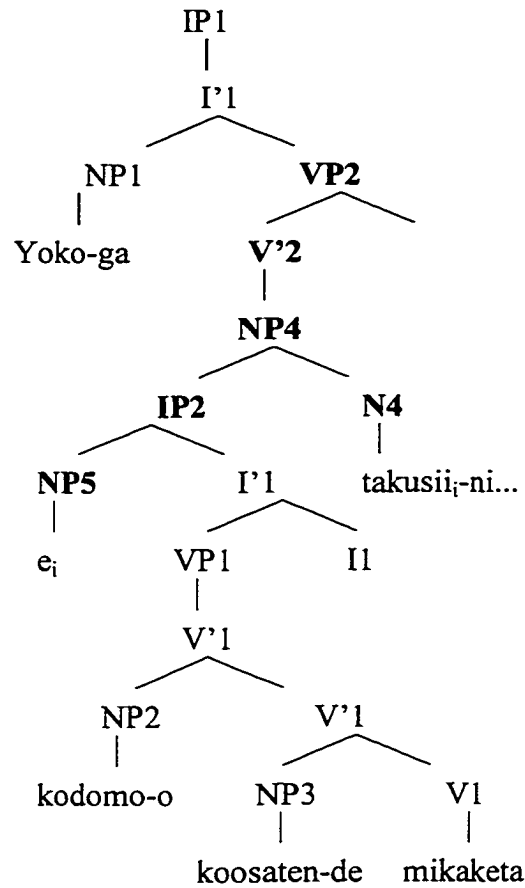


dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- d (VP1 NP2)
- d (VP1 NP3)
- d (VP1 V1)

As we have seen in 3.2.4. for similar examples, computation of the SR relative is achieved by adding new structural relations to this single clause structure without upsetting any of the existing dominance and precedence relations, as in (56).

(56)



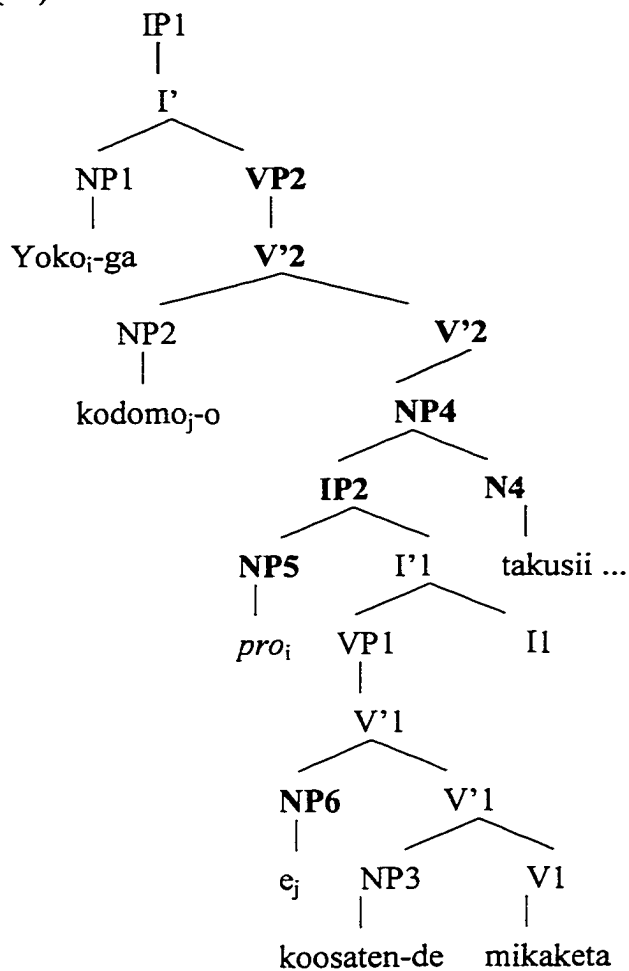
dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- d (VP1 NP2)
- d (VP1 NP3)
- d (VP1 V1)
- d (IP1 VP2)**
- d (VP2 NP4)**
- d (NP4 IP2)**
- d (NP4 N4)**
- d (IP2 NP5)**
- d (IP2 VP1)**

By contrast, the SOR structure is predicted to be unprocessable because there is no way of establishing the structural relations for it without deleting the dominance

relation between the object “kodomo-o” (shown as NP2) and the VP headed by “mikaketa” (shown as VP1) that was established during the first pass analysis (shown in (57)).

(57)



dominate (d)

- d (IP1 NP1)
- d (IP1 VP1)
- ~d (VP1 NP2)
- d (VP1 NP3)
- d (VP1 V1)
- d (IP1 VP2)
- d (VP2 NP4)

d (NP4 IP2)
d (NP4 N4)
d (IP2 NP5)
d (IP2 VP1)
d (VP1 NP6)

The SOR analysis would therefore be beyond the capacity of this parser regardless of whether there is an SR/SOR ambiguity. Even if the parser selects SOR instead of SR at the head noun, the structure is simply illegitimate once the single-clause analysis has been built. It could be created only if the first verb disambiguates, as in (17b) from Hirose (1995).

3.4.3.2 Top-down search strategy (Sturt & Crocker, 1996)

As we saw earlier in 3.2.4, Sturt & Crocker assume a tree-lowering mechanism for garden path revision, which, in the case of Japanese relative clause reanalysis, can be described as pushing the right side of the original clause down to create a relative clause. They account for the preference for SR structures by referring to the point of reanalysis, that is, the point at which the tree-lowering applies. The SR structure is obtained when the parser applies lowering at the VP or V' node which dominates both "kodomo-o" and the verb "mikaketa", while the SOR structure is obtained by lowering the intermediate (or lower) V' node which dominates "koosaten-de" (intersection-Loc) and the verb "mikaketa".

Sturt & Crocker propose a top-down search strategy for Japanese (as opposed to a bottom-up search strategy in English parsing). At the head noun in sentences such as (34)

and (33), where reanalysis to a relative clause is initiated, the parser searches downward for a node at which to apply lowering. In this case lowering the IP is not an option because an adjunct (temporal, locative, or reason, etc.) interpretation is not possible. The V' node (dominating both the object NP “kodomo-o” and the verb “mikaketa”) is selected first since it is in a higher position than the V node, and an SR structure such as (34) results. The SOR structure, which will turn out to be correct for (33), is obtained if lowering is applied at the V node, but this is tried only if lowering at the higher node has failed.

Thus this model implies that the SOR structure involves some additional process, over and above that for the SR relative. However, since Structural Determinism is not violated in modifying the tree to get an SOR structure, no severe difficulty should result. Whether any measurable cost can be expected in experimental tasks is unclear. Relevant to this, Sturt & Crocker specifically point out that when an SOR structure is the only plausible structure for a given verb and a head noun, it can be processed easily. This point will be extensively discussed in Chapter 4.

3.5 Conclusion

Most of the models reviewed here appear to be compatible with Mazuka & Itoh's observation that SR relatives are easier than SOR relatives when the disambiguator is the matrix verb.

All of the models we have considered predict that SOR is more troublesome than SR, and we focus on differences among the models concerning the status of the SOR analysis. In some models (Gibson, 1991; Lewis, 1993; Fodor & Inoue, 1994, 1998; Gorrell, 1995a, 1995b) the nature of the SR/SOR contrast is one between processable structures and structures that are unprocessable by the normal routines though they may be attainable by other means at some extra cost; SOR is predicted to be a severely difficult structure. The difficulty does not diminish even when it is the only possible analysis at the point at which the need for relative clause structure is first signaled by the head noun. For other models (Inoue, 1991; possibly Frazier & Clifton, 1998; Sturt & Crocker, 1996), SOR is difficult at the sentence-final disambiguation only (or primarily) because it is not selected when the SR/SOR ambiguity first arises, and hence must be created by reanalysis operations when the need for SOR becomes apparent later. The preference for SR derives from some structure-based processing principle or strategy. Such a principle may be a least-effort principle which favors SR *because* it is associated with a lower processing cost. But it is not required that any such cost difference should be as great as the cost difference observed at the subsequent disambiguation point. The difference at the disambiguation point is magnified by the garden path effect. We will call such accounts of SR/SOR structures *garden-path accounts* while the former type which attribute severe difficulty to the SOR analysis will be called *parse-failure accounts*.

In order to evaluate the above two groups of theories, we need to ask a further empirical question: whether an SOR structure is difficult even if some non-syntactic

information signals the correct analysis at the point of temporary structural ambiguity between SR and SOR. The parse-failure accounts predict that this additional non-syntactic information will not change the status of SOR, because the severe difficulty is inevitable in computing the syntactic structure for an SOR sentence. By contrast, the garden-path accounts allow for the existence of easily processable SOR sentences, when some information source can be used to bias the parser toward the SOR structure before the SR structure is adopted instead.

In the remaining chapters, we will focus on the roles of two types of bias which may be available when syntactic cues do not resolve an SR/SOR temporary ambiguity. We will discuss the influence of semantic/thematic compatibility in Chapter 4, and prosodic biases in silent reading in Chapters 5 and 6.

CHAPTER 4

THE ROLE OF THEMATIC INFORMATION

4.1 Introduction

In the previous chapter, we discussed the processing difficulty observed by Mazuka & Itoh (1995) in SOR sentences such as (33) in Chapter 3, repeated here as (1).

- (1) Yoko_i-ga kodomo-o [e_i e_j koosaten-de mikaketa] takusii-j-ni noseta.
 Yoko-Nom child-Acc intersection-Loc saw taxi-Dat put on
 "Yoko put the child into the taxi she saw at the intersection."

As noted in Chapter 3, some researchers believe that the processing difficulty is attributable to the structural change that must be made to the initial single clause analysis or to the memory cost associated with processing an SOR structure. Strictly, accounts of this kind predict that as long as the same type of structural change or same demand on memory is involved in the reanalysis process, the difficulty would not diminish regardless of how other aspects of the sentence are manipulated. Alternatively, the processing difference could be entirely due to factors other than the structural change. If so, the difficulty associated with an SOR could be made to completely disappear by manipulating the relevant factor(s). Finally, if instead the processing difficulty is due to

multiple factors, including the cost of the structural change among other costs, the difficulty could be lessened by removing the other factor(s) from the sentence, though some difficulty should still be observable compared with a suitable baseline.

Note that the temporary SR/SOR ambiguity arising at the head noun can be suppressed by changing its lexical content, so that it is not suited to the subject role in the relative clause, as shown in (2) (see (33) in Chapter 3). Native speakers report that an SOR sentence such as (2) is notably easier than (1). (Note that not all native speakers agree that (1) causes real difficulty. However, even those speakers who do not experience severe processing difficulty for (1) do report that (2) is easier than (1).) The facilitating effect of a plausibility mismatch between the head noun and the subject role of the embedded verb is also discussed in Sturt & Crocker (1996).¹

- (2) Yoko_i-ga kodomo-o [e_i e_j hiroba-de mikaketa] buranko_j-ni noseta.
 Yoko-Nom child-Acc square-Loc saw swing-Dat put on
 "Yoko put the child onto the swing she saw at the square."

In (2), the head noun "takusii" (taxi) is replaced with "buranko" (swing) and to maintain plausibility, "intersection" is replaced with "square". The reason (2) is easier

¹ Sturt & Crocker (1996) refer to the example below, from Mazuka & Itoh (1995).

- (i) Hirosi-ga aidoru kashu-o kakusita kamera-de totta .
 -Nom pop singer-Acc hid camera-Inst photographed
 "Hirosi photographed the pop singer with the camera he was hiding."

Mazuka & Itoh maintained that the above sentence is easy even though both the subject and the object NPs must end up in the higher clause because it is disambiguated at the first verb by the supposed implausibility of hiding a popular singer. Thus, we would not consider this sentence as an example of what we define as "SOR" sentences, because our SOR classification entails an initial single-clause misanalysis. Sturt & Crocker, however, assume that "kakusita" (hid) is acceptable in the single clause analysis, and that the sentence is first disambiguated by the oddness produced by the SR analysis (i.e., 'the camera that hid the pop singer'), which is exactly the case being discussed here.

than (1) seems to be related to the meaning of the head noun. As Mazuka & Itoh noted, at the point of the parse at which “taxi” in (1) is received, and recognized as a head noun, it can be interpreted not only as an object of the verb “see” but also as a subject, metaphorically meaning “the driver of the taxi”. That is, “taxi” can be either AGENT (EXPERIENCER) of “see” and hence associated with a subject gap in the relative clause, or THEME of “see” and hence associated with an object gap. The first of these possibilities is illustrated by the fact that the sentence could continue as in (3) (= (34) in Chapter 3).

- (3) Yoko-ga [e_i kodomo-o koosaten-de mikaketa] takusii,-ni donatta.
 Yoko-Nom child-Acc intersection-Loc saw taxi-Dat yelled at
 "Yoko yelled at the taxi which/whose driver saw the child at the intersection."

Therefore, "taxi" as the head noun does not uniquely signal what grammatical role it should play in the relative clause. On the other hand, "swing" cannot be assigned the AGENT role of the verb “see” and thus cannot be the subject.

As discussed in Chapter 3, a difference in the position of the gap often correlates with a difference in the position of the left edge of the relative clause boundary, i.e., which items in the word string belong to the relative clause and which to the matrix clause. In particular, in the SR/SOR ambiguity, a gap in subject position entails that the overt subject phrase must be in the matrix clause, no longer a clause-mate of the overt object phrase. A gap in object position implies that both the overt subject and the overt object are matrix constituents. The left boundary of the relative clause follows the subject in SR, and follows the object in SOR. The construction can

thus be disambiguated in principle either via gap position or via clause boundary position. In the second half of this dissertation we discuss prosodic disambiguation of the clause boundary. Here, we focus on thematic disambiguation of the gap position. If the parser is sensitive to the thematic relation between the head noun and the embedded verb, it can decide at “swing” in (2) that both the subject and the object should be analyzed as being outside the relative clause (SOR). In (1), however, at the head noun “taxi”, the parser cannot decide between the two possible reanalyses, one which reanalyzes only the subject (SR) and the other which reanalyzes both the subject and the object (SOR).

Summing up, temporary structural ambiguity in reanalysis can be resolved at the head noun in (2) but not in (1), if the parser can make use of lexical information about a head noun, e.g., its animacy. This information can determine the plausibility of the noun’s fit to the thematic roles that the relative clause verb can assign. We call this “thematic *compatibility* information” (to be distinguished from thematic information in the sense of the set of thematic roles selected by a verb). For animate head nouns and a relative clause verb of the appropriate kind, there is more than one plausible thematic role the noun could be assigned. We refer to this situation as one involving thematic-role-ambiguity. On the other hand an inanimate noun cannot usually (if non-metaphoric) take an AGENT role, but only THEME or some adjunct type. In principle, there may be a number of adjunct roles which could be considered, but they are not equally likely. Sturt & Crocker (1996) consider only locative and temporal as possible adjunct roles that the parser naturally considers. Following Saito (1985), we may consider reason and manner as well. In addition, in some special cases where

there is an appropriate “aboutness” link between the relative clause and the head noun, a gapless relative clause could be an option. The “role-unambiguous” inanimate head noun in the above example does not allow any of the locative, temporal, reason, or manner readings, nor a natural gapless relative reading. The “role-ambiguous” animate head noun could in principle allow oblique readings such as ACCOMPANIMENT or BENEFACTIVE, but since they are very marked as discussed in Chapter 2, we do not consider them here. Here we instead focus on the thematic role ambiguity between the two argument roles, AGENT and THEME, which are the only two prominent alternatives at the head noun in a sentence like (1).

We assume there are default principles linking properties like animacy to probable thematic roles. In Japanese, this relationship is fairly constrained, perhaps more so than in English. An animate noun may be either AGENT or THEME; an inanimate noun is unlikely to be an AGENT so we assume its default is to be THEME. So an animate noun exhibits thematic role ambiguity while an inanimate noun does not normally do so. In this chapter we raise the question of whether thematic-role ambiguity could be the sole (or perhaps major) source of the difficulty noted by Mazuka & Itoh for SOR structures.

The purpose of the experiments reported in this chapter is to evaluate the hypothesis that thematic compatibility information influences the difficulty of processing SOR relative clause structures. We have raised the possibility that it is incorrect to assume that severe difficulty is inevitably associated with the processing of SOR sentences. We argue that it may not be difficult to compute the SOR structure when it is clear from the outset that SOR is required, i.e., when only SOR is

thematically acceptable at the head noun. This can account for the informally observed variability in the processing cost of SOR structures: greater difficulty would be attributable to thematic ambiguity. Note that if this hypothesis is correct, it implies that the cost of actually effecting the reanalysis may be negligible. If so, “parsing-failure” accounts which predict that SOR revision carries a high cost must be wrong, while the facts would still be consistent with the “garden-path” account, which does not entail significant difficulty associated with SOR as long as an initial misanalysis to SR does not occur (see section 3.5). In section 4.2 to follow, data from two experiments (Experiments 1 and 2) are presented which support our conjecture that SOR sentences can be easier to process when the information provided by the head noun uniquely specifies an SOR structure.

4.2 An effect of head noun thematic compatibility

This section presents two experimental studies that were designed to test the generality of the intuitive observation made about (1) and (2); i.e., that sentences like (2), in which the head noun is thematically compatible only with an SOR structure, can be understood more easily than sentences like (1), in which the head noun is thematically compatible with both SR and SOR structures.

4.2.1 Experiment 1

Experiment 1, utilizing a whole sentence reading time experiment, tests the intuition that an SOR sentence is easier or harder to read depending on the thematic roles that are possible for the head noun.

Method

Subjects. Forty-eight undergraduate students from Nagoya University in Japan participated successfully in the experiment, 16 in each of the three versions of the experiment. All were native speakers of Japanese, and naive with respect to the purpose of the experiment. Subjects typically took about 25 minutes to complete the experiment.

Materials and Design. Three types of sentence, as illustrated in (4a-c), were constructed to satisfy an experimental design involving two interlocked pairwise contrasts. There were 12 such triplets for a materials list totaling 36 sentences. The full list of experimental sentence pairs is given in Appendix 1.

(4)

a. Yamaoka_i-ga kakusiisan-o [e_i e_j anotekonotede sagasidasita]
 Yamaoka-Nom hidden fortune-Acc after great effort discovered

mogurino bengosi_j-ni yamunaku azuketa.
 unlicensed lawyer-Dat unwillingly entrusted

"Yamaoka unwillingly entrusted his hidden fortune to the unlicensed lawyer who he discovered after great effort."

b. Yamaoka_i-ga kakusiisan-o [e_i e_j anotekonotede sagasidasita]
 Yamaoka-Nom hidden fortune-Acc after great effort discovered

mogurino kasikinko_j-ni yamunaku azuketa.
 unlicensed safe-Dat unwillingly entrusted

"Yamaoka unwillingly entrusted his hidden fortune to the unlicensed safe that he discovered after great effort."

- c. Yamaoka-ga [e;
Yamaoka-Nom kakusiisan-o
hidden fortune-Acc anotekonotede
after great effort sagasidasita]
discovered
- mogurino bengosi_i-ni yamunaku ayamatta.
unlicensed lawyer-Dat unwillingly apologized

"Yamaoka unwillingly apologized to the unlicensed lawyer who discovered his hidden fortune after great effort."

The main comparison that is of interest here is that between the first two sentence types, illustrated by (4a,b), both having an SOR relative clause. They differed in the content of the head noun which was animate in the (4a) type but inanimate in the (4b) type. Sentence (4a) is temporarily ambiguous with respect to relative clause reanalysis when the head noun "bengosi" (lawyer) is first encountered:² the animate head noun creates an AGENT / THEME ambiguity with respect to the relative clause verb (or an EXPERIENCER / THEME ambiguity where the relative clause used a "psych verb").³

⁴ This sentence is disambiguated by the final ditransitive matrix verb "azuketa" (entrusted) as an SOR sentence, in which both the first NP "Yamaoka-ga" (Yamaoka-Nom) and the second NP "kakusiisan-o" (hidden fortune-Acc) must be matrix clause

² The example presented here is the only one among 12 triplets in which the head noun was preceded by an adjective modifying that head noun.

³ Here, "psych verb" refers to a type of verb e.g., "fear", which describes the psychological state of a person and is subcategorized for [EXPERIENCER, THEME] where EXPERIENCER is an external argument. Other types of psych verbs have EXPERIENCER as internal argument, e.g., "please", "worry" but we do not discuss them here. For brevity, in the remainder of this dissertation, we will refer to the thematic-role ambiguity associated with the head noun in sentences such as (4a) as AGENT/THEME ambiguity

⁴ For some nouns (three of the 12 experimental items), the AGENT/THEME ambiguity may have derived from lexical ambiguity, for example, "haisha" can mean either a dentist or a dentist's clinic.

arguments. The appropriate interpretation of the two gaps that results in the embedded clause is to postulate a *pro* in the subject position and associate the relative clause gap with the object position; thus the head noun “bengosi” is interpreted as THEME of the embedded verb. Sentence (4b) has the same SOR disambiguation by the matrix verb as (4a), but the role of the head noun is not ambiguous; the inanimate noun “kasikinko” (safe) can only be interpreted as THEME object of the embedded verb. Therefore, the contrast of (4a) and (4b) provides a direct test of the hypothesis at issue, i.e., that the difficulty of SOR sentences depends on the ambiguity of the head noun. In (4b) the ambiguity is resolved correctly to SOR at the head noun; in (4a) an incorrect SR analysis is possible at the head noun, necessitating an SR-to-SOR reanalysis at the matrix verb.

Another comparison in the experimental design contrasted the first sentence type, i.e., (4a), with the third sentence type, illustrated by (4c): these are identical except for the final matrix verb. This comparison is relevant to the separate issue of the relative difficulty of SOR and SR structures. (4c) is identical to (4a) except that it is disambiguated in the opposite direction, toward SR, by the monotransitive matrix verb “ayamatta” (apologized), which does not take an accusative (NP-o) argument. Hence, the first NP “Yamaoka-ga” is a matrix clause constituent but the second NP “kakusiisan-o” must be retained in the relative clause. The head noun in (4c) thus has to be interpreted as AGENT subject of the embedded verb “sagasidasita” (discovered). However, like (4a), the sentence is temporarily ambiguous when the animate head noun is first encountered, and is not disambiguated until the matrix verb. Comparison

of (4a) and (4c) at the matrix verb can reveal which analysis is favored by the parser at a role-ambiguous head noun.

The 12 sentence triplets were counterbalanced across three lists so that within any version of the experiment, there were 4 instances of each of 3 sentence types with no repetition of lexical content. Within each triplet, the lexical items setting up the contrasts of sentence type, i.e., the head nouns in (4a,b) and the matrix verbs in (4a,c), were matched for length as measured in the number of characters (kanji and kana). There was no matching for frequency as no appropriate frequency database was available at the time of materials construction but item familiarity was approximately equated, by the judgment of the experimenter.

A further 72 sentences of variable length and structure were constructed to serve as fillers. The filler items, identical across versions of the experiment, were interspersed among the experimental items under a constraint prohibiting adjacency of experimental sentences. Thus, each version of the experiment presented 84 items in total, 12 experimental sentences and 72 fillers, and the presentation order of items was identical across the three lists. Five additional practice items were prepared for the warm-up session preceding the real experimental session. The length and complexity characteristics of the practice items were matched to the filler items.

For all sentences used in the experiment (including fillers), comprehension questions were prepared to which a YES/NO response was required. About half of the questions that followed experimental sentences could be answered correctly only if the subject had accurately assigned the correct structure, and for this reason the content of the question sometimes differed for the three sentences of a triplet (e.g., "Did

Yamaoka discover the unlicensed lawyer/safe? (YES) for (4a) and (4b), respectively, versus "Did the unlicensed lawyer discover the hidden fortune?" (YES) for (4c)). For the remainder, it was irrelevant whether the subject assigned the SR or SOR reading. The purpose of the comprehension questions was twofold: to distract the subject from the real purpose of the experiment, and to ensure that sentence reading was appropriately accurate.

Procedure. Whole sentences were presented on a computer screen, one at a time, each ending with a maru (the Japanese equivalent of the English period symbol), under the control of a custom-made Hypercard program on a Macintosh computer.⁵ Each sentence and question was displayed at a fixed central position on the liquid-crystal screen of a Macintosh Powerbook 145b notebook computer, in Japanese script.

Hosominchoo font was used, with display size about 1 x 1 cm for each character.

Presentation of a sentence was initiated when the subject first pressed the return key on a standard computer keyboard, which was labeled "YES" in English.⁶ The subjects were instructed to press a computer key as soon as they had understood the sentence; this terminated the sentence display and initiated display of a comprehension question. Responses to questions were made using the return key ("YES") or the tab key ("NO"). The time between the onset of presentation of the sentence and the key press initiating the comprehension question was recorded by the

⁵ The experimental program was developed at Ohio State University. We deeply thank Hiroko Yamashita and Mineharu Nakayama for making it available to us.

⁶ English words "YES" and "NO" are very familiar to ordinary Japanese students. It is highly unlikely that labeling the keys with these English words caused confusion to the subjects.

computer's internal clock as reading time in milliseconds. The subjects received no feedback about their YES/NO question responses.

At the beginning of the experimental session, each subject was instructed about the tasks they were expected to perform, both verbally and in a written instructions sheet. The purpose of the instructions was to convince the subjects that the post-sentential comprehension questions were the main interest of the experiment. It was also emphasized that the subjects were expected to read and answer questions as accurately and rapidly as possible.

Data Treatment. Fifty-two subjects participated in the experiment. Four subjects were rejected for unusually slow reading times, i.e., mean reading time for the whole sentence greater than 12 seconds, almost twice as long as the reading time of the remainder of the subjects.

Among all the data points from the 48 qualified subjects, reading times greater than 20 seconds were rejected as outliers: this trimming procedure affected 1.6% of the data. Also, any data point that was less than 1 second was similarly rejected. Finally, values falling beyond cutoffs established for each subject at mean plus-or-minus two standard deviations were replaced with those cutoff values, in order to limit the extent to which occasional extreme values might distort the mean.

Results and Discussion

Table 1 below summarizes the mean reading time for each of the three sentence types of Experiment 1. The table is configured to show the orthogonal pairings which were designed within those types.

Table 1. Mean whole sentence reading times (in seconds) as a function of reanalysis and head noun types

Head Noun Type	Reanalysis Type	
	SOR	SR
Ambiguous	7.76	7.39
Unambiguous	6.67	—

The main comparison was that between the sentence types whose matrix verb required the SOR structure, and this has a very clear outcome: Sentence reading times were more than one second faster when the head noun was informative of the correct reanalysis, allowing it only a THEME role in the relative clause. Analysis of variance confirmed that the difference was significant, $F_1(1,45) = 24.04$, $p < .001$, $F_2(1,9) = 5.63$, $p < .05$.

In the orthogonal comparison over sentences with role-ambiguous head nouns, across reanalysis types, the outcome is in the expected direction but muddier. Numerically, the sentences requiring SR structure were read slightly faster than those

requiring SOR structure, but the difference did not reach statistical significance, $F_1(1,45) = 1.43, p > .10, F_2 < 1$.

The experiment thus confirmed native intuitions about these sentences by showing that an unambiguous head noun makes SOR sentences easier. It even found evidence for the existence of an (unambiguous) SOR-type sentence which appears to be as easy or easier to parse than an (ambiguous) SR-type sentence. Note that the processing cost attributable to SOR compared to SR (as inferred from the reading time difference between (4a) and (4c) sentences) is less than that due to thematic ambiguity (as inferred from the reading time difference between (4a) and (4b) sentences), at least in terms of numerical values, suggesting that thematic role ambiguity is the major determinant of SOR difficulty. More work is needed, however, to establish the mechanism by which a role-ambiguous head noun leads to more difficult comprehension of SOR-type sentences. Thematic compatibility may directly influence the parser's choice between SR and SOR alternatives at the head noun; on the other hand, the parser may always choose SR initially, and thematic non-ambiguity would subsequently affect the process of reanalysis to SOR. Which of these alternatives is correct is important for evaluation of the various accounts of how the parser copes with ambiguity in reanalysis, discussed in Chapter 3.

To explore this, it is necessary to locate exactly where the disadvantage due to thematically role-ambiguous head nouns originates, i.e., at the head noun position where reanalysis ambiguity arises, or at the final matrix verb that resolves the SR/SOR ambiguity, or somewhere between. Whole sentence reading can provide only a global estimate of sentence difficulty. In Experiment 2, the same three structural types were

examined as in Experiment 1; however, a frame-by-frame self-paced reading procedure was employed.

4.2.2 Experiment 2

Experiment 2 aimed to determine the point at which the effect of thematic compatibility is reflected in reading times; i.e., at the site at which the thematic compatibility information first becomes available, or later where the SR/SOR is finally disambiguated. The same three types of sentence as used in Experiment 1 (though not exactly the same sentences) were tested in a frame-by-frame self-paced reading experiment.

Note that some inanimate head nouns may allow locative-gap readings, especially if the relative clause verb is [- stative]. In Experiments 2 and 3 to follow, for relative clauses with stative verbs such as “kiniitta” (liked) or “sitteita” (knew), a locative-gap reading is not a natural choice. For relative clause verbs which do quite naturally take a locative adjunct, we designed the sentences so as to minimize the chance that the inanimate head noun would be interpreted as locative by inserting an overt adverbial or prepositional phrase denoting location.⁷ Therefore, the role

⁷ Despite the overt locative in the relative clause, a locative gap reading is not entirely excluded, because two locatives are sometimes possible in the same clause (perhaps nested), and because the overt locative might be construed as a matrix clause constituent. As a matter of fact, this is not a very natural reading of the experimental sentences, according to the judgment of native speakers. In any case, even if some locative gap readings did occur, this could not have been the source of the results of interest in Experiment 2; it could only have weakened the effects obtained. See section 4.2.6.3 for a possible form of argument for the conclusion that non-argument readings are not a preferred choice.

ambiguity to be discussed will be quite clearly between two argument roles, either between AGENT and THEME or between EXPERIENCER and THEME.

Method

Subjects. Forty-five undergraduate students from Shoin University participated successfully in the experiment, 15 in each of the three versions of the experiment. All were native speakers of Japanese, and naive with respect to the purpose of the experiment. None had participated in Experiment 1. Subjects typically took 25-30 minutes to complete the experiment.

Materials and Design. Sentences of the same three types used in Experiment 1 were constructed. Item power was doubled so that there were 24 triplets; of those, 8 were adopted from Experiment 1 with some minor modifications. For presentation in the self-paced reading task, the sentences were divided into 8 frames, as illustrated in (5a-c) below. Frames 1 through 4 were identical across sentence types. Frame 5 was the head noun; Frame 6, an adverbial or prepositional phrase; and Frame 7, the matrix verb. Frame 8 was a “maru”.

(5)

	Frame 1	Frame 2	Frame 3	Frame 4 ...
	roojin-ga	sutego-o	atikoti kiite	sagasita
	old man-Nom	orphan-Acc	by asking in various places	looked for
a. ...	Frame 5	Frame 6	Frame 7	Frame 8
	bokusi-ni	tootoo	takusukotonisita	°
	priest-Dat	finally	decided to entrust	

“The old man finally decided to entrust the orphan to the priest who he looked for by asking in various places.”

b. ...	Frame 5	Frame 6	Frame 7	Frame 8
	sisetu-ni	tootoo	takusukotonisita	°
	orphanage-Dat	finally	decided to entrust	

“The old man finally decided to entrust the orphan to the orphanage which he looked for by asking in various places.”

c. ...	Frame 5	Frame 6	Frame 7	Frame 8
	bokusi-ni	tootoo	aukotonisita	°
	priest-Dat	finally	decided to meet	

“The old man finally decided to meet the priest who looked for the orphan by asking in various places.”

For variety, the number of words in noncritical frames could differ across items. Thus, 11 out of 24 experimental triplets had an adjective or a genitive NP modifying NP-o in Frame 2, and one had a genitive NP modifying the initial NP-ga in Frame 1. The two types of head noun within each triplet, e.g., animate “bokusi” (priest) in (5a,c) and inanimate “sisetu” (orphanage) in (5b), and the two types of matrix verbs, e.g., ditransitive “takusukotonisita” (decided to entrust) in (5a,b) and monotransitive “aukotonisita” (decided to meet) in (5c), were matched in length, as measured in number of characters (kanji and kana). All the other frames were identical across types. The list of experimental sentence pairs is given in Appendix 2. Only one item pair in the experimental sentences had an adjective modifying the head noun; it was presented in the same frame as the head noun.

As in Experiment 1, the lexical items used as head nouns were not matched in frequency within triplets. Instead, a separate experiment was conducted to assess basic reading times for the two types of nouns that would be used in Experiment 2 as role-ambiguous and role-unambiguous head nouns. Reading times were measured (for

13 subjects) in a test in which the subjects saw each noun on the computer screen, in isolation. They were instructed to press a key when they had read the noun on the screen; when the key was pressed, a second noun (not relevant to the experiment proper) was presented, and subjects made a judgment about whether the two nouns were related in meaning. The critical nouns were always presented first and reading times to those first nouns (time between the onset of the presentation and the key press to request the second noun) were of interest, rather than performance in the judgment task. The average reading times for Experiment 2's role-ambiguous (668 msec) and role-unambiguous head nouns (673 msec) did not differ significantly, $F < 1$ for both subject and item analyses.

A second pre-test was also conducted to assess the plausibility of the content expressed by the three types of sentences used in Experiment 2 (SOR with role-ambiguous head noun, SOR with role-unambiguous head noun, and SR with role-ambiguous head noun) in the absence of any temporary SR/SOR ambiguity. This test exploited the free word order of argument and adjuncts in Japanese. The sentential contents of (5a-c) were expressed by (6a-c), respectively. In (6a-c), the head noun is fronted together with the relative clause modifying it, making it evident that all the other constituents are matrix constituents.

An ANOVA conducted with item-based data over the three cases provided no evidence of systematic differences in plausibility, $F_2(2,46) = 2.37$, $p > .10$. An independent subanalysis comparing the content of the two types of SORs (ambiguous vs. unambiguous head noun) similarly gave a null result, $F_2(1,23) < 1$, as did a subanalysis comparing the content of SR and SOR (both role-ambiguous), $F_2(1,23) = 2.59$, $p > .10$.

An additional 66 sentences, varying in frame length and structure, were constructed as fillers and interspersed among the experimental items for Experiment 1 so that two experimental items were never presented adjacently. The experimental materials (24 triplets, thus 72 items) were distributed over three versions of the experiment in a counterbalanced design, so that the 24 experimental items within each version were made up of 8 instances of each of the 3 sentence types, without repetition of sentential content. Thus, each version of the experiment consisted of 90 items in total, 24 experimental sentences and 66 fillers. The filler items and the order of presentation of sentences were identical across the two versions. In addition, there were five additional practice items for the warm-up session preceding the real experimental session.

As in Experiment 1, YES/NO comprehension questions were prepared for all sentences used in the experiment (including fillers). The purpose and the characteristics of these questions were the same as those of the earlier experiment.

Procedure. The apparatus and procedure employed in the current experiment was the same as that in Experiment 1, except that each sentence was presented frame-by-frame. Presentation of the first frame of a sentence was initiated when the subject first

pressed the return key on a standard computer keyboard, which was labeled "YES" in English ; with each subsequent key press, a new frame immediately replaced the previous display. The key press following the final display (maru) initiated display of a question about the content of the sentence, to be answered by pressing either the YES key or the tab key labeled "NO". The time between the onset of presentation of any frame and the key press initiating the next frame was recorded as reading time, in milliseconds.

Data Treatment. Fifty-four subjects in total participated in the experiment; of those, 9 were rejected because of poor performance characteristics. Five were rejected because their overall error rate for the post-sentential YES/NO questions was 15% or higher. Four subjects were rejected for unusually slow reading times, i.e., mean reading time for Frames 5 to 8 greater than 1500 msec, more than twice as long as the mean reading time of the remainder of the subjects.

Reading times greater than 7500 msec (0.3% of the data) were rejected as outliers, as was any data point less than 100 msec. Finally, values falling beyond cutoffs established for each subject at mean plus-or-minus two standard deviations were replaced with those cutoff values, as in Experiment 1.

Results and Discussion

Table 2 below shows the mean reading times for the four frames that were relevant, i.e., Frames 5 through 8, for the three sentence types.

Table 2. Mean reading times (in milliseconds) per frame, as a function of sentence type

Sentence Type	Frame			
	5 Head N	6 AdvP	7 Matrix V	8 maru
SOR, head ambiguous	989	663	814	512
SOR, head unambiguous	912	680	767	460
SR, head ambiguous	977	708	792	490

The major comparison was between SOR role-ambiguous and SOR role-unambiguous sentences, e.g., (5a) versus (5b). This comparison showed that at Frame 5 (the head noun) thematic-role ambiguity led to reading times that were 77 msec longer, $F_1(1,42) = 6.89$, $p < .05$, $F_2(1,21) = 4.37$, $p < .05$. At the following AdvP position, Frame 6, no reliable difference in reading times was found, $F < 1$ for both subject and item analyses. At the matrix verb position, Frame 7, SOR sentences with a role-ambiguous head noun again yielded longer reading times than those with an unambiguous head noun (now, 47 msec longer), $F_1(1,42) = 6.68$, $p < .05$, $F_2(1,21) = 17.21$, $p < .001$. A difference in the same direction and of the same approximate magnitude (52 msec) was also found at the maru frame, $F_1(1,42) = 7.06$, $p < .05$, $F_2(1,21) = 7.26$, $p < .05$.

Overall, the results are remarkably consistent with Experiment 1, but add further important detail because of the finer grain of the self-paced reading task. That is, the longer whole sentence reading time for role-ambiguous SOR sentences compared to unambiguous SOR sentences that was found in Experiment 1 corresponds

to differences found in Experiment 2 at the matrix verb position, and also at the head noun position itself. We will discuss these results in detail in section 4.2.3.

In the orthogonal comparison between SOR and SR sentences with role-ambiguous head nouns, e.g., (5a) versus (5c), the outcome was not conclusive. These pairs were identical except for the matrix verb, and the positions of interest were therefore restricted to the end of the sentence. At the matrix verb, Frame 7, where the ambiguity as to relative clause type is resolved, no significant difference between SR and SOR sentences emerged, nor was any significant difference evident at the following maru frame, $F < 1$ in all analyses. However, in terms of numerical value, reading times at these positions for the SR sentences were somewhat less than those for corresponding SOR sentences; inspection of Table 2 reveals that values for SR sentences were roughly intermediate between those for the two SOR types.

The contrast between SR and SOR sentences sharing the same head nouns speaks to the issue of the relative difficulty of SOR and SR sentence types. In Experiment 2 as in Experiment 1, the comparison between SOR sentences with a role-ambiguous head noun and their SR counterparts failed to show a reliable difference in sentence-final reading times. The best that can be said is that, in each case, the direction of the numerical (but clearly non-significant) difference was as predicted by Mazuka & Itoh: Reading was just slightly slower for sentences ending with a verb forcing the SOR structure than for otherwise identical sentences disambiguated toward the SR structure. This comparison yielded a null finding, but one that is suggestive considering that other comparisons did reveal a significant difference. This indicates that the experiment itself is sensitive enough to be able to detect meaningful

differences. By seriously considering the null finding for the SR/SOR comparison, we argue that the outcome is consistent with a garden-path account of costly SORs; a parse-failure account is not supported by these data.

4.2.3 Implications for the use of thematic compatibility information

4.2.3.1 Effect of thematic compatibility on SOR processing

The crucial new finding of Experiment 2 is of a difference between SOR sentence subtypes at the head noun itself: role-ambiguous (AGENT / THEME) head nouns resulted immediately in reading times that were longer than those for role-unambiguous (THEME-only) head nouns. Additionally, as noted, a difference in the same direction was found later in these sentences, at the sentence-final matrix verb and spilling over to the *maru*. Arguably the effect observed at the head noun and the matrix verb positions must have independent sources, since reading times did *not* differ at the adverb position which intervened between these.

The effect observed sentence-finally, at the matrix verb disambiguating toward SOR and at the following *maru* is most naturally interpreted as reflecting an initial wrong choice of SR at the role-ambiguous head noun, while no such choice could have been made at the role-unambiguous head noun, for which the SR structure's AGENT interpretation of the head noun is impossible. This is compatible with any theory which assumes that SR is always or necessarily a preferred choice over SOR, as do some of the theories discussed in Chapter 3. There are two points to be noted. First,

the data do not necessarily confirm that this preference is *structural*. For all we can tell at this point, it could be preference for AGENT reading of animate nouns, or a preference for a gap in external argument (subject) position, or could have some other source. For brevity, we will continue to refer to this as an SR preference without taking a stand on its source. We return to this point in section 4.2.3.2. The second point is that these data do not provide positive support for the claim that SR is preferred to SOR. They show only that SR was preferred on enough occasions to create a measurable problem at the point of SOR disambiguation. Thus, SOR might be chosen some of the time (as probabilistic serial models could assume; Mitchell, 1989; Ferreira & Henderson, 1990).

There are some alternative accounts of these findings which need to be considered. Some parallel models (e.g., Just & Carpenter, 1992; MacDonald, Pearlmutter, & Seidenberg, 1994) would predict that the parser carries out parallel computation of both possible relative clause analyses in the case of sentences with a role-ambiguous head noun, and that this is the cause of their greater processing cost for the role-ambiguous noun than for the role-unambiguous noun. However, this is not compatible with the fact that no reading time difference was observed at the adverb position following the head noun. The temporal separation of the processing costs at the head noun (Frame 5) and the matrix verb (Frame 7) suggests that two different phenomena are occurring. At least by the adverb, it seems that a choice between relative clause structures has been made.

The differences found at the head noun and the matrix verb positions in the role-ambiguous/unambiguous SOR conditions pose a problem for theories which claim that

SOR is not merely unpreferred, but inherently problematic and perhaps unprocessable by the normal parsing routines. In Gibson's model, a pruning decision is made at the first verb, before the head noun is encountered: an SOR relative clause analysis is dropped from consideration, because too many noun phrases lack thematic roles compared with the single clause analysis. The presence or absence of role ambiguity at the noun should therefore have no effect on processing an SOR structure.⁸ Gorrell's structural determinism model is not compatible with the findings either: as noted in Chapter 3, this model predicts that all SOR constructions are equally unprocessable, since they require breaking the dominance relation between the object and the VP node. (However, see discussion by Sturt & Crocker, 1996.) The only factor discriminating difficult (impossible) from easy revisions in Gorrell's model is the nature of the structural change between the initial (single-clause) analysis and the final analysis. For a thematically ambiguous noun, an initial SR choice would require this change to be made in two steps: single clause to SR, then later SR to SOR; an initial SOR choice would require it to be made in one step. Nonetheless, it is illegal in both cases, in Gorrell's model.

For theories presenting garden-path accounts of the additional difficulty of SOR processing (e.g., Frazier & Clifton, 1998; Inoue, 1991; Sturt & Crocker, 1996), the contrast in reading times at the matrix verb depending on the ambiguity of the noun is

⁸ A ranked parallel model like Gibson's (1991) but which nonetheless allows both SR and SOR structures to stay "live" after the embedded verb, and with some mechanism that links the number of parses being run to processing cost, might be able to predict the higher cost at the role-ambiguous noun compared to its unambiguous counterpart. However, this might lead to mispredictions of other constructions. Also the ambiguity cost would have to be carried during the entire ambiguity region. As noted above, this is not consistent with the adverb data.

explicable as long as it is assumed that the parser prefers SR to SOR at the head noun and this would have to be a structure-based preference in garden path models. (In fact, they predict the parser's default preference is a relative clause structure in which a gap is associated with a non-argument position, because then none of the overt arguments need to undergo reanalysis. Such readings are not considered at the moment because they are not possible for the sentences under consideration here. We will return to this point later in section 4.2.6.3) An SR choice at the role-ambiguous noun would lead to a problem when the matrix verb disambiguates toward SOR. Thus it would explain the contrasting results for sentences like (5a) vs. (5c), in a garden-path model. However, the different results observed at the role-ambiguous and unambiguous head noun position ((5a,c) vs. (5b)) remain to be explained in a garden-path model. We turn to this issue now.

4.2.3.2 Early use of thematic compatibility information

An ambiguity-induced cost at the very site of ambiguity is quite unexpected in standard garden path theories. These models posit that when deciding which type of relative clause to build (SR or SOR), in the absence of any syntactic disambiguation, the parser's priority is to base its decision on structurally-grounded reanalysis principles or strategies of the sort discussed in Chapter 3. That is, a candidate structure would be selected without reference to head noun content. Thematic compatibility information would be used only subsequently in a follow-up assessment of the candidate's viability. Structure selection establishes the head noun (or rather its

associated gap) as an argument of a particular kind of the embedded verb (subject, in the case of SR; object, in the case of SOR). This assignment, together with the argument structure of the verb, determines the thematic role of the noun in the relative clause (AGENT for SR; THEME for SOR, for the verbs used in these experiments). Then the thematic check would assess the plausibility of the thematic role implied: Is the head noun content compatible with its assigned thematic role? The thematic check would lead to rejection of a structure (and a disruption of processing) when the resulting interpretation is implausible, and to acceptance otherwise. Sturt & Crocker's (1996) "tree-lowering" model of reanalysis, among others, is an instantiation of this procedure.

This ordering of parser priorities does not lead to an account of Experiment 2's finding that head noun content has an *immediate* consequence, with role-ambiguous head nouns being read more slowly than role-unambiguous head nouns. Role-ambiguous head nouns, by design, have semantic content that is compatible with both SR and SOR structures; thus, processing of the head noun should go through smoothly regardless of what structural decision was made, since a thematic check will discover a plausible interpretation whichever structure was selected. Role-unambiguous nouns, by design, fit the SOR structure and are incompatible with the SR structure; thus, processing at the unambiguous head noun would go through smoothly if SOR were the parser's structural preference, just as it does when the noun is role-ambiguous. But processing would be disrupted if the parser's structural choice were SR when the implausible interpretation detected by the second-stage check (e.g., "an orphanage looking for something") results in rejection of the SR structure. Putting these

considerations together to derive predictions about a difference in processing difficulty turning on head noun content cannot produce the right result. If the parser's structural preference is for the SR structure, it is role-unambiguous nouns that will be predicted to lead to processing disruption, the opposite of the reading time pattern observed. Even if it were supposed that SOR is the parser's structural default, the prediction is one of no difference if the default uniformly applies since SOR has a plausible interpretation in both conditions. If anything, there would be a greater difficulty for the unambiguous noun (which is the opposite of the result obtained). The observed cost of ambiguity is thus not explained. Two possible alternative accounts are proposed below.

Account 1: Thematic-indecisiveness account

We have pointed out that standard two-stage garden-path models in which structure-driven preference principles are applied first, followed by thematic compatibility information, fail to account for the observed results at the head noun in Experiment 2. Reversing that ordering of priorities opens up the possibility of an account of the data, although many details remain to be worked out. Suppose that when syntactic information is absent, the parser tries to select an appropriate relative clause structure by *first* consulting thematic compatibility information before applying structural preference principles. When the head noun allows only one thematic role, the parser can simply accept the structure that is thematically indicated. (Note that this is possible because of the tight relation between thematic roles and structural positions, especially in Japanese. This is unlike some proposed cases of plausibility

influencing structure assignment, where it is difficult to see how the preferred interpretation could select the appropriate structure.) However, when the head noun is role-ambiguous, thematic compatibility information necessarily fails to specify a unique analysis. If parsing is incremental, the parser needs to make a decision, but in this situation it has neither syntactic nor thematic information as a basis for that decision. In order to settle on one relative clause structure it must find some other criterion to apply. Thus, encountering a role-ambiguous head noun would result in a period of indecisiveness while encountering a role-unambiguous head noun would not. On the assumption that indecisiveness and further processing steps are reflected in longer reading times, the direction of the difference predicted accords with the experimental result. In the following discussion, this account will be referred to as the “thematic-indecisiveness” account, signifying that the parser attempts to use thematic information before resorting to any preference strategies (either structure-based or thematic-based).

This “indecisiveness” effect is not dissimilar to the competition cost assumed in constraint-based theories in which there are two (or more) information sources, which create biases of roughly equal strength in opposite directions. However, the two proposals exhibit some important differences also. The indecisiveness account does not need two opposed pressures, but applies where there is no clear information biasing the decision in either direction.

Account 2: Simultaneous application of thematic and structural biases

A somewhat different evaluation of alternatives is implied if it is assumed instead that thematic information and structural preferences are applied simultaneously in resolving ambiguity. Such a scenario may be found in “constraint-satisfaction” models (MacDonald, 1994; MacDonald et al., 1994; Juliano & Tanenhaus, 1994, among others), which assume that the parser integrates all relevant available information and evaluates all possible syntactic alternatives in parallel to select an analysis. According to such models, ambiguity resolution is a continuous process of satisfaction of constraints, including those that are lexical in origin (such as thematic constraints, frequency of argument structure, etc.), and those concerning ‘higher’ levels of information such as plausibility. In these models, processing difficulty is a reflection of competition between inconsistent biasing information supplied by different information sources; for example, difficulty would be increased if a less frequent alternative argument structure is supported by a better thematic fit.

In this approach, it might be possible to explain the longer reading time at the ambiguous head noun in Experiment 2 as a consequence of a competition between two opposed preferences applied simultaneously. The likeliest candidates would be a structure-driven parsing preference (toward either SR or SOR) and a thematic bias (toward either AGENT or THEME). This account will be referred to as the “competing-preferences” account. For example, the competition at a role-ambiguous (AGENT / THEME) head noun such as those used in Experiments 1 and 2 would be accounted for by assuming a combination of either (i) a structure-driven bias toward

SR and a thematic bias toward THEME, or (ii) a structure-driven bias toward SOR and a thematic bias toward AGENT.

The outcome of (i) provides straightforward grounds for rejecting it, because it would predict a competition not only at the role-ambiguous (AGENT/THEME) head nouns but also at the role-unambiguous (THEME-only) head nouns. In either case (ambiguous or unambiguous), the structure-driven bias toward SR would end up in a competition with the thematic choice of THEME at the head noun. Therefore, the difference in processing cost between the two types of head nouns would not be explained.

In order to correctly predict not only the competition at the role-ambiguous head noun, but also the absence of competition at the role-unambiguous head noun, we would have to assume the latter combination (ii), i.e., a thematic-driven preference toward AGENT (or EXPERIENCER), and some other source of preference toward SOR. No such preference is supported by any existing theories (see Chapter 3). However, it is conceivable to assume a structure-based preference toward SOR in a number of ways. For example, if Sturt & Crocker (1996) assumed a language-universal bottom-up search strategy for node insertion, the SOR structure would be predicted as preferred. Hirose & Inoue (1998) also note a possible processing advantage for SOR, arising from the fact that the matrix subject and the relative clause subject are co-indexed, thus creating a “parallel-subject” structure. If some such basis for SOR preference can be assumed, the competition between the two biases would be manifested in elevated reading times at the role-ambiguous head noun. By contrast,

no such competition should arise at the role-unambiguous (THEME-only) noun, for which the two constraints agree in choosing the same reanalysis.

We have outlined a possible explanation of the head noun ambiguity cost within the constraint-satisfaction approach: the cost could be due to two conflicting biases, one structure-driven preferring an SOR structure, and the other thematic-driven preferring AGENT to THEME when both roles are permitted by the content of the head noun. Our next question concerns ambiguity resolution: when the two biases are in conflict, which one eventually wins? The reading times at the matrix verb (longer reading times for SOR-disambiguated sentences with a role-ambiguous head noun) in Experiment 2 indicate that SR must have been chosen in some substantial proportion of trials. This is consistent with either of the following scenarios: (a) the thematic bias toward AGENT (thus SR) eventually overrides the structural bias toward SOR, or (b) the choice is probabilistically made. The data reject any proposal that the structural bias always wins over the thematic one, which would predict that SOR would be uniformly chosen.

The results of Experiment 2 do not distinguish between the thematic-indecisiveness account and the competing-preferences account. The question will have to remain open here. But see section 4.2.6.4 below on a possible way to resolve the issue.

4.2.3.3 Questions about incrementality in relative clause processing

We have argued that thematic compatibility information is used quite early in the disambiguating process, at least no later than any structure-based preference principle. Our next question concerns whether SR/SOR reanalysis decisions are initiated only at the head noun. Consider the pair of sentences in (7a,b) below. These are modified version of the two types of SOR sentence previously studied in Experiments 1 and 2. In both sentences types, as in the first two conditions in the previous experiments, the final verb provides disambiguation in favor of SOR, and one type has a thematically ambiguous head noun, while the other has a thematically unambiguous (THEME-only) head noun. However, unlike the items in the previous experiments, the head nouns are preceded by an adjective which is able to modify either animate or inanimate nouns, and hence which does not disclose the thematic status of the head noun.

(7)

- a. roojin-ga sutego-o atikoti kiite sagasita
 old man-Nom orphan-Acc by asking in various places looked for
- ryoosintekina bokusi-ni tootoo takusukotonisita.
 good priest-Dat finally decided to entrust

"The old man finally decided to entrust the orphan to the good priest who he looked for by asking in various places."

- b. roojin-ga sutego-o atikoti kiite sagasita
 old man-Nom orphan-Acc by asking various places looked for
- ryoosintekina sisetu-ni tootoo takusukotonisita
 good orphanage-Dat finally decided to entrust

"The old man finally decided to entrust the orphan to the good orphanage which he looked for by asking in various places."

For an incremental full-attachment parser, the syntactic cue for relative clause reanalysis in these examples is the adjective, since it indicates that a head noun will follow. The first question that we raise is whether the parser attempts to build a particular relative clause structure upon encountering the post-verbal adjective. It is not obvious that it will. A head-driven model such as that of Pritchett (1991) should predict that a relative clause construction is not postulated at the adjective, because the relative clause is a constituent of a complex NP, whose head (the head noun) has not yet been encountered. Thus no reanalysis of the single-clause analysis to a relative clause structure is activated at the adjective. In a non-head-driven parser, a relative clause construction can be recognized at the adjective. But the decision as to what kind of relative clause should be built could be postponed until the head noun is received, if the parser tries to make its reanalysis decision on the basis of thematic information when syntactic disambiguation is lacking. The head noun might provide the thematic information which the adjective in these sentences fails to provide, so the parser might sacrifice incrementality in order to wait and see if such information will be provided. In Chapter 3, we discussed claims that parsing is strictly incremental (Inoue & Fodor, 1995; Gorrell, 1995a; Sturt & Crocker, 1996; Frazier & Clifton, 1998, among others), i.e., that every item is given its place in the CPPM as it is

encountered. This seems to be a more reasonable strategy than head-driven parsing because it circumvents the enormous delays of semantic interpretation, given that in Japanese the verb is not normally encountered until the very end of the clause. A number of studies have argued for attachment of argument and adjunct NPs to VP and IP nodes before the verb (the head of the clause) is encountered (Yamashita, 1994; Inoue & Fodor, 1995; Mazuka & Itoh, 1995; Hirose, 1995; Kamide, 1998). These observations support the incrementality of phrase structure assignment to the input word string. In (7), an incremental parser will be constrained to create a relative clause at the adjective, so a decision is forced about its gap position (and which NPs are in the matrix versus relative clause), and this decision must be made by means other than either syntactic or thematic information. If the parser has a preference toward either SR or SOR, the decision will be made accordingly.⁹

Between SR and SOR, SR would be a reasonable choice according to most theoretical proposals about structure-based parsing preferences (Inoue, 1991; Sturt & Crocker, 1996; Frazier & Clifton, 1998). SR would also be the most likely choice if the parser's preference is thematically based, since it is often observed that the AGENT role ranks higher than other roles such as THEME, for items compatible with both. However, we noted that an SOR preference must be postulated as competing with an AGENT preference on the competing-preferences account discussed above. These incremental approaches (despite their differences) all predict that the same factors should be at work at the adjective in sentences like (7) as at the noun in

⁹ On the possibility of non-argument-gap relative clauses, see section 4.2.6.3 below.

Experiments 1 and 2.¹⁰ Thus, the absence of syntactic or thematic disambiguation should make processing harder (the ambiguity cost of Experiment 2), but an SR preference should then emerge in at least a substantial number of cases. Experiment 3, reported below, does not address the question of whether there is an ambiguity cost (since no thematically unambiguous adjective was tested as a baseline) but it does test the hypothesis that there is an SR preference at the adjective. If there is, it should cause easier processing of a subsequent animate noun than of an inanimate noun which is incompatible with the SR reading. The incrementality of relative clause processing can thus be evaluated. Non-incremental models, as discussed above, would predict no decision-making at the adjective, so that the pattern of reading times at the head noun and at subsequent positions should not differ from those in Experiment 2: an ambiguity cost at the animate noun, followed by a garden-path at the matrix verb (SOR disambiguation) for sentences with a role-ambiguous (animate) head noun.

¹⁰ There is a possible difference, that is of interest. Arguably, the adjective in (7) is *neutral* (not ambiguous) with respect to the animacy of a noun that can follow, and in the absence of animacy information, the default principle which links animacy to probable thematic roles is not activated. Therefore, unlike the head nouns in Experiments 1 and 2 (which we take to be *ambiguous* between specific thematic roles), it could be that the adjectives in examples (7) do not even speak to evaluation of what role would be possible for the head noun. Examples in English of this kind of neutrality are adjectives like “good”, “strange”, or “tall”, which can be applied appropriately to persons and objects. By contrast, adjective such as “kind” or “wooden” apply exclusively to animate and inanimate entities respectively. It is reasonable to assume that an inanimate-only adjectives such as “semakurusii” (cramped, unspacious) could bias the parser toward an SOR decision. (Strube, Hemforth, & Wrobel, 1990, claim that thematic information can occur at a prenominal adjectives in English; they found a processing cost for an animate-preferring adjective such as “blond” in an ambiguous context favoring an INSTRUMENTAL role, e.g., “Peter watched the girl with ...”) But animacy-neutral adjectives might fail to activate any thematic evaluation, so they would not present the parser with an SR/SOR choice. If so, then possibly no thematic default would be applied, in which case any structural default would show up clearly in the absence of competition. This is a possibility that deserves to be pursued in future research but we will not discuss it further here.

4.2.4 Experiment 3

A frame-by-frame self-paced reading task was employed to measure processing load at different positions in sentences modeled on the two types of SOR sentence employed in Experiment 2 (see (5a) and (5b), earlier): one type has a thematically role-ambiguous head noun, and the other a thematically role-unambiguous (THEME-only) head noun. The construction of materials differed from the previous experiment only in that an adjective was inserted which modified the head noun, e.g., “ryoosintekina” (good). The adjective was presented in a separate frame occurring between the relative clause verb and the head noun. The adjectives in Experiment 3 were selected to be equally natural as modifiers of animate and inanimate nouns.

Method

Subjects. Twenty-four undergraduate students from Doshisha University participated successfully in the experiment, 12 in each of the two versions of the experiment. All were native speakers of Japanese, and naive with respect to the purpose of the experiment. Subjects typically took 20-30 minutes to complete the experiment.

Materials and Design. The experimental sentences were constructed to form pairs, differing only in their head nouns (animate/inanimate), and were identical to the two types of SOR sentences used in Experiment 2 except for the presence of an adjective preceding the head noun. The sentences were divided into 9 frames, as illustrated in (8a-b) below. Frames 1 through 5 were identical across the two sentence types. The

positions at which reading times are of interest were Frame 6, the head noun; Frame 7, an adverbial or prepositional phrase; and Frame 8, the matrix verb. Frame 9 was a maru.

(8)

Frame 1	Frame 2	Frame 3	Frame 4	Frame 5
roojin-ga	sutego-o	atikoti kiite	sagasita	ryoosintekina ...
old man-Nom	orphan-Acc	by asking in various places	looked for	good

a.

Frame 6	Frame 7	Frame 8	Frame 9
... bokusi-ni	tootoo	takusukotonisita	°
priest-Dat	finally	decided to entrust	

"The old man finally decided to entrust the orphan to the good priest who he looked for by asking in various places."

b.

Frame 6	Frame 7	Frame 8	Frame 9
... sisetu-ni	tootoo	takusukotonisita	°
orphanage-Dat	finally	decided to entrust	

"The old man finally decided to entrust the orphan to the good orphanage which he looked for by asking in various places."

There were 24 such sentence pairs, and the two sentences in each pair differed only in the identity of their head noun (e.g., "bokusi"/ "sisesu"), one of which was role-ambiguous and the other compatible only with THEME role. The complete set of experimental sentence pairs is given in Appendix 3. The adjectives appearing in Frame 5 were selected to be equally compatible with the role-ambiguous (animate) head nouns and their role-unambiguous (inanimate) counterparts appearing in Frame 6. This was checked informally by consulting three native speakers.^{11, 12}

¹¹ Informants were asked to judge if the modification of each noun in a pair by the adjective was either 3 ("natural"), 2 ("neither natural nor weird (in between)"), or 1 ("weird"). Only those pairs in which

The total number (66) and characteristics of the filler items were the same as those in Experiment 2, except that 24 SR-type sentences were also included to avoid biasing subjects toward the SOR reading, since all the experimental items were SOR-type relative clause constructions in this experiment. An example SR filler sentence is shown in (9) below.

- (9) itamae-ga ryoori-o kiniiranakatta joorenkyaku-ni ikinari donatta
 chef-Nom dish-Acc disliked customer-Dat suddenly yelled at
 "The chef suddenly yelled at the customer who disliked the dish."

The experimental materials (24 pairs, thus 48 items) were distributed over two versions of the experiment in a counterbalanced design, so that the 24 experimental items within each version were made up of 12 instances of each of 2 conditions, without repetition of sentential content.

For all sentences used in the experiment (including fillers), comprehension questions were prepared to which a YES/NO response was required. The purpose and the characteristics of the comprehension questions were the same as in Experiments 1 and 2.

Procedure. The procedure was the same as in Experiment 2, except that some consideration was given to the speed of performance, given that the reading times reported in Experiment 2 were somewhat slow. In this experiment, therefore, the

both combinations of adjective and noun were predominantly judged to be "natural" were used as experimental items.

¹² A preliminary experiment was conducted using a separate group of subjects to ensure that the reading times for the nouns when preceded by the adjectives used in Experiment 3 did not differ significantly. This preliminary experiment is not reported here since Experiment 3B reported below addresses this question with a more controlled design.

experimenter supervised the practice trial of each subject individually, and advised subjects to try to perform the reading task at a reasonable speed. If a subject's performance was unexpectedly slow and unlike normal reading behavior, an additional instruction was offered (in Japanese) as follows: "You look as if you were trying to memorize each word to be able to answer the question. However, the questions will be simple enough so that most of the time you will be able to answer without having to memorize the sentence word-by-word. Actually, other people typically go a little faster. You can proceed as if you were reading the sentences under normal circumstances."

Data Treatment. Thirty-one subjects participated in the experiment; of those, 7 were rejected because of poor or abnormal performance characteristics. Three subjects were rejected because their overall error rate for the post-sentential YES/NO questions was 15% or higher. One subject was rejected for unusually slow reading times, i.e., mean reading time for frames 5 through 8 greater than 1250 msec, more than twice as long as the mean reading time of the remainder of the subjects. Three subjects were rejected because they produced too many very fast reading times (13.5% or more of the data points for experimental sentences fell below 100 msec). Apparently, such subjects were very often pressing the response key purely rhythmically, since 100 msec cannot possibly be a genuine reading time.

Reaction times greater than 3000 msec were rejected as outliers, and this trimming procedure affected 0.9% of the data. Also, any data point that was less than 100 msec was similarly rejected. Finally, values falling beyond cutoffs established for

each subject at mean plus-or-minus two standard deviations were replaced with those cutoff values.

Results and Discussion

Table 3 below shows the mean reading times for the five frames that were relevant, i.e., Frames 5 through 9, for each SOR sentence type.

Table 3. Mean reading times (in milliseconds) per frame, as a function of head noun type

	Frame				
	5 Adj	6 Head N	7 AdvP	8 Matrix V	9 maru
Head Noun Type					
Ambiguous	572	590	413	662	416
Unambiguous	570	623	486	586	367

The comparison between role-ambiguous and unambiguous SOR sentences showed that at Frame 6 (head noun), thematic-role ambiguity led to reading times that were, overall, 33 msec shorter than those for thematically unambiguous head nouns, though the difference did not reach significance, $F_1(1,22) = 2.30, p > .10, F_2(1,22) = 1.13, p > .10$. At the following Frame 7 which presented an adverbial phrase (AdvP), sentences with ambiguous head nouns yielded reading times 73 msec shorter than those with unambiguous head nouns, and the effect was highly significant, $F_1(1,22) = 11.61, p < .005, F_2(1,22) = 9.48, p < .01$. At the matrix verb position, Frame 8, the

direction of reading time differences reversed; now, SOR sentences with an ambiguous head noun yielded reading times longer by 76 msec than those with an unambiguous head noun, $F_1(1,22) = 9.54, p < .01, F_2(1,22) = 8.25, p < .01$. A difference in the same direction was found at the maru position, $F_1(1,22) = 9.19, p < .01, F_2(1,22) = 6.30, p < .05$.

The reading times at the matrix verb (Frame 8, with spillover onto the maru) showed the same pattern as in Experiment 2: head-ambiguous SOR sentences were associated with longer reading times than head-unambiguous SORs. This can be interpreted as a garden path effect resulting from the parser's prior commitment to SR. However, reading times at the head noun (Frame 6) and the adverb (Frame 7) did not show the same pattern as Experiment 2. Overall, the pattern of costs associated with thematic-role ambiguity of a head noun that was found in Experiment 2 was not replicated in this experiment, in which the input first signaling the relative clause structure was not the head noun itself but rather an adjective modifying the head noun, appearing in a preceding frame. That is, it was *not* the case that ambiguous head nouns led to slower reading at early stages of the relative clause analysis: Experiment 2's "ambiguity cost" was absent. Instead, the longer reading times at the adverb position following an *unambiguous* noun suggest that the parser did not delay relative clause reanalysis until the head noun was received, but made a commitment at the adjective to SR.

Let us consider further the longer reading times observed for the adverbial phrase following an unambiguous THEME-bias head noun, compared to the same phrase following an ambiguous head noun. It can reasonably be assumed, since the

content is identical, that the reading time difference found at this position is a delayed effect of the preceding head noun.¹³ Thus we conclude that an unambiguous THEME head noun causes more difficulty than an ambiguous noun. This is consistent with the parser's making an SR choice at the prior adjective position on at least some proportion of trials. Whenever an SR analysis was selected at the adjective, it would turn out to be incompatible with the thematically unambiguous head noun which allows only the SOR analysis; there would be no such incompatibility between an SR decision at the adjective and a following ambiguous noun.

The interpretation offered above depends crucially on the assumption that the data pattern observed (for the adverb following the head noun, particularly) reflects the cost of processing steps that are peculiar to the operations by which a relative clause structure is built. To be fully confident about the conclusions drawn, we need to rule out the possibility that some other, uncontrolled property of Experiment 3's experimental sentences is the source of the reading time differences. Checks built into construction of the materials were intended to rule out any systematic difference in goodness-of-fit between the adjectives and the two types of the nouns used in the experiment; however, it is important to confirm that no such potential difference might have affected reading time. Thus, Experiment 3B follows up Experiment 3, to provide the necessary assurance that this is not the case. In Experiment 3B, adapted versions

¹³ Similar "delayed" garden path effects are frequently reported in self-paced reading studies (e.g., Yamashita, Stowe, and Nakayama, 1993) and even eye-movement studies (e.g., Traxler, Pickering, & Clifton., 1998). The reason why the predicted effect was found at a frame after the predicted frame in Experiment 3 while no such delayed effect was observed in Experiment 2 may be due to the difference in the instructions we gave to the subjects: Considering the relatively slower reading times in Experiment 2, subjects whose performance appeared slow in the practice session were encouraged to perform a little faster, before proceeding to the real experimental session (see the procedure section of Experiment 3).

of Experiment 3's critical materials are presented in which the material constituting the relative clause is omitted altogether.

4.2.5 Experiment 3B

The frame-by-frame self-paced reading task was again employed to measure processing load on the critical lexical items of Experiment 3B; however, in this experiment, unlike Experiment 3, the sentential context did not include a relative clause structure. As examples (10a-b) below illustrate, the experimental items were simplex sentences with the same matrix verbs and matrix arguments as the corresponding sentences in Experiment 3.

(10)

a.

roojin-ga ryoosintekina bokusi-ni tootoo sutego-o takusukotonisita.
 old man-Nom good priest-Dat finally orphan-Acc decided to entrust
 "The old man finally decided to entrust the orphan to the good priest."

b.

roojin-ga ryoosintekina sisetu-ni tootoo sutego-o takusukotonisita.
 old man-Nom good orphanage-Dat finally orphan-Acc decided to entrust
 "The old man finally decided to entrust the orphan to the good orphanage."

Unlike (7a-b), earlier, the indirect object (e.g., "bokusi", priest; "sisetsu", orphanage) was not modified by a relative clause, and the indirect and direct objects were in canonical rather than scrambled order. The purpose of this experiment was to check whether the pattern of reading time difference observed in Experiment 3 at the noun and adverb positions merely reflected differences stemming from the particular lexical

items employed at the head noun position when preceded by a certain adjective, for example, the plausibility match between the adjective and the noun, rather than costs associated with the establishment of the relative clause structure.

Method

Subjects. Twenty four undergraduate students from Doshisha University participated successfully in the experiment, 12 in each of the two versions of the experiment. All were native speakers of Japanese. Although the subject pool was the same as for Experiment 3, none of the subjects had previously participated in Experiment 3. Subjects typically took 25-30 minutes to complete the experiment.

Materials and Design. The 48 experimental sentences, directly derived from those of Experiment 3, were constructed as 24 pairs. (See Appendix 4 for a full listing of experimental sentences.) The sentences were divided into 6 frames, illustrated in (11a-b) below. The content of all frames was identical across items in a pair, except for Frame 3, which contrasted two types of noun (the animate and inanimate head nouns on which Experiment 3's design had turned).

(11)

a.	Frame 1 roojin-ga old man-Nom	Frame 2 ryoosintekina good	Frame 3 bokusi-ni priest-Dat	Frame 4 tootoo finally
	Frame 5 sutego-o orphan-Acc	takusukotonisita decided to entrust	Frame 6 o	

"The old man finally decided to entrust the orphan to the good priest."

b.	Frame 1 roojin-ga old man-Nom	Frame 2 ryoosintekina good	Frame 3 sisetu-ni orphanage-Dat	Frame 4 tootoo finally
	Frame 5 sutego-o orphan-Acc	takusukotonisita decided to entrust	Frame 6 o	

"The old man finally decided to entrust the orphan to the good orphanage."

An additional 66 sentences served as fillers. The characteristics of the filler sentences departed from those of Experiment 3 in two respects. First, fillers could vary in frame length; that is, some filler sentences had a frame consisting of more than one word in the beginning part of the sentences, and some had a long frame in the middle part of the sentences.¹⁴ Second, there were no deliberately built-in SR relative clause sentences among the filler items, since the experimental items no longer included a modifying relative clause. Just as in Experiment 3, all sentences, including fillers, were accompanied by YES/NO comprehension questions.

Procedure. The procedure was the same as in Experiment 3, except that no additional advice about the speed of the task was given after the practice trials. The experimenter judged that the performance speed of the subjects was in general not problematic.

Data Treatment. Twenty-seven subjects participated in the experiment. Three subjects were rejected for unusually slow reading times, i.e., mean reading times for Frames 1 through 4 greater than 1100 msec. For these frames, an absolute upper cutoff was set at 3000 msec, affecting 1.2% of the data; the cutoff for Frame 5, which contained two lexical words, was set at 5000 msec, affecting 0.7 % of data on this

¹⁴ This length manipulation was a requirement for another experiment which was combined with Experiment 3B.

frame. Data points less than 100 msec were also excluded, and the procedure limiting the impact of occasional extreme values was applied, as in Experiment 3. Reading times for *maru* were not considered in this experiment.

Results and Discussion

Table 4 below shows the mean reading time for each of the five frames of the experimental sentences. In this experiment, the critical materials do not contain relative clauses and hence head noun ambiguity is not at issue; however, for convenience in the comparison with Experiment 3, the nouns in Frame 3 are still referred to as "ambiguous nouns" and "unambiguous nouns", respectively.

Table 4. Mean reading times (in milliseconds) per frame, as a function of noun type

	Frame				
	1 NP-ga	2 Adj	3 N-ni	4 AdvP	5 NP-o + verb
Noun Type					
“Ambiguous”	646	523	602	512	1357
“Unambiguous”	667	528	638	527	1329

The comparison between the two types of sentences yielded no significant difference at Frame 3, the contrasting noun position (e.g., "bokusi-ni"/"sisetu-ni"), $F_1(1,22) = 2.52, p > .10$, $F_2(1,22) = 1.30, p > .10$. In the following frame for the adverbial phrase, (where a 73 msec cost was found in Experiment 3) no significant difference was found

either, $F < 1$ in both subject- and item-based analyses. No significant difference was found at any other frame, $F < 1$ in all analyses.

Though these are all null findings, it appears safe to interpret them in relation to the outcomes of the prior experiments. We conclude that the specific lexical content of the indirect object phrase could not itself have been the source of the reading time differences found in Experiment 3, since those differences disappear when the relative clause modifying the indirect object is omitted. It is reasonable, therefore, to ascribe the differences observed in Experiment 3 to processing associated specifically with relative clause reanalysis.

4.2.6 General Discussion

Experiment 3's critical finding is that when the head noun was preceded by an adjective signaling a relative clause but not its gap position, reading of the noun was faster for role-ambiguous head nouns than for role-unambiguous (THEME-only) nouns.

4.2.6.1 Implication for incremental processing in reanalysis

If reanalysis decisions regarding the type of relative clause were always deferred until the head noun is available, the reading time pattern at the head noun and the final matrix verb would not have differed from that of Experiment 2, i.e., reading time for the ambiguous head noun should have been longer than that for the

unambiguous head noun. Thus we conclude that the reanalysis decision was made at the adjective.

The current results indicate that not only initial parsing decisions but also reanalysis decisions are made without delay. As soon as the incorrect initial single-clause analysis of a relative clause is falsified, a reanalysis decision is made concerning the relative clause structure including the position of the relative clause gap. It could be expected that the parser would find it helpful to wait just a word or two for more relevant information such as thematic compatibility information provided by another modifier and/or the head noun. (Of course there is no *guarantee* that these later words will be any more informative than the initial animacy-neutral adjective, but there is a good probability that they will.) Thematic compatibility information, as we have seen, can be very useful in deciding on the correct relative clause structure and it is in fact in many cases the only useful cue for doing so. The fact that the parser does *not* wait for such information suggests that its decision making is strongly incremental.

4.2.6.2 An argument against structure-based reanalysis choice

We turn now to a somewhat different point. Note that the proposed structure-based principles or strategies discussed in Chapter 3 should in principle predict that the optimal reanalysis would be in fact not to pursue argument relative clauses of any type, but to create adjunct or gapless relative clauses for which all the arguments originally processed as clausemates can remain so in the reanalyzed structure. This is

because these theories assume that the optimal reanalysis amounts to the minimal *structural* reanalysis, in which case it is non-argument relatives that count as optimal.

We did not consider this possibility in the previous experiments, because the content of the head noun should have eliminated the possibility for adjunct or gapless relative clauses. However, the adjectives in Experiment 3 do not limit the possible role for the head nouns to AGENT or THEME. For example, the word string in (7) up to the adjective “ryoosintekina” could continue as follows.

(12)

a. (reason)

roojin-ga	sutego-o	atikoti kiite	sagasita	ryoosintekina
old man-Nom	orphan-Acc	by asking in various places	looked for	good

dooki-o	minna-ga	bakanisita.
motivation-Acc	everybody	made fun of

"Everyone made fun of the good (conscientious) motivation with which the old man looked for the orphan by asking in various places."

b. (manner)

roojin-ga	sutego-o	atikoti kiite	sagasita	ryoosintekina
old man-Nom	orphan-Acc	by asking in various places	looked for	good

hoo-hoo-o	minna-ga	omoidasita.
method/way-Dat	everybody	remembered

"Everyone remembered the good (conscientious) way in which the old man looked for the orphan by asking in various places."

(12a,b) are adjunct relative clauses in which all the constituents prior to the verb are clausemates. The head noun plays reason and manner roles in the relative clause, respectively.

The above mentioned structure-based principles and strategies predict that the parser first postulates a non-argument relative clause at the adjective if possible, because it is a simpler revision. When the head noun is subsequently encountered, it turns out that neither type of the head noun in (7a,b) is compatible with any adjunct reading. Therefore, processing would be disrupted for both head noun types. At this point, for an inanimate head noun, the correct SOR reading would be adopted, because only the THEME role is compatible with the meaning of the head noun. For an animate head noun, both AGENT and THEME are available. By analogy with the results of Experiment 2, we would therefore expect that it would be the ambiguous head noun which is associated with more processing cost, if anything.

Contrary to this, the results indicate that an SR choice was made at the adjective on at least a sufficient proportion of occasions to produce a statistically significant difference. The longer reading times at the role-unambiguous inanimate head noun presumably indicate that the initial choice of SR proved to be incompatible with the AGENT-prohibiting head noun. For the ambiguous head noun, on the other hand, there would be no reason for a conflict because the head noun would just be checked for thematic compatibility with the earlier decision, and the result would be acceptable.

Although this is not definitive evidence, it does make it seem likely that the SR preference at the adjective in Experiment 3, and perhaps also the SR preference at the head noun in Experiment 2, are thematic in origin, not structure-based.¹⁵ If this is so,

¹⁵ The preference might concern grammatical *relations*, e.g., it might favor subject over object gaps (Keenan & Comrie, 1977). This is intermediate between pure structure-based and thematic accounts.

it will require re-thinking of structure-based theories. Possibly, the structure-based preference principles do not apply in Japanese, or perhaps they are outweighed by thematic preferences. Note also that the evidence that adjunct readings are not favored offers some support for the assumption that the sentences in Experiment 2 offered a clean choice between SR and SOR. Assuming, then, that the observed SR preference is thematic in origin, we are not able to establish exactly what thematic principle may be its source. It would be natural to assume, however, that this is related to the thematic hierarchy often observed in linguistics, such that AGENT is more salient than other thematic roles.

4.2.6.3 Implications for the Modularity Hypothesis and universals of parsing

Let us discuss the implications of the experimental data for the Modularity thesis. Fodor (1983) proposed a model of human information processing in which various input systems, or "modules", feed into a central processing system which integrates and organizes information. Fodor was concerned with independence of the language processing system as a whole from other cognitive functions. But under an extended modularity hypothesis it may be proposed that the language processing system is internally decomposed into hierarchically organized modules, such that lexical processing, syntactic processing, and semantic processing are all in separate encapsulated domains.

The garden-path model (Frazier, 1978) is a model of human sentence processing in accord with the concept of modularity. Both syntactic information and

structure-based preference principles or strategies play a privileged role in initially structuring the linguistic input. When encountering structural ambiguity (in which, by definition, syntactic information is not sufficient to choose one analysis), the choice among alternative syntactic structures is made by principles defined in terms of syntactic representations, not by reference to semantic or any higher level information. Thematic or conceptual information is used only after structural decisions are made, in order to evaluate such decisions. Experimental evidence in support of the inability of the parser to access thematic information in on-line resolution of syntactic ambiguity has been reported by Ferreira & Clifton (1986) among others.¹⁶ The prediction would be that, in both Experiments 2 and 3, it would be the unambiguous head nouns that would cause extra processing cost, due to the mismatch that is detected after the SR analysis was chosen by a structure-based preference principle. Obviously this prediction was not borne out in Experiment 2; we have observed that the SR/SOR choice is influenced by a non-syntactic property (thematic compatibility) of the head noun, and that when thematic compatibility information is not available, it is more effortful for the parser to select a reanalysis structure. When this information is available, it does influence reanalysis choice, superseding structure-based preference principles or strategies. The results of Experiment 3 suggest further (though this is not a decisive inference) that even a *preference* for SR, in the absence of syntactic or thematic *information*, is probably a thematic preference for AGENT rather than a

¹⁶ The Ferreira & Clifton study has been criticized on the basis of the inappropriateness of some of the experimental items and uncontrolled verb bias (Tanenhaus, Carlson & Trueswell, 1989; Trueswell & Tanenhaus, 1994). Later experiments with more controlled materials have disconfirmed the early Ferreira & Clifton results (Trueswell, Tanenhaus & Garnsey, 1994; Trueswell, 1996). The garden path effect observed by Ferreira & Clifton to be independent of plausibility was in later experiments reduced at the

structure-based preference (minimize structural revision, avoid erasing domination relations, etc.). (Note that it can still be maintained that wherever syntactic *information* is available, it determines the correct analysis and the order of application of structural biases and thematic biases is not even an issue.) This is contrary to any processing model which entails strict two-stage application of syntactic biases and then thematic related biases, with precedence of syntactic ones. In such a model, when syntactic information is not available to make the choice, syntactic preferences would apply first and only afterwards would the parser exercise thematic preference or respond to a plausibility mismatch between the head noun and verbal thematic role information.

This appears to pose a challenge for a strict Modularity Hypothesis for Japanese parsing. Because modularity is such a central issue in psycholinguistics, it is important to be clear about whether the data from Experiments 1, 2 and 3 do conflict with modularity or not. This section ends with three ways in which the data might be reconciled with modularity.

One possibility is to adopt the weak-interaction hypothesis (Crain & Steedman, 1985), whereby alternative syntactic structures at the point of ambiguity are proposed by the syntactic processor, and the semantic or thematic processor makes the choice among the proposed alternatives. Non-syntactic information is taken into consideration in choosing one analysis over alternative possibilities, sometimes overriding structure-based preference principles such as Minimal Attachment. In the types of Japanese relative clauses currently under consideration, the post-verbal adjective or head noun does provide syntactic information that some type of relative

syntactic disambiguating region, presumably by suppression of the structurally simpler analysis by thematic influences.

clause must be constructed, i.e., a head noun must be associated with some position within the relative clause via a relative clause gap. What hinders the parser is a lack of information as to what kind of relative clause structure must be constructed, i.e., with what position in the relative clause the gap should be associated. All the syntax can do at this point is to propose possible alternative gap positions corresponding to different types of relative clause structures, including SR and SOR. Modularity is preserved because it is only then that thematic compatibility information comes into play in selecting the most plausible gap role. Thematic information may choose the most plausible analysis before any structure-based choice preference principles apply. This approach would presumably not be acceptable, however, within a standard garden-path model in which the choice between the two syntactic alternatives is assumed to be resolved on the basis of whatever syntactic preferences are applicable.

A different way to reconcile the Japanese data with modularity would be to assume that the structure-based preferences observed for English and related languages do not apply at all in Japanese or at least, do not apply to relative clauses. Thus thematic information and thematic preferences would determine the choice of analysis wherever clear syntactic disambiguation is absent. Why should this be so? The reason is not known, but it could be conjectured to be related to the frequent absence of syntactic disambiguation in Japanese, especially in relative clause constructions. Possibly the whole structure-based parsing component clauses down in such constructions. Or possibly no structure-based preferences develop for the language because they would be inefficient compared with thematic plausibility considerations.

If this approach is correct it implies that languages can differ with respect to the information sources that control their parsing. This might be due to the setting of a parsing parameter (cf. Mazuka & Lust, 1990; Gibson, Pearlmutter, Canseco-Gonzalez, & Hickok, 1996; Weinberg, 1993), or to experience-based tuning of the system for optimum efficiency (Mitchell, 1994; Mitchell & Cuetos, 1991). In either case, this way of reconciling modularity with the findings for Japanese would call for attention to the general issue of cross-linguistic differences in parsing.

Finally, the violation of modularity in Japanese may be only apparent, because the experimental findings concern reanalysis. If thematic information becomes accessible after syntactic processing on the first pass, it could be available for second-pass processing as soon as reanalysis has been triggered. This could be claimed while maintaining delayed use of thematic information by the first pass processing mechanism as in standard garden-path models which give priority to structural considerations. By its nature, reanalysis involves operations on an already computed phrase-marker, over which thematic processes have had an opportunity to run. In relative clause processing, the argument structure associated with the verb which will be reanalyzed from matrix verb to embedded verb has already been accessed, and the basis for exploiting thematic information is therefore potentially available to ongoing processing. Clifton (1993) specifically argues within the framework of a garden-path model that correct reanalysis would be facilitated by thematic information not available at the first-pass stage. Our data showing that thematic role information plays a primary role in making reanalysis choices in Japanese may thus be fully compatible

with strict modularity in all languages (without parameterization) for first-pass parsing.

We must leave these ideas to be evaluated in further research comparing first-pass parsing and reanalysis, for a variety of languages and constructions.

4.2.6.4 Teasing apart the thematic-indecisiveness and the competing-preferences accounts

We noted earlier (section 4.2.3.2) that the ambiguity cost observed at the head noun in Experiment 2 could be due *either* to indecisiveness between two plausible thematic roles, *or* to competition between a thematic AGENT preference and a structural object-gap preference (or dividing the original clause after the overt object). None of the preceding experiments were designed to judge these alternative explanations. With suitable material, however, they could be evaluated experimentally. First, note some essential assumptions of each of the accounts. The thematic-indecisiveness account would predict that the indecisiveness effect would not show up as long as the head noun is role-unambiguous, whether the only possible role compatible with the head noun is THEME or AGENT. In contrast, the competing-preferences account would have to predict a processing cost due to competition wherever the only possible thematic role for an unambiguous head noun does not coincide with the preferred syntactic structure (which, as noted earlier, has to be assumed to be SOR). So, testing an AGENT-only unambiguous head noun can be

informative. Comparing the following three types of sentences should eliminate one or the other of the two possibilities.

(13)

a. SR, head noun ambiguous on-line between AGENT/THEME of “look for”:

Makoto-ga hihyoo-o koogi-no ato sagasiteita kyooju-ni dekuwasita.
 -Nom review-Acc after class was looking for professor-Dat bumped into
 “Makoto bumped into the professor who was looking for the review after the class.”

b. SR, head noun can only be AGENT of “write”:

Makoto-ga hihyoo-o koogi-no ato kaiteita kyooju-ni dekuwasita.
 -Nom review-Acc after class was writing professor-Dat bumped into
 “Makoto bumped into the professor who was writing the review after the class.”

c. SOR, head noun can only be THEME of “write”:

Makoto-ga hihyoo-o koogi-no ato kaiteita repooto-ni noseta.
 -Nom review-Acc after class was writing report-Dat put onto
 “Makoto put the review onto the report that he was writing.”

(13a,b) are both SR sentences sharing the same animate head noun but contrasting with respect to the meaning of the relative clause verb. The animate head noun could be either AGENT or THEME of “sagasiteita” (was looking for) in (a), but can only be AGENT of “kaiteita” (was writing) in (b). (13c) is an SOR sentence, in which the inanimate head noun “repooto” (report) can only be the THEME for the same embedded verb “kaiteita” as in (b).

For processing the head noun of these three types of sentences, the thematic-indecisiveness account would predict an indecisiveness effect for (a) only. For (b) and (c), the thematic processor can make its decision immediately: since thematic compatibility determines a unique syntactic structure (SR for (b), and SOR for (c)), the

processing of the head noun would proceed easily compared with (a). In short, the reading time pattern at the head noun for the three types of sentences should be $(a) > (b) = (c)$, other things (such as idiosyncratic differences between lexical items) being equal.

The competing-preferences account makes different predictions. On the basis of Experiment 2's data it was concluded that a structure-based default preference compatible with this account would have to be for SOR. Therefore, there should be a competition effect at the head noun in (b), since the only possible thematic role for the head noun is AGENT, which is compatible only with SR. The same competition should be found in (a). This is because, in order to explain Experiment 2's result, this account has to assume a thematic-based bias toward AGENT for role-ambiguous nouns. The only case without any competition should be (c), in which the thematic role can only be THEME, which is in accord with the structure-driven bias toward SOR. The predicted pattern of processing cost at the head nouns in the three types would therefore be $(a) = (b) > (c)$, as long as no other factor affects the reading times for the head nouns in the sentences of each type.

This experiment has not yet been conducted, but is planned for future research.

4.3 Conclusion

We started with the question of whether plausibility relations between nouns and thematic roles is the cause of informally observed difficulties in processing SOR relative clause structures. Experiments 1 and 2 found facilitation of an SOR by early

thematic resolution, and at the same time failed to find a significant difference in processing difficulty between SR and SOR sentences when SOR sentences were not troubled by thematic ambiguity. Based on these results, we argued against the parse-failure account of SOR sentences: SOR sentences can be relatively easy when the information provided by the head noun uniquely specifies an SOR structure. Only a garden-path account is consistent with these findings.

In Experiment 2, we have also shown that this complicating effect of thematic role ambiguity arises at the very site of ambiguity, i.e., the head noun, suggesting that the SR/SOR reanalysis decision is being made there. In contrast, in Experiment 3, the ambiguity cost disappeared when the head nouns were preceded by a thematically uninformative adjective. Based on the outcomes of Experiments 2 and 3 together, we argued that the parser makes use of thematic compatibility information when it is available, no later than the application of structure-based preference principles (if any). Thus, one conclusion is that structure-based preferences are not the primary means of resolving relative clause ambiguity in Japanese. Another conclusion to be drawn is that, when thematic compatibility does not select a unique reanalysis, the parser does not delay its reanalysis decision-making (until the next word); it appears that parsing is incremental in the reanalysis stage as well as in the first-pass stage.

The insignificance of structure-based preferences in Japanese relative clause processing is a challenging fact. Though there may be a structure-based SR preference which applies following the use of any available thematic disambiguating information, we have argued that even an SR-preference may be thematic in origin (favoring AGENT gaps). This is because any structure-based considerations that would favor

SR over SOR should also favor adjunct-gap or gapless relative clauses over SR, but the experimental data (Experiment 3) do not support the latter prediction: SR is computed even in some cases where an adjunct gap would have been possible.

The apparent predominance of thematic considerations may be characteristic of reanalysis processing, or possibly of Japanese processing as compared with other languages such as English, or it might be construed as evidence for “weak interaction” rather than the strict structure-orientation of standard garden-path theories. This needs to be pursued in further research, and so do some further empirical facts such as the relative difficulty of SR and SOR structures when *both* are disambiguated at the head noun, and whether there is an advantage for an unambiguous noun if it is unambiguously an AGENT (cf. unambiguous THEME in the experiments above). The latter points bears on the question of whether SR is selected by the parser only some of the time, or almost all of the time. The current results leave this open. However, a later chapter will provide more support for the assumption that the human parser has a default preference for SR.

CHAPTER 5

AN EFFECT OF CONSTITUENT LENGTH ON RELATIVE CLAUSE PROCESSING

5.1 Introduction

Our general goal has been to find out (i) whether SR is always easier than SOR; (ii) if so, why; (iii) if not, under what circumstances SOR is easier. All of this is in order to discover the nature of the operations by which Japanese relative clauses are parsed, and in particular how the human parser deals with ambiguity within reanalysis.

The experimental results reported in Chapter 4 revealed that in resolving the SR versus SOR ambiguity, thematic compatibility information can play an important role. We have observed that SOR can be processed easily by virtue of thematic compatibility information provided by the head noun, if it uniquely chooses the SOR structure. However, it is still not clear what the status of the SOR structure is, in the absence of thematic compatibility information. Although it has been widely accepted by researchers that the SOR structure is more costly to process, native intuitions are not quite in agreement with the prediction that the SOR reanalysis is associated with a heavy processing cost, even if we limit attention now to cases in which the head noun of the relative clause is ambiguous.

Native speakers consulted informally agree that the SOR sentence shown in (2) are not necessarily more difficult than the SR sentence shown in (1). Some informants even report a preference for the SOR structure; that is, they report experiencing a garden path in reading (1), and not in reading (2). This is seemingly inconsistent with the observation of Mazuka & Itoh (1995), which was introduced in Chapter 3. This reported preference for SOR cannot be accounted for in terms of the kind of thematic factor proposed in Chapter 4, since the head noun “yuujintati” (friends) is compatible with both an EXPERIENCER role and a THEME role for the verb “sinyoosita” (trusted).

- (1) Morisita-ga [e_i sinyaku-o kokorokara sinyoosita]
 Morisita-Nom new medicine-Acc truly trusted
- yuujintati;-ni tootoo atta.
 friends-Dat finally met

“Morisita finally met the friends who truly trusted the new medicine.”

- (2) Morisita;-ga sinyaku-o [e_i e_j kokorokara sinyoosita]
 Morisita-Nom new medicine-Acc truly trusted
- yuujintati;-ni tootoo miseta.
 friends-Dat finally showed

“Morisita finally showed the new medicine to the friends whom he truly trusted.”

Interestingly, an intuitive preference for SR becomes stronger if the sentence-initial matrix subject NP “Morisita-ga” is changed into a conjoined NP such as “Hosokawa-to Morisita-ga” (Hosokawa-and Morisita-Nom), as shown in (3) and (4) below.

- (3) Hosokawa-to Morisita-ga [e_i sinyaku-o kokorokara
 Hosokawa-and Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujintati_i-ni tootoo atta.
 trusted friends-Dat finally met
- “Hosokawa and Morisita finally met the friends who truly trusted the new medicine.”

- (4) [Hosokawa-to Morisita]_i-ga sinyaku-o [*pro*_i e_j kokorokara
 Hosokawa-and Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujintati_j-ni tootoo miseta.
 trusted friends-Dat finally showed
- “Hosokawa and Morisita finally showed the new medicine to the friends whom they truly trusted.”

Informal judgments indicate that when “Hosokawa-to” is added to the initial nominative NP, the preference for the SR reading seems to increase. This influence on SR/SOR preference, by the internal composition of the subject, is not predicted by any of the parsing models discussed in Chapter 3. Investigation is needed to determine what the effective difference between a simple subject and a conjoined subject actually is, and how that difference could be responsible for the choice between SR and SOR structures. It may be the number of words or referents to be processed, or the syntactic structure of the subject NP. However, in the present chapter we will refer to it as an effect of length, while cautioning that structural and semantic correlates of added length may also be relevant. In chapter 6 we will propose that what underlies the length effect is prosodic phrasing in silent reading. For convenience in later discussions, we hereafter mark the lexical accent patterns in all examples, although we do not discuss prosodic factors

throughout this chapter. A lexically accented mora is indicated with an apostrophe following the accented vowel.

In this chapter, we focus on this length factor that can apparently influence the SR versus SOR preference, holding constant the thematic influence discussed in chapter 4. We will present data showing that when the sentence-initial nominative NP consists of two conjoined nouns, the preference toward SR is quite robust, while this preference is weakened (or even an SOR preference sometimes emerges) when the initial nominative NP is just a simple noun plus case marker. Other ways of lengthening the subject (e.g., inclusion of adjectives) have not been tested. So, there is no way as yet to establish whether the length effect on SR/SOR preference is intrinsic to the “-to” conjunction structure *per se* (but see footnote 5 below). However, the working assumption adopted in this chapter (and discussed in Chapter 6) is that the coordination of NPs has a negligible effect on any other aspect of the sentence besides constituent length. It is anticipated, then, that the length effect should in principle hold also for other ways of lengthening the subject, to the extent that other factors can be held constant. Independent evidence of a length effect on the processing of a different construction (one-word and two-word adjective phrases) will be discussed later in section 5.4. Informal observations of effects of constituent length on parsing are familiar since Frazier & Fodor (1978).

In sections 5.2 and 5.3 we report data from two experiments (Experiment 4 and Experiment 5) which establish the existence of a length effect on the reanalysis choice between SR and SOR structures. In Experiment 1 of Chapter 4, the lengths of constituents were controlled within pairs of experimental sentences, but not across pairs. Crucially, in Experiments 4 and 5 the phrase length of the initial subject NP is

manipulated (to contrast a simple NP with a conjoined NP) while the phrase length of following constituents is controlled so that these are always a single lexical word.

Experiment 4 (reported in 5.2) is a sentence completion study, which investigates the likelihood of SR choice as a function of the length of the initial nominative NP.

Experiment 5 (reported in 5.3) is an on-line self-paced reading experiment, examining reading times for a word that disambiguates toward the SR structure, when the initial nominative NP was a single noun versus a conjoined NP.

5.2 Experiment 4

Patterns of SR/SOR preference were examined in an off-line sentence-completion study using sentence fragments as illustrated in (5) and (6) below.

- (5) Mori'sita-ga si'nyaku-o kokoro'kara
 Morisita-Nom new medicine-Acc truly
 sinyoosita yuujin'tati-ni tootoo
 trusted friends-Dat finally
- (6) Hosokawa-to Mori'sita-ga si'nyaku-o kokoro'kara
 Hosokawa-and Morisita-Nom new medicine-Acc truly
 sinyoosita yuujin'tati-ni to'otoo
 trusted friends-Dat finally

Fragments in a pair were identical except that one had a subject NP consisting of a single noun (simple subject), and the other had a subject NP consisting of conjoined NPs (conjoined subject). Both fragments ended at the adverb following the head noun

(marked with a dative case marker *-ni*) of a relative clause, so that respondents in the sentence-completion task were obliged to add at least a main verb to create a complete well-formed sentence. The fragments were ambiguous as to whether an SR structure or an SOR structure was required; the head noun given in the fragments ("yuujin'tati", friends, in (5) and (6)) was compatible with either structure.

The structure assigned to a sentence fragment by a respondent in the sentence-completion task could be determined on the basis of the final verb that was added. The structure must have been an SR if the sentence was completed with a dative-object matrix verb such as "a'tta" (met) as in an example of a completed sentence shown in (7) below; because "a'tta" cannot take an accusative object, the accusative NP-o given in the fragment ("si'nyaku-o", new medicine-Acc) must be in the relative clause, not in the matrix clause.

- (7) (Hoso'kawa-to) Mori'sita-ga [e_i si'nyaku-o kokoro'kara
 (Hosokawa-and) Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujin'tati;-ni to'otoo a'tta.
 Trusted friends-Dat finally met

“(Hosokawa and) Morisita finally met the friends who truly trusted the new medicine.”

An SR structure could also be inferred if the sentence was completed with a ditransitive verb if an additional accusative object NP was provided in the completion response, as in the example (8).

- (8) (Hoso'kawa-to) Mori'sita-ga [_i si'nyaku-o kokoro'kara
 (Hosokawa-and) Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujin'tati;-ni shohoosen-o to'otoo okutta.
 trusted friends-Dat prescription-Acc finally sent

“(Hosokawa and) Morisita finally sent the prescription to the friends who truly trusted the new medicine.”

An SOR analysis must have been adopted if the fragment was completed with a ditransitive matrix verb such as "mi'seta" (showed) and no additional argument, as in (9) below, because then the NP-o in the given fragment is obligatorily a matrix constituent.¹

- (9) [(Hoso'kawa-to) Mori'sita];-ga si'nyaku-o [*pro*_i e_j kokoro'kara
 (Hosokawa-and) Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujin'tati;-ni to'otoo mi'seta.
 trusted friends-Dat finally showed

“(Hosokawa and) Morisita finally showed the new medicine to the friends whom he (they) truly trusted.”

If there is a preference for SR, as discussed in Chapter 3 (when the choice is not biased by the head noun), an overall bias toward SR interpretations would be expected in this experiment, with a preponderance of completions such as (7) and (8), independent of the length of the sentence-initial NP-ga phrase. If informal intuitions are correct, however, there should be more SR completion for the conjoined subject fragments than for the simple subject fragments.

¹ Given the availability of a discourse-bound null-pronoun in Japanese, as discussed in chapter 2, it would be possible to interpret the word string corresponding to (9) (“Mori'sita-ga si'nyaku-o kokoro'kara sinyoosita yuujin'tati-ni mi'seta”) to mean “Morisita showed *pro* to the friends who truly trusted the new medicine”. However, it would not be very natural to interpret isolated experimental sentences with a discourse-bound *pro* in the absence of any preceding discourse.

Method

Subjects. Eighteen undergraduate and graduate students of Nagoya University and Nanzan University, all native speakers of Japanese, volunteered for the experiment. Nine subjects were assigned to each of two versions of a sentence-completion questionnaire, which took 30-40 minutes to fill out.

Materials. The experimental materials were 12 pairs of sentence fragments as illustrated in (5) and (6) above. (See Appendix 5 for a full listing of experimental fragments.) Sixty filler fragments were also included in the experiment. Twenty-four of the fillers had an adjective phrase (AP) modifying a complex noun phrase, and like the experimental items, were constructed as 12 pairs (one-word versus two-word APs); only half of these appeared in any version of the questionnaire.² The remaining 48 fillers were pure fillers of varying length and structure, and were identical across the two versions of the experiment.

A basic item order was prepared, with filler items interspersed among experimental items so that the experimental items were never consecutive. The experimental materials (12 pairs, thus 24 items) were distributed over the experiment in two versions in a counterbalanced design, so that the 12 experimental items within any version were made up of 6 instances of each of two conditions (defined by the length of

² These fillers constitute the experimental items of a different study that is not included in this dissertation. An example fragment pair is shown in (i) and (ii) below.

- | | | | | | |
|------|---------------------|---------------------|------------------------|------------------------------|------------------------------|
| (i) | kawairasi'i
cute | e'nji-no
kid-Gen | ri'bon-o
ribbon-Acc | fuku'ya-ga ...
tailor-Nom | |
| (ii) | tai'soo
quite | kawairasi'i
cute | e'nji-no
kid-Gen | ri'bon-o
ribbon-Acc | fuku'ya-ga ...
tailor-Nom |

the subject phrase), without repetition of sentential content.

The sentence fragments were printed on three A4 pages (24 items per page) in 12 point *Hosominchoo* font. An attached cover page included the instructions, three sample sentence fragments that were not part of the real experiment, and a blank column in which the subjects were asked to write down the time they started and the time they completed the task.

Procedure. Subjects were instructed to complete each fragment by inserting words in a bracketed space following each item, so as to create a grammatical sentence. Each subject completed the questionnaire individually without interruption in a quiet place. They were told that the main purpose of the experiment was to assess how native speakers of Japanese typically complete sentence fragments, rather than testing any type of language skill, and that they just should write down any linguistic material that came to mind first. They were also instructed not to go back to and change their responses to fragments they had already completed. There was no stated limit for the number of words that could be added, but the space allowed in fact could accommodate roughly three words at most. In order to discourage the subjects from spending excessive time on any one item, they were told that the time taken to perform the task was of interest, and were asked to record the time they started and the time they finished. None of the subjects took more than 40 minutes and all subjects' data were included in the analysis.

Data Treatment. Subjects' sentence completion responses were coded in terms of the structural assignment (SR or SOR) that their content implied. Ditransitive verbs that require an accusative NP as argument were coded as SOR responses unless the response included an additional accusative NP for the matrix object. Monotransitive verbs that

cannot take an accusative NP were coded as SR responses, as were ditransitive verbs with an accusative object as part of the response. Ungrammatical responses, such as those with an argument structure mismatch, were omitted from the analysis; this amounted to 1.4% of the responses.

Some completion responses were ambiguous with respect to the SR/SOR classification that was the focus of the analysis. This occurred when the verb added by a respondent was one that optionally takes an accusative object NP-o phrase. For the fragments presented in (5) and (6) above, for example, completion with the verb “yakusokusita” (promised) would illustrate this kind of ambiguity. This verb can take the NP-o phrase given in the fragment as its direct object, for an SOR interpretation with the meaning “promised the new medicine to the friends”. Alternatively, it can occur without any NP-o, for an SR interpretation with the meaning “made a promise to the friends”; in this case, the NP-o would be in the relative clause. In all such ambiguous cases, the respondent was consulted after the task, and the response was included in the data only if a clear interpretation was immediately provided; otherwise, the response was omitted from the analysis. In all, 5.6% of responses were excluded on grounds of unresolved ambiguity.

In total, then, 201 responses (93% of the 216 possible) were available for analysis after instances of ungrammaticality and ambiguity were excluded.

Results and discussion

The data are presented in Table 5 below.

Table 5. Percentage of sentence-completion responses showing SR and SOR interpretations

Fragment Type	Interpretation	
	SR	SOR
Simple subject	55	45
Conjoined subject	73	27

A comparison across fragment types revealed that SR completion was more likely for fragments with two-word subjects than for those with one-word subjects, $t_1(17) = 2.27$, $p < .05$, $t_2(11) = 4.71$, $p < .001$. The likelihood of SR interpretation significantly exceeded 50% only for the two-word subject type, $t_1(17) = 6.85$, $p < .001$, $t_2(11) = 2.75$, $p < .025$; for the one-word condition, the likelihood of SR interpretation did not differ from 50%, $t_1(17) = 0.85$, $p > .25$, $t_2(11) = 0.61$, $p > 0.25$. The results support an effect of constituent length on the choice between SR and SOR structures in reanalysis from a main to a relative clause.

A more detailed look at the issue of constituent length is provided by Experiment 5, which employed an on-line task utilizing complete sentences in which the reanalysis ambiguity was resolved by the presence of an accusative NP following the head noun of the relative clause, which forced the SR structure.

5.3 Experiment 5

The same contrast (simple versus conjoined subject) was tested as in Experiment 4, and the materials differed only in that the experimental items were complete sentences,

all disambiguated toward the SR structure.³ A frame-by-frame self-paced reading task was employed to measure processing load at the disambiguation point. The materials are illustrated in (10) and (11). (See Appendix 6 for a full listing.)

- (10) Mori'sita-ga [e_i si'nyaku-o kokoro'kara
 Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujin'tati;-ni shohoosen-o okutta.
 trusted friends-Dat prescription-Acc sent

"Morisita sent the prescription to the friends who truly trusted the new medicine."

- (11) Hosokawa-to Mori'sita-ga [e_i si'nyaku-o kokoro'kara
 Hosokawa-and Morisita-Nom new medicine-Acc truly
 sinyoosita] yuujin'tati;-ni shohoosen-o okutta.
 trusted friends-Dat prescription-Acc sent

"Hosokawa and Morisita sent the prescription to the friends who truly trusted the new medicine."

The sentences were temporarily ambiguous with respect to whether SR reanalysis or SOR reanalysis was required; disambiguation was provided by an accusative NP (e.g., "shohoosen-o", prescription-Acc) following the head noun. This NP cannot be a co-argument of the earlier accusative NP (e.g., "sinyaku-o", new medicine-Acc) in the same

³ An experiment addressing the same question could in principle be designed with SOR-disambiguated sentences, in which a sentence-final ditransitive verb disambiguates the structure. We avoided such design and instead employed sentence pairs disambiguated toward SR by an overt accusative NP preceding the matrix verb. There are two reasons for this.

If our prediction for this experiment is correct, SOR-disambiguated sentences should show a greater processing cost when the initial subject is conjoined, than when it is a single noun. But the results may be ambiguous between this predicted cost and the potential cost associated with the conjoined-subject sentences which can be independently predicted simply due to the accumulated processing load as a function of distance from the beginning of the sentence.

Also, the sentence-final matrix verb is not in fact desirable as a critical point of measurement, because potential sentence wrap-up effects may muddy the results. In the present experiment we chose to test sentence pairs disambiguated toward SR by an overt accusative NP preceding the matrix verb.

clause since there cannot be two accusative arguments in the same clause. The second accusative NP cannot be in the relative clause, and so would most likely attach in the direct object position in the matrix clause. If the first accusative NP was analyzed as a matrix clause constituent (as in the SOR analysis), this would force the first accusative NP to be reanalyzed as a relative clause constituent.⁴ Hence the SR structure will be constructed.

Method

Subjects. Twenty-four undergraduate students of Nagoya University and Doshisha University, native speakers of Japanese, and naive with respect to the purpose of the experiment, participated successfully in the experiment, 12 in each of two versions of the experiment. Subjects typically took 25-30 minutes to complete the task.

Materials and Design. The lexical content of experimental sentences was divided into 3 frames; a maru appeared as the fourth and final frame. Frame 1 was a long chunk in which everything from the first word to the head noun was presented together, and consisted of 5 words for the simple subject sentences and 6 words for the conjoined subject sentences. Frame 2 was the accusative NP that resolved the SR/SOR ambiguity by eliminating the SOR possibility. Frame 3 was the matrix verb, in all cases a ditransitive verb which confirmed that the SR analysis must be correct: the sentence-

⁴ Strictly speaking, the second accusative NP “shohoosen-o” does not completely disambiguate the structure because it could be part of an embedded clause: either it begins a new embedded clause such as an adverbial clause, or it is a co-argument to the complex NP [kokoro’kara sinyoosita yuujin’tati]-ni (the friends who truly trusted *pro*) in an embedded clause. For these analyses, there would be a certain amount of processing cost in building another clause, which would result in longer RT, compared with when there is no conflict to resolve between the two accusative NPs (because an SR analysis was selected earlier). However, we do not regard it as likely that the parser considers such structures on-line. In any case, they would not weaken the test of the hypothesis of interest in Experiment 5.

initial nominative NP that was expelled from the relative clause is the matrix subject; the dative NP which is modified by the relative clause is the matrix indirect object; and the accusative NP which immediately preceded the matrix verb is its direct object. The position of interest in this experiment was Frame 2. Whenever the initial reanalysis choice that the parser makes on encountering the head noun is SOR, a garden path would result at the second frame; possibly, garden path effects might also spill over to the third frame. If the parser adopts the SR analysis initially, no such garden path will occur.

There were 16 pairs of experimental sentences selected by a plausibility pretest described below. (Six of the pairs were based on the materials used in Experiment 4, and were constructed by completing the fragments with an accusative NP and a verb; occasionally modification was made in the tense or aspect of the embedded verb to match with those of the matrix verb. Ten experimental pairs were entirely new.) For all pairs, the two sentences were identical except for the presence of the NP-to in the two-word subject version, so that at Frames 2 and 3 where the reading time measurements of interest were made, the comparison was across identical words.

An additional 88 sentences varying in sentence length, structure, and frame length were constructed as fillers for the experiment. Since all the experimental items contained SR relative clauses, 16 SOR-type sentences were included among the filler items, to avoid biasing subjects toward the SR reading. Also, 24 filler sentences contained a conjoined NP structure (NP-to NP), at various positions, so that the experimental sentences in the two-word subject condition would not stand out from other sentences.

The experimental materials were distributed to form an experiment in two versions in a counterbalanced design, so that the 16 experimental items within any

version were made up of 8 instances of each of the 2 conditions, without repetition of sentential content. Each version of the experiment contained 104 items (16 experimental, and 88 filler), and these were presented in a randomized order. Eight additional items were prepared for a practice session preceding the experiment proper.

For all sentences used in the experiment, including fillers, comprehension questions were prepared, to which a YES/NO response was required, as in Experiments 1, 2, 3 and 3B of Chapter 4. The purpose and characteristics of the comprehension questions were the same as those of other self-paced reading experiments in this dissertation.

A preliminary norming test was conducted to assess the plausibility of the content expressed by each of the two types of relative clause at issue, i.e., those involving SR and SOR interpretations. These contents were expressed as simplex sentences. For example, (12) paraphrases the relative clause reading required for the SR interpretation of (10) and (11); the difference in the length of the matrix subject is not relevant here because the matrix subject NP is not part of the relative clause construction. (13) paraphrases the relative clause reading required for the SOR interpretation of (10); (14) does the same for (11), and thus (14) is identical to (13) except for the presence of the NP-to phrase.

- | | | | | |
|------|---|--------------------------------|----------------------|------------------------|
| (12) | Yuujin'tati-ga
friends-Nom | si'nyaku-o
new medicine-Acc | kokoro'kara
truly | sinyoosita.
trusted |
| | “The friends truly trusted the new medicine.” | | | |
| (13) | Mori'sita-ga
Morisita-Nom | yuujin'tati-o
friends-Acc | kokoro'kara
truly | sinyoosita.
trusted |
| | “Morisita truly trusted his friends.” | | | |

- (14) Hosokawa-to Mori'sita-ga yuujin'tati-o kokoro'kara sinyoosita.
 Hosokawa-and Morisita-Nom friends-Acc truly trusted
 "Hosokawa and Morisita truly trusted their friends."

For the plausibility test, a superset of 72 items was constructed, consisting of 24 such triplets. These were counterbalanced over three lists, each containing 24 test items and 48 filler sentences. Items were rated for plausibility on a 7-point scale (1: a very plausible, familiar situation; 7: a very implausible, unfamiliar situation) by 15 native speakers of Japanese, none of whom participated in the main experimental session or any other experiment reported in this dissertation.

For the main experiment, we selected for use as experimental items those 16 sentence pairs for which the corresponding triplets showed rating scores that differed among conditions by less than 0.5 rating points. The mean rated plausibility for the SR, SOR (one-word subject), and SOR (two-word subject) paraphrases of the final item set was 1.19, 1.29, and 1.27, respectively.

Procedure. The procedure of the experiment was the same as the other self-paced reading experiments reported earlier in this dissertation (Experiments 2, 3, and 3B). Additional advice about reading speed (see Experiment 3 procedure) was given to the subject after the practice items when the experimenter observed that a subject's performance during the practice session was unusually slow.

Data Treatment. Thirty-one subjects in all participated in the experiment; of those, the data of 7 were rejected from the analysis. The criterion for rejecting subjects on the basis of their error rate on YES/NO questions was the same as the other experiments reported earlier in Chapter 4 (Experiments 1, 2, 3 and 3B): Two subjects with error rate greater than 15% were rejected. Five further subjects were rejected because their mean reading

times for Frames 2 and 3 were greater than 1400 msec, approximately twice as long as the mean reading time of the remainder of the subjects.

For Frames 2 and 3, an absolute upper cutoff was set to 4000 msec, affecting 0.8% of the data. The absolute cutoff value for Frame 1, consisting of 5 or 6 words, was established separately: reading times greater than 10000 msec were rejected, affecting 1.2% of the data. The absolute lower cutoff was the same as earlier experiments, 100 msec. After these extreme values were eliminated, the standard 2SD treatment was applied to limit the impact of outliers, as in the other experiments.

Results and discussion

Table 6 below summarizes reading times for the three frames (before the maru) in the two experimental sentence types. Frame 1 begins the sentence, and includes the head noun and all preceding phrases; Frame 2 presents the NP-o phrase which disambiguates the structure in favor of the SR interpretation; and Frame 3 presents the sentence-final matrix verb which confirms the SR interpretation.

Table 6. Mean reading times (in milliseconds) per frame, as a function of sentence type

Sentence Type	Frame		
	1	2	3
Simple subject	4732	720	669
Conjoined subject	5293	634	598

For the initial frame, reading time was longer for sentences with two-word subjects, $F_1(1,22) = 13.86$, $p < .005$, $F_2(1,14) = 10.86$, $p < .01$, as could be expected. At Frame 2, which is the position of major interest, reading time for the accusative NP phrase was longer by 86 msec for the one-word subject version than for the two-word subject version, $F_1(1,22) = 6.66$, $p < .025$, $F_2(1,14) = 7.31$, $p < .025$. A difference in the same direction and only a little smaller (71 msec) was observed in reading times for the following matrix verb but neither analysis reached conventional levels of significance, $F_1(1,22) = 2.84$, $p > .10$, $F_2(1,14) = 2.71$, $p > .10$.

The results indicate that processing cost for the matrix accusative NP in Frame 2 (with some spillover to Frame 3's verb) is greater in the case of simple subject sentences than in the case of conjoined subject sentences. It is reasonable to interpret this data pattern as an indication of the relative frequency of an SOR choice, leading to a garden path, in simple vs. conjoined subject sentences. Reanalysis from SOR to SR, with its attendant processing cost, is apparently more common in the former sentence type than in the latter. We conclude that for conjoined subject sentences, more than for simple subject sentences, the initial choice of relative clause structure (made at the head noun) was SR. The findings here reinforce those in Experiment 4, namely, that SR preference is greater for conjoined subjects than for simple subjects.

5.4 Effect of length on another construction type (Hirose, Inoue, Fodor, & Bradley, 1998)

Our working assumption has been that it is the relative lengths of the two phrase types that is responsible for the difference between simple subjects and conjoined

subjects observed in Experiments 4 and 5. It will be important in further research to eliminate the possibility that what matters is in fact something peculiar to the syntactic or semantic structure of a conjoined NP as compared with that of a simple NP. This dissertation does not include such studies. However, Chapter 6 provides a rationale for the length effect, which contributes to its plausibility. And an earlier study by Hirose, Inoue, Bradley & Fodor (1998) demonstrates an effect of constituent length in a quite different Japanese construction, which provides some corroborating evidence for the significance of constituent length in parsing. (See also Frazier & Fodor, 1978, for informal judgments of length-related phenomena in a variety of constructions in English.)

Hirose et al. (1998) tested four versions of an [AP + N1-Gen + N2] construction, in which the semantic compatibility of the AP with N1 or N2 was manipulated, and the length of the AP was varied by the presence or absence of an adverb modifying the adjective. For the short APs, a sentence adverb was included at the beginning of the clause, to compensate for the extra word in the long APs. Note that the two types of adverbs (modifying adjective and modifying sentence) were both completely unambiguous. Structurally, the adjective could modify either N1 or N2, though both readings were not always semantically coherent. Examples are shown in (15).

(15)

a.	nishuukan ma'e two weeks ago	usugura'i dim	suna'kku-no bar-Gen	ho'sutesu-o hostess-Acc
	Satoru-ga Satoru-Nom	bujokusita . insulted		

N1 association interpretation only : "Two weeks ago Satoru insulted the hostess of the dim bar."

- b. nishuukan ma'e hinnona'i suna'kku-no ho'sutesu-o
 two weeks ago unsophisticated bar-Gen hostess-Acc
- Satoru-ga bujokushita .
 Satoru-Nom insulted

N1 association interpretation: "Two weeks ago Satoru insulted the hostess of the unsophisticated bar."

N2 association interpretation: "Two weeks ago Satoru insulted the unsophisticated hostess of the bar."

- c. nantona'ku usugura'i suna'kku-no ho'sutesu-o
 somewhat dim bar-Gen hostess-Acc
- Satoru-ga bujokushita .
 Satoru-Nom insulted

N1 association interpretation only : "Satoru insulted the hostess of the somewhat dim bar."

- d. nantona'ku hinnona'i suna'kku-no ho'sutesu-o
 somewhat unsophisticated bar-Gen hostess-Acc
- Satoru-ga bujokushita .
 Satoru-Nom insulted

N1 association interpretation: "Satoru insulted the hostess of the somewhat unsophisticated bar."

N2 association interpretation: "Satoru insulted the somewhat unsophisticated hostess of the bar."

Further details can be found in the full description of this experiment in Appendix 7.

The results showed there was a significant preference for N2 association for the long AP, as revealed by a garden path effect at the N2 position when the adjective was not compatible with N2, as in (15c), compared with when the adjective was compatible

with either noun, N1 as in (15d)). No such preference was observed when the AP was a single adjective, as in (15a) versus (15b). Thus, the length of an AP manipulated by the presence of an adverb within that AP has an influence on AP association preference in a complex noun phrase.

This provides some background support for assuming that the results of Experiments 4 and 5 can be ascribed to the difference between a one-word and a two-word noun phrase, rather than to the syntax or semantics of coordination. In Chapter 6 we will make a specific proposal about the source of length effects in reading, which provides a unified explanation of the AP association phenomenon and the relative clause reanalysis preference.

5.5 General discussion

We started out our investigation to examine whether SR is always preferred to SOR. What we have found so far is that SR is not always preferred. In Chapter 4, we found that SOR can be easier under strong thematic pressure. What we have observed in this chapter is the opposite case, in which SR preference is enhanced (or perhaps created). The results of Experiments 4 and 5 reported in this chapter indicate a significant SR preference in conjoined subject sentences, and no preference, or a weaker SR preference in simple subject sentences. Presumably, the length of the subject phrase modulates whatever background SR/SOR preference exists (if any), and the data do not permit us to say whether the length effect is due to a default SR preference which is counteracted by the effect of a one-word subject or there is no default structural preference but SR

preference is induced by a conjoined subject. Since there is no such thing as a noun phrase with no particular length, it may not even be sensible to speculate about a default preference independent of length. All we can say at this point is that there is a significantly greater SR preference in sentences with conjoined subjects than in simple subject sentences. Theoretical models must take this into account. But for this, we must first establish the source of the length effect.

What could account for the experimental results reported in this chapter? There is every reason to assume that processing conjoined NPs incurs more cost than processing simple NPs, due to the difference in structural complexity internal to the NP.⁵ The question is, whether a cost associated with building an early sentence constituent should have an impact later when the SR versus SOR choice must be made. Structure-adding parsing models (which ‘lower’ the relative clause) such as those proposed by Gorrell (1995a, 1995b) and Sturt & Crocker (1996) predict no such later influence, because both SR and SOR types would be obtained by adding new structure to the already computed phrase markers; the internal complexity of the already computed structure has no impact on the parser’s actions. It might be possible to interpret Minimal Expulsion (Inoue, 1991)

⁵ STOP PRESS: The effect of subject length has recently been replicated in another sentence-completion experiment (the same design as Experiment 4) testing two types of subject (short name vs. long name subjects) which are both single NPs (12 items, 22 subjects). In one type (short name), the fragment initial subject consisted of a single noun such as a first name (e.g., “Ma’saki”), a surname (e.g., “Mori’sita”), or a common noun (e.g., “hi’sho”, secretary). In the other version (long name), the initial subject was either a full name (e.g., “Mori’sita Sini’tiroo” to contrast with “Mori’sita”) or a surname plus a title (e.g., “Oogo’oti hi’sho”, secretary Oogo’oti, to contrast with “hi’sho”). (Some names were followed by “-san” (Mr. or Ms.) but this was controlled across matched pairs.) SR completion was found to be more likely for fragments with long-name subjects than for those with short-name subjects. The likelihood of SR interpretation significantly exceeded 50% only for fragments with a long-name subject.

The outcome supports the idea that the length effects in Experiment 4 are prosodic in nature, because in the new experiment the two types of fragment tested differed in terms of prosodic phrasing (one minor phrase versus two) but did not differ syntactically or semantically.

or Minimal Revisions (Frazier & Clifton, 1998) to predict that the reanalysis of conjoined subjects would be more costly than the reanalysis of simple subjects, because more nodes of structure would be affected by the reanalysis operation (which raises or expels the matrix clause constituents). This is dubious, however, since reanalysis should 'see' only the highest NP node over the whole conjoined phrase; the two lower NP nodes would not technically be affected but would have a 'free ride'. Moreover, any added complexity would be present in both SR and SOR structures, so there is no reason why it should interact with SR/SOR preference.

Processing conjoined NPs also entails the semantic interpretation of an extra referent compared to the simple NPs, as well as the processing of extra syntactic nodes. Suppose it is the case that reading time per word increases over the course of a sentence, due to accumulated processing workload. Then a complexity early on could affect reading times later in the sentence. However, as noted in footnote 3, this would predict more cost for conjoined subject sentences at all comparable points of a sentence compared to simple subject sentences, which is the opposite of the results in Experiment 5.

It is imaginable that the difference between conjoined and simple NPs makes a difference in overall memory cost, the central theoretical construct in some models of sentence processing (e.g., Gibson, 1991). But for theories which estimate processing load in terms of memory cost, whether the difference between a sentence-initial conjoined NP and a simple NP differentially affects SR and SOR structures would depend crucially on the way in which the memory cost is calculated. For example, in Gibson (1991), the cost-weighting principle relevant to the SR/SOR contrast would be the Property of Thematic

Reception (PTR), as discussed in Chapter 3. A sentence-initial conjoined subject NP and a simple subject NP would have exactly the same status under PTR, since a thematic role would be assigned to the whole NP, regardless of whether it dominates a conjoined NP or a simple NP.

For models which depict an initial stage of parsing as involving a chunking of the input string, there may be consequences of subject NP length for the SR/SOR preference, depending on the way in which the chunks are established. For example, Marcus (1980) proposes a limited delay model with a look ahead device whereby an input buffer holds three constituents, constituents being defined by some shallow level of parsing. Although it is reasonable to assume that conjoined NPs and simple NPs would have an equivalent status for a buffer that counts constituents, it is possible to imagine a system in which two conjoined NPs take up two constituent spaces while simple NPs would take just one. Even then, Marcus's three-constituent buffer model still would not explain why an SR structure is more likely in one sentence type than another. It would do so only if disambiguating information were in the buffer while the first NP-o is being attached in the case of the simple subject sentences. But the disambiguating information (NP-Acc) is 4 constituents (possibly 3 constituents) later than the first NP-o in buffer cell-one, and so would not be available.

Finally, let us consider a chunking mechanism such as the one proposed in the Sausage Machine model (Frazier & Fodor, 1978), which is assumed to operate at an early stage of structure processing. We can extend the idea so that chunk boundaries in the Preliminary Phrase Packager (PPP) influence breakpoints in reanalysis. The Sausage Machine Model assumes that the default chunking size is approximately six words and

this does not explain our data because the word string up to the head noun would in fact fit in a single package in both conditions (single/conjoined subject). In any case, Wanner (1980) gave reasons for doubting the correctness of the 6-word estimate of the packaging size. More recently, Fodor (1998) has suggested that the packaging principle is based on prosodic balance, rather than absolute number of words. In the next chapter, we will consider Fodor's proposal as a possible explanation of the length effect that we have observed in Experiments 4 and 5. The proposal we will put forward is that the preference between SR and SOR structures stems from the (silent) prosodic chunking imposed initially on the input string.

CHAPTER 6

PROSODIC PHRASING OF RELATIVE CLAUSE STRUCTURES

6.1 Introduction

In the previous chapter, we found that the length of the sentence-initial nominative NP (a single noun or two conjoined nouns) influences the choice of SR or SOR structures for a relative clause. The preference for SR was stronger when the subject was conjoined than when it was a single noun (Experiments 4 and 5). No significant bias toward SR was found for simple subject fragments in the off-line sentence completion study (Experiment 4). In this chapter we consider the source of the contrast between simple and conjoined NPs with respect to the SR/SOR choice in on-line sentence processing, and propose that the length effect is mediated by the mental representation of prosodic phrasing in silent reading.

Section 6.2 establishes that it is reasonable to seek an explanation of the length effect in prosody. Experiment 6 examines whether the length manipulation (simple/conjoined) of the subject phrase of a sentence fragment like the ones used in the sentence completion study in Experiment 4, has a direct impact on the prosodic pattern when such fragments are read aloud. The results indicate a greater tendency toward a prosodic break following a conjoined subject. This may be why the clause break in the reanalyzed

relative clause construction tends to follow the subject (SR preference) when the subject is conjoined. The remainder of the chapter explores aspects of this idea.

Given that there is a correlation (even if imperfect) between syntactic structure and its prosodic representation, we consider to what extent prosody can reveal the syntactic structure of an ambiguous relative clause structure in auditory sentence processing. In section 6.3, we review some experimental studies reported in the literature which establish that a prosodic major phrase boundary serves as a cue to disambiguate the SR/SOR structural ambiguity in speech. An SR structure and an SOR structure differ with respect to where the relative clause begins in the word string, and in speech that position is often marked by a major phrase boundary. Hearers can identify the syntactic structure by relying on acoustic cues that signal characteristics of a major phrase boundary.

In 6.4, following Bader (1998) and Fodor (1998), we propose that processing of written sentences involves not only computing the syntactic structure but also implicitly computing a prosodic phrasing to fit the syntax. When the initially computed syntactic structure has to be reanalyzed, this prosodic pattern would need to be adjusted if it conflicts with the syntactic structure that is reassigned. Based on this, we propose that structural ambiguity at the reanalysis stage is preferentially resolved in favor of a structure in which the prosodic pattern initially assigned to the first-pass structure can be maintained. This follows naturally from the Minimal Revision principle, if we assume that creation of prosody is part of sentence processing in normal silent reading (Slowiacek & Clifton, 1980), including reanalysis following a garden path.

6.2 Length and Prosody

In this section, we briefly overview the basic facts of prosodic structure in Japanese. We establish that the major (prosodic) phrase level is most relevant to the length effect observed in the previous chapter. We consider what acoustic manifestations can signal the pattern of prosodic phrasing at the major phrase level. In Experiment 6, we demonstrate that manipulation of the length (simple/conjoined) of the subject phrase of sentence fragments has an impact on major phrase formation, as revealed by these acoustic factors.

6.2.1 Prosodic organization and its acoustic correlates

In studies of the prosodic structure of a variety of languages, researchers have identified a hierarchical organization above the level of the word. In the terminology adopted in this dissertation (Poser, 1984; Kubozono, 1988), units at successively higher levels of prosodic structure are referred to as the minor phrase (minP), the major phrase (MP), and the intonational phrase (IntP), the latter usually corresponding to a complete clause, often to an entire utterance in Japanese.¹ Minor phrases are constituents of major phrases, which in turn are constituents of intonational phrases.

A minor phrase is an intonationally defined prosodic constituent, the melody of which in Japanese depends on whether its content is accented or unaccented.

¹ Some researchers, e.g., Beckman & Pierrehumbert (1986), use the terms “accentual phrase” and “intermediate phrase” to refer to the minor and major phrases, respectively. In aspects relevant to the topic of this dissertation, alternative frameworks make essentially equivalent claims. Thus the choice of one terminology over the other is a matter of convenience.

Accentuation is lexically determined. In standard (Tokyo) Japanese, an accented minor phrase is marked by a sharp HL (high-low) fall on the accented mora, and the minor phrase can include at most one lexical accent.² (Unless the first mora carries a lexical accent, the minor phrase is delimited at its left edge by a default LH (low-high) pattern, the result of an initial lowering rule.³) Thus the sequence of nouns and adverb which began the critical fragments and sentences in Experiments 4 and 5 of Chapter 5 can be divided into separate minor phrases, one per *bunsetsu*: {Mori'sita-ga_{minP}} {si'nyaku-o_{minP}} {kokoro'kara_{minP}}... (see example (1) of section 5.1 in the previous chapter). For conjoined subjects the minor phrases are: {Hosokawa-to_{minP}} {Mori'sita-ga_{minP}} {si'nyaku-o_{minP}} {kokoro'kara_{minP}}.... Thus there is a prosodic difference between the sentence types at the minor phrase level: conjoined subjects introduce an additional minor phrase.

The major phrase is the unit which we consider relevant in explaining the length effect on parsing of this construction. A major phrase consists of one or more minor phrase(s). While there is no necessary limit on how many minor phrases a major phrase can contain (except perhaps as determined by breath capacity), it appears that the number of minor phrases grouped together to form a major phrase is sensitive to several factors, which act jointly to determine major phrase length. It has been proposed that prosodic structure at the major phrase level is often closely related to syntactic phrasing or

² In Chapters 5 and 6, we focus on cases in which all the words are accented, thus each forms a minor phrase. Unaccented words, which we do not consider here, tend to be dephrased, i.e., combined together with a following accented word, or one or more following unaccented words, into one minor phrase.

³ The Initial Lowering Rule, as originally stated in Haraguchi (1977), converts the initial H tone to a L tone if it is followed by another H-toned mora. Recent theories including Poser (1984), Beckman & Pierrehumbert (1986) and Kubozono (1988) regard the phenomenon as a rise of pitch at the beginning of a constituent to a H pitch on the second mora.

constituency, and that phrase size *per se* (or the size balance between successive major phrases) is also relevant. We defer consideration of these matters for the moment (but see section 6.2.3), to focus on the empirical investigations that have sought to establish major phrase boundaries in Japanese. These phenomena provide the basis for Experiment 6 (reported in section 6.2.2 below), which explores the contrasting patterns of prosodic phrasing resulting from simple and conjoined subjects.

The phonologically conditioned process of downstep or catathesis (Pierrehumbert & Beckman, 1988) by which the pitch range of a minor phrase is lowered has as its domain the major phrase. That is, a consecutive sequence of accented minor phrases within a major phrase is uttered with successively lower pitches.⁴ Since downstep is blocked by a major phrase boundary, the first word of a following major phrase exhibits an F0 peak roughly equal to or perhaps higher than that of the pre-boundary word.

In addition to the F0 pattern, there are other acoustic cues that may mark a major phrase boundary. These include the presence of a pause between words or phrases and a greater than normal duration for the final segment(s) of each major phrase. Azuma & Tsukuma (1990, 1991) argue that pause duration is not entirely robust as a marker of major phrase boundaries (certainly, less robust than the F0 pattern), but other studies focusing on phrase-final lengthening have found that a longer final mora is often followed by a pause (Kaiki, Takeda & Sagisaka, 1990; Ueyama, 1997; Venditti & van Santen, 1998).

We start by asking an empirical question: whether and how the length

⁴ The physical correlate of pitch is fundamental frequency (F0) and thus the F0 contour for downstepped sequences is staircase-like, with peak F0 values successively declining from word to word.

manipulation (simple/conjoined subject) employed in Experiments 4 and 5 correlates with the prosodic structure of the materials.

6.2.2 Experiment 6

In Experiment 6, the set of sentence fragments used in Experiment 4 were read aloud by a Japanese native speaker. The rationale of this experiment is based on the study by Kondo & Mazuka (1996) which demonstrates that when Japanese speakers read aloud a sentence with a local ambiguity such that the syntactic structure of that sentence cannot be determined immediately, the readers do not wait until the disambiguating information is provided; instead, they produce a prosodic structure determined only by the limited current information. Kondo & Mazuka's examination of eye-voice span revealed that Japanese readers normally do not look ahead more than a word. Taking these results together, it is reasonable to assume that when a speaker reads the sentence fragments used in Experiment 4 the prosodic pattern assigned to the material prior to the verb would be based on the single clause analysis of the material up to that verb. Given the eye-voice span suggested by Kondo and Mazuka, the head noun, the disambiguator toward a relative clause, would not normally be recognized until the point at which the reader utters the verb, and certainly not during the reading of the subject and object.

The elicited fragment readings in Experiment 6 were subjected to phonetic analyses: measurements were taken of pause durations and F0 patterns (the standard indicators of major phrase boundaries). We predict that any differences between sentence types would most likely be captured at the major phrase level.

Method

Subject. One female graduate student participated in the experiment. She was a native speaker of Saitama Japanese, which has the same accent patterns and intonational structure as Standard (Tokyo) Japanese.⁵

Materials and Design. The items were identical to those used in Experiment 4. These materials (12 pairs, thus 24 items) were divided between two versions of the experiment in a counterbalanced design.

(1)	Mori'sita-ga Morisita-Nom	si'nyaku-o new medicine-Acc	kokoro'kara truly
	sinyoosita trusted	yuujin'tati-ni friends-Dat	to'otoo finally
(2)	Hoso'kawa-to Hosokawa-and	Mori'sita-ga Morisita-Nom	si'nyaku-o new medicine-Acc
	kokoro'kara truly	sinyoosita trusted	yuujin'tati-ni to'otoo friends-Dat finally

An additional 36 filler fragments and 3 practice fragments were also created. Twenty-four of the fillers, also constructed as 12 pairs (contrasting one-word versus two-word adjective phrase (AP)) to be distributed in a counterbalanced design, had an adjective phrase (AP) modifying a complex noun phrase; they were identical to a subset of the fillers in Experiment 4. The remaining 12 fillers were varied in length and structure, and

⁵ The F0 and the pause results were replicated in recently-collected production data from two more female speakers, although these data are not reported in this dissertation (see Hirose, Fodor, Inoue, and Bradley, in prep).

were identical across the two experimental lists. Thus, each list consisted of 36 items in total, 12 experimental sentences (6 with conjoined subject, 6 with simple subject), 12 fillers with an AP + complex NP construction (6 one-word AP, 6 two-word AP) and 12 pure fillers.

Each fragment was printed on a strip of paper and the whole set of fragments was bound together into a stack so that the subject could see only one stimulus item at any time. Items were presented in a fixed order with filler items interspersed between experimental items. The subject read the two lists on different occasions, separated by 5 days.

Procedure. The subject was instructed to read each fragment aloud at a comfortable speech rate. For each fragment, she was told to read it three times consecutively under the following conditions. For the first reading, she was told to read aloud the fragment as she saw it at first glance, i.e., without reading through the entire stimulus first. It was emphasized that it was important to read without planning how to complete the fragment. For the second, the subject read the fragment again and now completed it, by adding word(s) in writing at the end of the fragment. Finally, the subject read aloud the completed sentence. Only the data from the first reading were of interest in Experiment 6, and the sentence completion responses are not analyzed here.

The recordings were made in a sound-proof booth using a portable DAT recorder (SONY TCD-D7). The subject remained in the booth until the whole session was completed, but was encouraged to take breaks between items during the recording session so that she could maintain concentration on the task. Taped utterances were transferred to an SGI workstation and were analyzed using Entropic ESPS/Waves+ speech software.

The analysis focused on pauses between constituents and on the F0 of the first 4 minor phrase peaks (3 peaks, for simple subject fragments), i.e., all items up to and including the adverb.

Data Treatment. The durations of pauses after *ga* (nominative case marker attached to the subject NP) and after *o* (accusative case marker attached to the object NP) were measured, from the offset of F2 in the preceding vowel to the onset of the following consonant. (For stop consonants, the onset was taken as the start of the burst.) For the simple subject fragments, F0 peaks were measured for the *ga*- marked noun, the *o*-marked noun, and the following adjunct phrase (adverb or locative). For the conjoined subject fragments, F0 peaks were measured for these same phrases and for the *to*-marked noun.

Results and Discussion

Duration. Table 7 summarizes mean pause durations.

Table 7. Mean pause duration (in milliseconds, standard deviations in parentheses) as a function of location and fragment type

Fragment Type	Location	
	After <i>ga</i>	After <i>o</i>
Simple subject	55 (55)	67 (51)
Conjoined subject	146 (119)	41 (38)

Pause duration showed an interaction between location (after *ga* / after *o*) and fragment type (simple/conjoined subject), $F_2(1,11) = 7.23$, $p < .05$. Subanalyses within each fragment type revealed that for conjoined subject fragments, pause durations were more than three times longer after the *ga* marked noun than after the *o* marked noun, $F_2(1,11) = 10.35$, $p < .01$; for simple subject fragments a difference in the opposite direction was not significant, $F_2(1,11) < 1$. Thus, in the conjoined subject fragments, the evidence is compatible with a major phrase boundary following the subject NP (separating the subject NP from the predicate VP), but no major phrase boundary after the *o*-marked noun. The pause duration at these same two locations in the simple subject fragments gives no real indication of a major phrase boundary within this sequence, either between subject and object, or between object and adverb/PP. (At most, the mean values here suggest that if there were a major phrase boundary internal to this sequence, it may be more likely to fall after the object phrase than after the subject phrase.)

F0 pattern. F0 values for the same phrase across fragment types cannot be statistically compared in this study because the positions of corresponding words were not matched and cumulative downstepping effects complicate any direct comparison. Thus the pitch patterns for each fragment type are discussed separately, and these are summarized in figures showing F0 peaks at the relevant positions. Figure 1 gives mean F0 peaks for the first four bunsetsu (NP-to NP-*ga* NP-*o* Adv/PP) in conjoined subject fragments, and Figure 2 gives mean peaks for the first three bunsetsu (NP-*ga* NP-*o* Adv/PP) in simple subject fragments. (Figures 3 and 4 present F0 contours in full, for two prosodic phrasing subtypes that emerged in the analysis of simple subject fragments.)

In Figure 1 (conjoined subject fragments), peak values averaged over 12 fragment

stimuli reveal a pattern in which F0 falls very sharply between the two elements of the subject phrase (dropping 66 Hz on average, standard deviation 11 Hz); this is downstep.⁶ At the following NP-o, F0 is higher than for the preceding *ga*- marked noun (rising 39 Hz on average, standard deviation 16 Hz), indicating a reset. There was little variability for this fragment type, all fragments showing this pattern to a greater or lesser extent. The data suggest that a major phrase boundary occurs between the *ga*-marked noun and the NP-o, i.e., exactly the location indicated by the data for pauses. The change in peak F0 between NP-o and the following adjunct phrase shows a less dramatic fall overall, and more item-to-item variability (mean peak value declining by 28 Hz, standard deviation 27 Hz). We take this to indicate that these two items mostly (but not always) occur in the same major phrase. One utterance did not show any downstep at this point (peak F0 at the adjunct was higher than at NP-o by 5 Hz) and three other utterances showed a decline less than 10Hz, which probably does not constitute a downstep pattern.

⁶ Whether a drop in F0 between two accented minor phrases (as in these materials) qualifies as downstep is properly determined by comparison with a baseline condition in which the first element is unaccented, in which case no downstep occurs. In the present experiment there was no baseline condition, so the magnitude of true downstep can only be estimated (as in Selkirk & Tateishi, 1991). However, we believe that the downstep phenomena reported here fall well within normal limits.

Figure 1. Conjoined-subject fragments: F0 peak values (Hz; mean, standard deviation) at four successive lexical elements

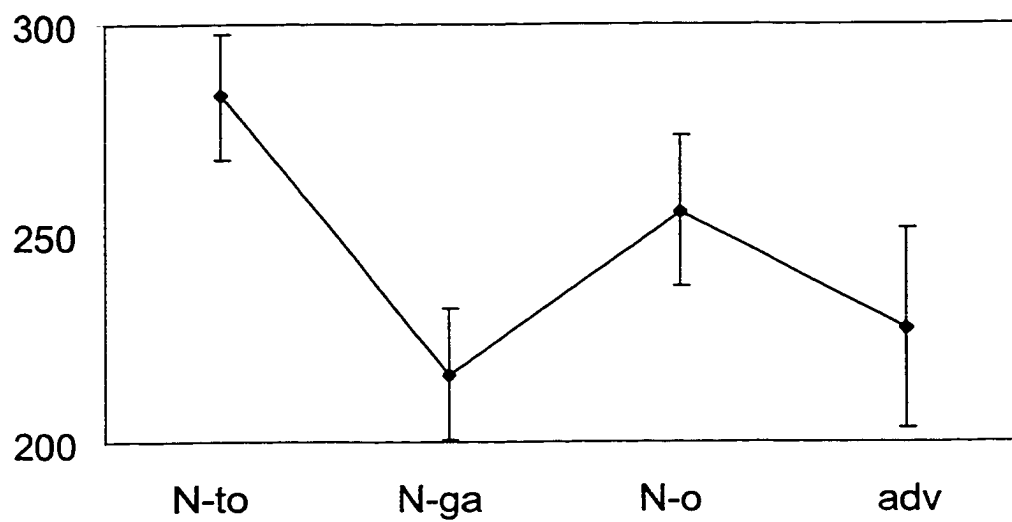
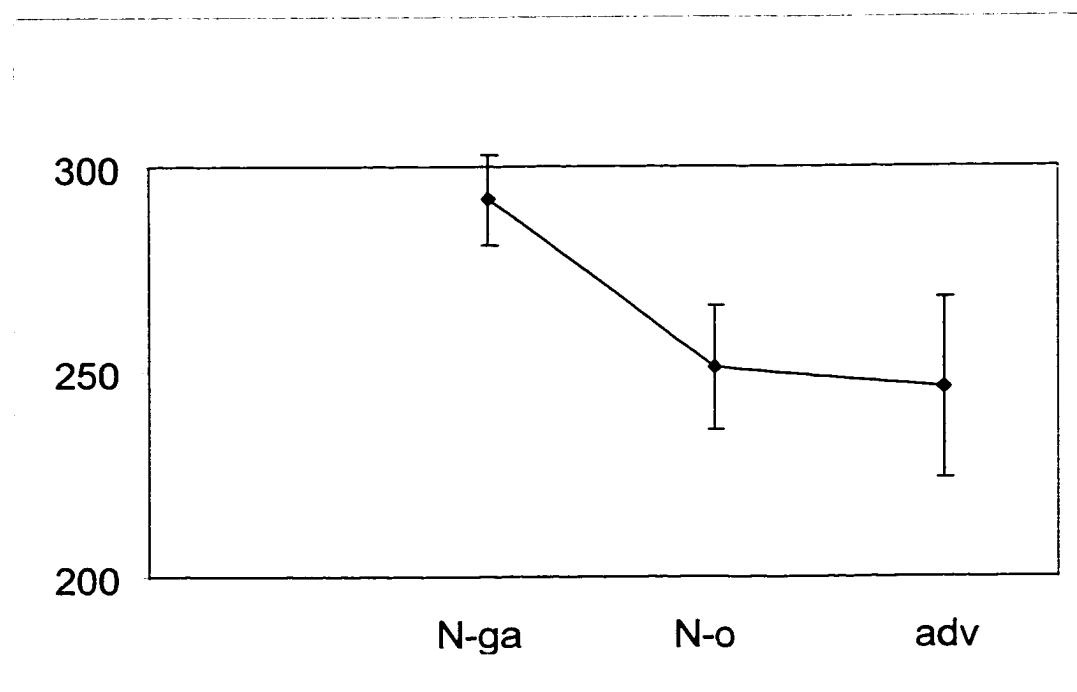


Figure 2 presents the peak F0 data for simple subject fragments, again averaged over 12 fragment stimuli. The pattern now is for a fall between utterance-initial NP-ga and NP-o. The decline between these two separate phrases (41 Hz on average, standard deviation 19 Hz) is less than that between the two conjoined nouns of the conjoined subject fragments. Nonetheless, it is substantial and fairly consistent across the 12 stimuli. This is most reasonably interpreted as a downstepping pattern, indicating that these two minor phrases are assigned to a single major phrase. This finding for F0 agrees with the relatively brief pause at the same site.

At the next word, (the adjunct phrase), the mean F0 peak value is only a little lower than the peak at NP-o (by 5 Hz on average, standard deviation 27 Hz), which is not a robust case of downstep.

Figure 2. Simple-subject fragments: F0 peak values (Hz; mean, standard deviation) at three successive lexical elements



This could be interpreted as showing that downstep often did not extend to the adjunct phrase, and hence that the object and adjunct are generally not in the same major phrase. However, inspection of individual items reveals some variability in the relation between the F0 peaks at NP-o and the adjunct phrase.⁷ For nine of the 12 items, there were indications of a reset from downstepping at the adjunct, the peak value of the adjunct being higher than that of NP-o, or almost the same.⁸ For the remaining three items, the pattern of peak values suggested that downstepping did continue through the adjunct, the peak value of the adjunct being lower than that of NP-o by more than 35 Hz. Two examples representing opposite extremes, i.e., clear reset, and continuous downstepping, are shown in Figures 3 and 4, respectively. In these figures, each for a single utterance, the pitch track is shown in full through the relevant sequence, in contrast to Figures 1 and 2 which display only mean peak F0 for each minor phrase.

⁷ Tsumaki (1994) reports that “focus” adverbs (those that intensify the degree, frequency, or the duration of the state or action expressed by the verb, e.g., “extremely”, “all the time”, or “for a long time”) tend to have higher F0 values compared to other adverbs, which could counteract any downstep. In the materials, five items may have been affected by this. However, since the adverbs were identical between the two types of fragment, the difference in F0 patterns for the fragment types could not be due to this.

⁸ In two among the nine instances regarded here as “reset”, the peak F0 value of the adjunct was lower than that of the preceding NP-o by 10 Hz. In one case the vowels at the NP-o and adjunct peaks were [a] and [o] respectively. In the other case, they were [u] and [a] respectively. So, there is no possibility that the height of the adverb peak relative to the NP-o peak was elevated due to a difference in intrinsic F0 for these vowels; if anything, intrinsic F0 would have the opposite effect.

Figure 3. Sample F0 contour for simple-subject fragments, exhibiting reset at adjunct phrase

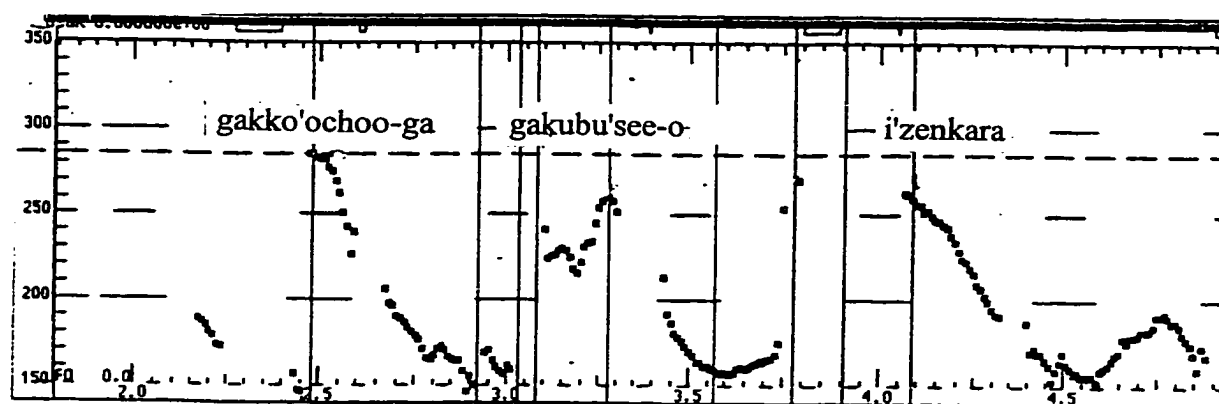
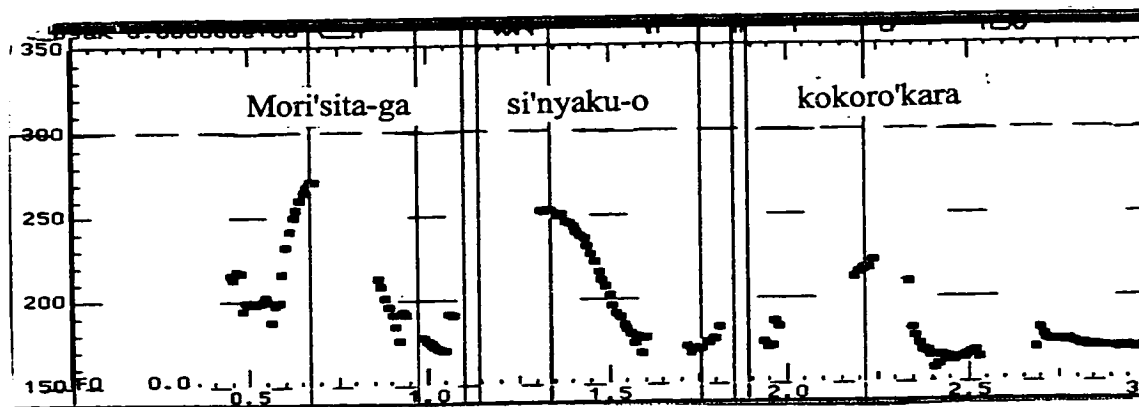


Figure 4. Sample F0 contour for simple-subject fragments, with downstep extending through adjunct phrase



It appears, then, that the major phrase beginning at the simple subject may contain at least three minor phrases, though it is more often contains only two, ending after the direct object. In short, the results confirmed that the presence or absence of an additional minor phrase does influence prosodic phrasing; specifically, it affects the location of a major phrase boundary. When the fragment-initial NP-ga consisted of two minor phrases, the subject NP itself formed a major phrase separate from the following items. In contrast, when the subject NP was one minor phrase, it became a co-constituent of a major phrase with the following minor phrase or phrases (object NP, and sometimes adverb/PP); in these fragments, the major phrase boundary falls after NP-o, or (presumably) somewhere to the right of that.

In the following section, we compare the results with some prosodic theories which consider constituent length as a factor that affects the pattern of prosodic phrasing, together with other factors sensitive to syntactic structure.

6.2.3 Factors affecting prosody: structure and length

Researchers generally agree that there is a regular relationship, in many instances, between syntactic and prosodic structure. That is, differences in syntactic phrasal structure within a clause are often reflected in the way the utterance is prosodically structured at the major phrase level. To capture these regularities, Selkirk (1986) proposed that the relation between syntax and prosody is defined in terms of the edges of syntactic constituents.

Allowing the direction of the edge (left or right) to be a language-specific

parameter, Selkirk's theory accounts for a variety of cross-linguistic data. The relevant phenomena concern the relationship between major phrases and syntactic maximal projections (XP). For example, data from the Xiamen dialect of Chinese (originally presented by Chen, 1987) indicate that the domain of tone sandhi is determined by the right edge of XP; while data from Ewe tone sandhi (presented by Clements, 1978) show that the sandhi domain is determined by the left edge of XP. Selkirk & Tateishi (1991) further developed this to apply to Japanese, and proposed that the edge-direction parameter is set to the left. In support of this claim, they presented a set of F0 data showing that major phrase boundaries (as identified by downstep-reset) correspond to the left edges of syntactic XPs.

The natural application of this theory to the materials of Experiment 6 would predict that a major phrase boundary within the sequence leading up to the verb in (1) and (2) would fall between the subject NP-ga and the object NP-o, because this position coincides with the left edge of VP. If the prosodic pattern were solely determined by this kind of structural constraint, the outcome of Experiment 6 is not explained. Certainly, the markedly different prosodic phrasing given to conjoined and simple subject fragments cannot be accounted for. Moreover, there is a more serious problem when the patterns found for each of the fragment types is considered: while the prediction is borne out well enough for the conjoined subject fragments, it is not for simple subject fragments. It seems reasonable to assume that the syntax-prosody mapping emerges in a system that also recognizes other constraints. Indeed, researchers have noticed for some time now that not only the syntactic structure but also the length of constituents has an impact on the prosodic pattern.

In her more recent work, Selkirk (1996) has expressed this idea within the framework of Optimality Theory (OT) (Prince & Smolensky, 1993). The OT framework supposes that the grammar does not state a unique language-specific setting of any parameter (like the edge-direction parameter mentioned above), but rather lists all realizable possibilities in the form of universal but violable constraints. Thus, the grammar of Japanese would list both a constraint setting edge-direction left and its counterpart setting edge-direction right (as well as any other relevant configurations). The effect of a unique parameter setting is achieved in Optimality Theory by a ranking of constraints; a constraint ranked sufficiently low will essentially never surface to control prosodic phrasing.

Selkirk (1996) argues for universal constraints on the minimum and maximum size of prosodic constituents, in addition to constraints sensitive to aspects of syntactic structure such as Align XP. The size constraint may apply to any level of prosodic structure, in that the grouping of phrases at a given level is determined by constraints on the well-formedness of phrases at the next higher level. The constraints applying to the major phrase level are formalized as follows:

Binary Maximum (BinMax): A major phrase must consist of at most two minor phrases.

Binary Minimum (BinMin): A major phrase must consist of at least two minor phrases.

For English, these constraints can be used to explain the contrast in acceptability among (3)-(5) (without focus on any phrase) which is not accounted for by other structure-based constraints in Optimality Theory such as Align XP. Note that the unacceptable (5) obeys

Align XP, as does (4) which is acceptable. The explanation requires the assumption that Binmax and BinMin are co-equal, i.e., unranked with respect to each other.

(3) She lo'aned her ro'llerblades to Ro'bin
 { MP }

(4) She lo'aned her ro'llerblades to Ro'bin
 { MP } { MP }

(5) * She lo'aned her ro'llerblades to Ro'bin
 { MP } { MP } { MP }

The apostrophe in the examples represents a phrasal accent in English (cf. lexical accent in Japanese), which is assumed here to head a minor phrase.⁹ (5) is ruled out because it violates BinMin three times. (3) and (4) are the “winning” candidates among all logically possible phrasing patterns, including others not presented here.¹⁰ (3) incurs one violation of BinMax and (4) one violation of BinMin, and they are optimal since zero violations is impossible when there are three minor phrases.

Interestingly, the phrasing pattern in (3) becomes unacceptable when the sentence-final indirect object consists of two accented words, as shown in (6)-(8) below. Here, the binary branching (7) is the only acceptable phrasing.

⁹ In English, the existence of a minor phrase as a prosodic unit is controversial. Some argue against assuming minor phrases as a unit in the prosodic hierarchy (Beckman & Pierrehumbert, 1986), because of lack of delimitative tone and absence of a relationship with prosodic words. Selkirk simply defines a minor phrase as a phrase that contains an accent.

¹⁰ The following pattern, for example, is ruled out independently by a violation of Align XP, which in English must be ranked higher than the size constraints:

*She lo'aned her ro'llerblades to Ro'bin .
 { MP } { MP }

- (6) *She lo'aned her ro'llerblades to Ro'bin's si'ster
 { MP }
- (7) She lo'aned her ro'llerblades to Ro'bin's si'ster
 { MP } { MP }
- (8) *She lo'aned her ro'llerblades to Ro'bin's si'ster
 { MP } { MP } { MP }

Selkirk explains that this is because candidate (7) now does not violate any of the size constraints (cf. one violation of BinMin for (4), one violation of BinMax for (6) and two violations of BinMin for (8)), and is thus superior to any other alternative.

The exact nature of the size constraints on major phrases remains to be established. As we have seen, the Optimality Theory framework handles size-effects by setting limits on how few (BinMin) and how many (BinMax) minor phrases can optimally be included in a major phrase. An alternative to these numerical generalizations supposes instead that it is relative rather than absolute size that is relevant, and so proposes that there must be a length *balance* between successive major phrases. Just this kind of preference for balanced prosodic phrasing is embodied in the “bisection principle” of Gee & Grosjean (1983) which they proposed in response to their observation that the syntactic structure and the prosodic structure (which otherwise would match) can mismatch with each other to maintain a balance in the length of the constituents. Grosjean, Grosjean, & Lane (1979) observed that the prosodic break in an English sentence is generally consistent with the major syntactic break between the subject and the VP, as shown in (9). But alignment with the major syntactic break can be

sacrificed to give the two prosodic phrases similar lengths, as shown in (10).

(9) [Waiters who remember well_{NP}] [serve orders correctly_{VP}].
 { } { }

(10) [Chickens_{NP}] [were eating the remaining green vegetables_{VP}].
 { } { }

The work of Kubozono (1988, 1989, 1993) offers direct evidence that, in Japanese, the prosodic pattern is controlled not only by syntactic structure but also by the number of constituents. Kubozono first showed that three-element constructions contrasting with respect to syntactic structure, such as the complex NPs shown in (11) and (12), are associated with different F0 contours. The example in (11) has a right-branching structure in which “kowa’i” (fearful) modifies the complex NP “me’-no ya’mai” (eye-Gen disease); (12) has a left-branching structure in which “kowa’i” modifies only the immediately following NP “me’-no” (eye-Gen). (Each element is lexically accented.)

(11) [kowa’i [me’-no ya’mai]]
 fearful eye-Gen disease
 “fearful disease of eye”

(12) [[kowa’i me’-no] oma’wari]
 fearful eye-Gen policeman
 “a policeman with fearful eyes”

Kubozono found that the F0 peak of the second word “me’-no” is higher in (11), at the left edge of the “me’-no ya’mai” (eye-Gen disease) than in (12), at the right edge of

“kowa'i me'-no” (fearful eye-Gen).

Although syntactic structure was mirrored exactly in the prosodic pattern for three-word strings, Kubozono found that a uniformly left-branching four-word string favored a 2+2 prosodic pattern appropriate to a double binary syntactic structure, even though this conflicts with the semantic interpretation. For instance, he observed that the NPs with different syntactic structures exemplified in (13) and (14) exhibited an identical prosodic pattern.

- (13) [[a'iko-no ne'esan-no] [u'uru-no eri'maki]]
 Aiko-Gen sister-Gen wool-Gen muffler
 "Aiko's sister's woolen muffler"
- (14) [[[yu'mi-no no'nda] w'ain-no] nio'i]
 Yumi-Gen drank wine-Gen smell
 "the smell of wine that Yumi drank"

The F0 pattern for (13) is as expected: the third element “u'uru-no” (wool-Gen) is at the left edge of the constituent “u'uru-no eri'maki” (woolen muffler), cf. “me'-no” (eye-Gen) in (11), and is realized with a high F0 peak. But the same structural considerations cannot apply to “wain-no” (wine-Gen) in (14), which is *not* positioned at a left edge, and some other factor must be responsible for the fact that the same high F0 peak occurs in this case. Kubozono formulates an account by referring to the “principle of rhythmic alternation” proposed by Selkirk (1984), which favors prominences at regular intervals. The effect of Selkirk’s principle is to promote prosodic balance. Kubozono himself does not offer an analysis of (13) and (14) in terms of a difference at the major phrase level. He argues that the F0 rise he observed in examples (11), (13), and (14) does *not*

correspond to a reset of downstep, as would occur after a major phrase boundary. In fact, he takes (14) to constitute a single major phrase. He attributes the F0 rise at the third word in (14) to another process that he calls “metrical boost”, applying *within* a major phrase. His argument is that he found downstep on the third element in a structure such as (14), when he compared it to a baseline consisting of the same structure in which the second element was unaccented (see also footnote 6 and 13 below). The presence of downstep is incompatible with a major phrase boundary at that point, by the standard acoustic characterization of major phrase boundary. Thus, the proposal is that lexically accented words which would otherwise show the impact of downstep can in some circumstances be subject to a different process which modifies their F0 realizations. Specifically, Kubozono proposes that metrical boost is triggered at the left edge of a right-branching syntactic structure internal to a major phrase, as in (11) and (13).¹¹ However, the branching pattern of (14) does not satisfy the environment required for metrical boost. Kubozono’s analysis makes this a special case in which the structure of a left-branching sequence of four minor phrases, as in (14), is converted to a symmetric structure. Then, (14) as well as (13) provides the environment for metrical boost to occur. (This subcase of metrical boost is called “rhythmic boost”). As a result, what surfaces is a contour mimicking the effect of reset of downstep, though it is in fact just a local boost of pitch within a major phrase. Kubozono’s account of these data is an alternative to a simpler account according to which there is a major phrase boundary between the second and third words in (14). This is relevant to the prosodic analysis of

¹¹ He intends the left edge of any branching right-branching node, which he explains as “a phrase-internal opening bracket, in bracket notation”. For example, it applies to the second element in (a), the third element in (b), and the second and the third element in (c), but not to any element in (d).

(a) [A [BC]] (b) [[AB][CD]] (c) [A[B[CD]]]] (d) [[[A] B] C] D]

the experimental materials illustrated in (1) and (2), because if Kubozono is right, there may be no real major phrase boundary preceding the NP-o in (2). This is because the NP-o is the left edge of a right-branching syntactic phrase, and hence fits the context for metrical boost. However, the two phenomena are perceptually very similar, so a perceiver might well treat occurrence of a metrical boost as the same phenomenon as occurrence of a major phrase boundary. In the discussion that follows, we will for simplicity avoid distinguishing an F0 rise as either a reset of downstep or a metrical boost. We will refer to it as a reset of downstep except where specifically relevant to the argument at hand.

The data presented by Kubozono, whatever its appropriate analysis, confirms that syntactic structure is not the only determinant of prosody. The contrast in contour between (12) and (14) such that only (14) has an F0 rise at the third item (despite left-branching structure), shows that the number of minor phrases, i.e., length, also matters. In Kubozono's terms, instances like (13) and (14) with very different syntactic structures are neutralized prosodically when the number of minor phrases is four (or possibly any number greater than three), which is sufficient to trigger a special process of rhythmic boost, creating "rhythmic alternation". Length and syntactic structure are co-determinants of the prosodic pattern.

Length-sensitive theories of prosodic patterning differ with respect to whether they suppose that there is an optimal absolute *size* for a prosodic phrase in terms of the number of constituents (prosodic sub-units, e.g., minor phrases) that it can contain, or instead that there is an optimal *balance* (depending on relative size) between successive prosodic phrases. What is certain at this point is that the syntax-prosody mapping is not

strictly regular, and that a default prosodic pattern based on syntax is often overridden or modified by length considerations. For concreteness we adopt here the “absolute size” approach which establishes the optimal number of minor phrases in a major phrase.

6.3 Prosody and spoken sentence processing

In section 6.2.2, we observed that the initially-assigned prosodic pattern of sentence fragments that exhibit an SR/SOR temporary ambiguity is influenced by the number of minor phrases in the subject NP. The SR/SOR ambiguity involves ambiguity about the location of the relative clause boundary which is a natural locus for a major prosodic boundary, as we now show for relative clause structures in utterances where the speaker is aware of the intended syntactic analysis. We will review some data showing that the Align XP constraint does not always apply: the left edge of a CP is systematically aligned with the left boundary of a major phrase, whereas the relationship is less clear for VP. We also establish that when prosodic cues are supplied in the input, hearers can successfully use them to arrive at the correct structure.

6.3.1 Syntax and major phrases

Venditti (1993) reports that a gapless relative clause, an SR-type relative clause, and a relative clause similar to an SOR-type relative clause (see (15a-c) respectively) are all prosodically distinguished from each other. In (15b) and (15c), there is a major phrase boundary at the position of the (sentence-internal) left edge of the relative clause, marked

by a non-downstepping F0 pattern across the boundary and phrase-final lengthening preceding the boundary.

(15)

- a. [Ma'yuko-ga Nobu'yuki-ni me'ron-o na'geta] e'ngi-wa omosirokatta .
 -Nom -Dat melon-Acc threw performance-Top was interesting
 "The performance in which Mayuko threw the melon to Nobuyuki was interesting."
- b. Ma'yuko-ga [e_i Nobu'yuki-ni me'ron-o na'geta] e'nji-o sikatta .
 -Nom -Dat melon-Acc threw child-Acc scolded
 "Mayuko scolded the child who threw the melon at Nobuyuki."
- c. Ma'yuko-ga Nobu'yuki-ni [e_i me'ron-o na'meta] e'nji-o azu'keta .
 -Nom -Dat melon-Acc licked child-Acc left in care of
 "Mayuko left the child in Nobuyuki's care who licked the melon."

(15a) is a sentence-initial gapless relative clause (see Chapter 2). (15b) is an SR-type relative clause, with a clause boundary between the sentence-initial subject NP and the following object NP. (15c) is similar to an SOR relative in that the sentence-initial subject and indirect object are both matrix clause constituents and the relative clause boundary is between the second and the third constituents.¹²

In this experiment, the speakers were instructed to read the sentences so that the intended meaning was clear. In (15a), Venditti found a continuous downstepping pattern on the peaks of all the constituents through the head noun: the height of the peaks on each word declined in a stair-case-like pattern throughout the utterance. In (15b) and (15c), an F0 reset was observed at the peak of the first word in the relative clause, i.e., at

¹² In terms of processing, (15c) differs from an SOR structure because the argument structure of the embedded verb does not match all of the preceding constituents so a perceiver can tell at that verb that the word string spans two clauses. However, the proper division of the clauses is ambiguous, as in the materials for Experiment 6 and other experiments reported in this dissertation; (15c) contrasts with (15b) with respect to the position of the left edge of the relative clause.

“Nobu’yuki-ni” (Nobuyuki-Dat) in (15b) and “me’ron-o” (melon-Acc) in (15c), respectively.¹³ Also, the beginning of the relative clause was marked by phrase-final lengthening of the immediately preceding constituent: the case particle attached to an NP had a longer duration when the NP immediately preceded the relative clause than when it did not. Similar results are reported by Venditti (1994, see below), and by Venditti & Yamashita (1994), for studies in which the speakers were aware of the intended meaning of the sentence but were not specifically instructed to try to disambiguate the structures.

Recall that Selkirk & Tateishi (1991) proposed that the edge of a major phrase boundary aligns with the left edge of every XP in Japanese, including CP and VP. This would predict that there should be a major phrase boundary between the subject NP and the indirect or direct object NP in any kind of clause in canonical order, because that position corresponds to the beginning of a VP. This prediction was not supported by the results of Experiment 6; we did not observe an F0 rise following the subject NP, when the subject was a single noun. The prediction was disconfirmed by Venditti’s finding as well, as there was no significant F0 rise observed following the subject, unless it coincided with the left edge of the relative clause CP. On the other hand, Venditti’s data do support Selkirk & Tateishi’s proposal as far as the left edge of the CP (relative clause) is concerned. Prosody could thus, at least in principle, be used in sentence processing as a cue to the beginning of a subordinate clause.

¹³ Venditti (1993, 1994) did not report mean F0 values because she assessed occurrence or reset of downstep by a different method. In order to determine the presence of downstep between the first and second words, and between the second and third words in (15a-c), Venditti had a baseline condition in which the first word was an unaccented name (“Mayumi”). As observed in footnote 3 above, downstep does not occur following an unaccented word. Therefore, if a peak does not reflect a reset at the start of a major phrase but is just a minor pitch boost (Kubozono, 1988) while downstep is continuing, then, as in other cases of downstep, it will have a lower F0 value when preceded by an accented word than it would if it were preceded by an unaccented word.

6.3.2 Role of prosody in parsing of spoken stimuli

In the previous section we considered evidence suggesting that prosody is available to provide cues to the syntactic structure at least with respect to the left edge of a relative clause CP, even if the mapping between syntax and prosody is not always fully reliable at all levels of syntactic structure.

A number of studies of spoken sentence processing have shown that prosodic information can, at least to some limited extent, guide the interpretation of ambiguous syntactic structures. This kind of prosodic disambiguation has been shown to occur when a phrase break in the prosodic structure coincides with a syntactic break in one of the alternative syntactic analyses but not in the other(s). This has been demonstrated by Pynte & Prieur, 1996; Marslen-Wilson, Tyler, Warren, Crenier, & Lee, 1992; Beach, 1991; Lehiste, 1973; Nespor & Vogel, 1986; Speer, Crowder, & Thomas, 1993; Price, Ostendorf, Shattuck-Hufnagel, & Fong al., 1991; among others.

The ambiguity of clause boundary location associated with Japanese relative clauses is no exception, and empirical studies indicate that perceivers are sensitive to the prosodic cues that signal boundary location. Uyeno, Hayashibe, Imai, Imagawa, & Kiritani (1980) investigated whether relative clause constructions such as (16), which are globally ambiguous with respect to the position of the left edge of the clause boundary, can be disambiguated with the aid of prosody. A perception test was conducted on edited (re-synthesized) stimuli for which the height of the pitch in the first word (the adverb) and the second word (the relative clause verb) was manipulated.

(16) a'rutoki ni'geta e'nji-ga ka'ita.
 at one time ran away child-Nom drew

a. [a'rutoki ni'geta] e'nji-ga ka'ita.
 at one time ran away child-Nom drew

“The kindergarten child who at one time ran away drew.”

b. a'rutoki [ni'geta] e'nji-ga ka'ita.
 at one time ran away child-Nom drew

“The kindergarten child who ran away drew at one time.”

When the F0 peak of the verb was lower than the peak of the adverb (the ratio of F0 height at the verb to F0 at the adverb appears to have been less than approximately 85%; the mean difference roughly 20Hz), showing a typical downstep pattern, interpretation (16a) was significantly more frequent, although the preference did not reach 100% (in the range of 67~85%). When the F0 peak of the relative clause verb was the same height or higher than the peak of the initial adverb, showing the pattern typically indicating a major phrase boundary between the two, the interpretation shown in (16b) was significantly more frequent (in the range of 66~90%).

Venditti (1994) presents both production and perception data on the two distinct syntactic structures exemplified in (17a) and (17b) corresponding to the fully ambiguous word string in (17). Each bunsetsu corresponds to a minor phrase here because each bunsetsu is accented. In the production study, two speakers were asked to read the sentences preceded by a context which made only one of the analyses of the ambiguous material appropriate.

- (17) kyo'nen a'nda eri'maki-ga nusuma'reta.
 last year knitted scarf-Nom was stolen
- a. [kyo'nen a'nda] eri'maki-ga nusuma'reta .
 last year knitted scarf-Nom was stolen
 "The scarf that I knitted last year was stolen."
- b. kyo'nen [a'nda] eri'maki-ga nusuma'reta .
 last year knitted scarf-Nom was stolen
 "The scarf that I knitted was stolen last year."

In this study, the speakers were thus aware of the structural ambiguity but were not asked in particular to intentionally disambiguate the sentence when reading aloud. The results demonstrated that the two structures tend to be realized with different F0 patterns, as in the results of Venditti (1993). For (17a), in which the left edge of the relative clause is at the beginning of the sentence, there is a pattern of downstep with descending F0 on each successive minor phrase, indicating that all elements belong to one major phrase. In (17b), by contrast, there is a reset of the pitch range that occurs on the peak of "a'nda" (knitted), indicating a major phrase boundary between "kyo'nen" (last year) and "a'nda", according to standard assumptions.

The elicited utterances used in the production data were also subject to a perception test. It was found that the two different F0 patterns observed in the production of sentence (17), which reveal a prosodic difference between the two versions at the major phrase level, were useful to hearers in recovering the intended structure. The subjects listened to the read stimuli, and were asked to judge which of (17a) or (17b) was the intended reading of each token. When the peak of the second word was lower than that of the first, thus consistent with downstep, the subjects more often judged the

sentence to mean (17a). However, they tended to judge the sentence meant (17b) when the peak of the second word (the relative clause verb) was as high as, or higher than, that of the first word (the adverb), thus indicating a downstep reset and a major phrase boundary. This effect of the F0 contour in disambiguating a relative clause boundary was also reported by Azuma & Tsukuma (1991) for Tokyo Japanese, and by Azuma & Tsukuma (1990) for Kinki (Osaka) dialect. Venditti also found that when there was no pause between the first word and the second word, the subjects tended to judge the sentences to mean (17a), while they judged it to mean (17b) when there was a pause after the first word.

In this section, we have briefly noted experimental studies indicating that the presence of a major phrase boundary influences the parsing of syntactically ambiguous spoken input. It appears that a hearer can use that prosodic information to deduce the presence and the position of a syntactically ambiguous clause boundary in a Japanese relative clause construction.

In what follows, our interest will be extended to whether and how the parser responds to the prosodic characteristics of sentences when the sentences are read silently, not heard. It might seem that prosodic factors would be completely irrelevant in the processing of non-auditory input. However, we propose that a perceiver mentally establishes a prosodic representation based on the low-level syntactic structure available at that stage, and that this prosodic representation is used as information in the subsequent assignment of the higher-level syntactic structure as if it had been part of the input.

6.4 Prosody and processing in silent reading

The idea of "implicit prosody" or "prosody in silent reading" may be first found in Slowiaczek & Clifton (1980). The function of subvocalization in silent reading of written sentences had been pursued in a number of early studies (Hardyck & Petrinovich, 1970; Kleiman, 1975; Levy, 1978) and it has generally been assumed to be a means of translating a visual (written language) input into a phonological code that would allow it to be maintained securely in working memory. Slowiaczek & Clifton found that when subvocalization was blocked (subjects were instructed to engage in repetitive irrelevant speech while silently reading short passages), comprehension was impaired. They concluded that this impairment is due to lack of access to a fully formulated phonological representation of the visual input, and speculated that what normally aids comprehension in silent reading is a computed prosodic representation which compensates for information such as intonation contours and sentence rhythms available in spoken input.¹⁴

In the recent literature (Bader, 1998; Fodor, 1998), the notion of "implicit prosody" computed in silent reading has been proposed as a factor that can affect the syntactic processing of written sentences. These proposals differ from each other with respect to the stage of processing at which the pattern imposed by the prosodic processor affects syntactic parsing: Bader discusses garden path reanalysis while Fodor considers first-pass parsing.

Bader presented experimental data on the silent reading of German which indicate

¹⁴ Recent findings of Mazuka, Itoh, Kondo, & Brown (1999) employing eye-movement and self-paced reading techniques suggests that it is the number of morae, rather than the number of characters that determines reading times even in silent reading. This provides some indirect supporting evidence for an influence of implicit prosody, at least of lower level unit, in language comprehension in Japanese.

that reanalysis of an initially constructed syntactic structure is costly if it entails revising the prosodic structure assigned during first pass reading. A series of self-paced reading experiments was conducted on sentences exemplified by (18) and (19), the German version of a type of temporary ambiguity first studied by Frazier (1978).

(18) ... dass man (sogar) ihr Geld ...
 ... that one (even) her-Gen/Dat money ...

(19)
 a. ... dass man (sogar) ihr Geld beschlagnahmt hat.
 ... that one (even) her-Gen money confiscated had
 "... that someone confiscated (even) her money."
 b. ... dass man (sogar) ihr Geld anvertraut hat.
 ... that one (even) her-Dat money entrusted had
 "... that someone entrusted money (even) to her."

When "ihr Geld" is first encountered in the initial analysis, "ihr" (her) is taken to be a possessive pronoun modifying "Geld" (money).¹⁵ For (19a) this is correct, but in the garden-path sentence (19b) "ihr" should be the indirect object of the verb "anvertraut" (entrusted), hence a garden path effect is expected to occur when "anvertraut" is processed. Reanalysis of (19b) was substantially more difficult when a focus operator such as "sogar" (even) was present. Bader argues that this is because the default stress on "Geld" required by the focus operator "sogar" in the first-pass analysis of "ihr" as possessive has to be reassigned to "ihr" in the reanalyzed syntactic structure in which "ihr" is the indirect object. Bader concludes that revision of prosody is a source of

¹⁵ At an earlier stage at which only "ihr" is encountered but not "Geld", "ihr" is probably processed as a dative pronoun, according to Minimal Attachment.

reanalysis difficulty. Bader formulated a Prosodic Constraint on Reanalysis, as stated below:

Prosodic Constraint on Reanalysis (PCR): Revising a syntactic structure is difficult if it necessitates a concomitant reanalysis of the associated prosodic structure.

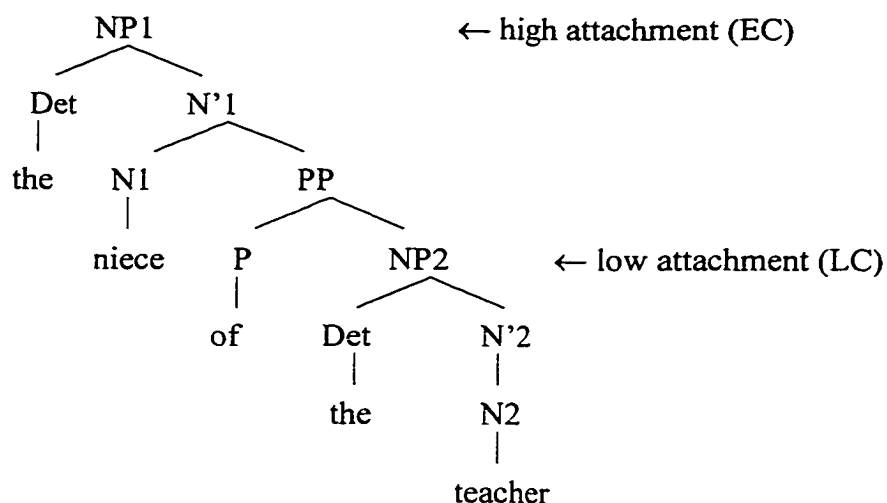
Bader's explanation of his data presupposes that readers establish a prosodic contour as a consequence of first-pass parsing. Fodor (1998) also proposes that prosodic structure is established in first-pass parsing in silent reading. She suggests that this occurs in parallel with syntactic processing: the prosodic processor operates on fairly low-level lexical and syntactic information to establish prosodic phrasing, which then influences structural choices in case of ambiguity. Fodor argues that her proposal may offer a unified explanation of a variety of phenomena including the difference in Late Closure versus Early Closure preference between English and Spanish observed by Cuetos & Mitchell (1988). This is illustrated in (20a-b)

(20)

- a. la sobrina del maestro que esta en el partido comunista (EC preferred)
the niece of the teacher who is in the party communist
(English equivalent below)
- b. the niece of the teacher who belongs to the communist party (LC preferred)

In Spanish the relative clause tends to attach high to the first of the two nouns: this is an Early Closure (EC) preference. In English there is a slight tendency for the relative clause to attach to the second noun, within the PP; this is the Late Closure (LC) structure. These alternatives are illustrated in (21).

(21)



EC preference in relative clause attachment has since been observed in a variety of other languages; Brysbaert & Mitchell (1996) summarize the facts. Unless these exceptions to the LC principle can be explained away, it must be concluded that LC is not a universal principle.

Fodor (1998) proposes that these cross-linguistic variations in parsing preferences are prosodic in origin. Language specific parsing preferences can be attributed to the language specific aspects of the prosodic component of the grammar. If correct, this proposal makes it possible to maintain the universality of the parser and its parsing principles.

Fodor notes a variety of evidence suggesting that heavy constituents (long APs, PPs, relative clauses) tend to attach high, and proposes that this is because a to-be-attached constituent prefers to associate with a sister constituent of equal weight, to achieve a prosodic balance (Gee & Grosjean, 1983). Because constituent length is correlated with height in the tree, this naturally results in a difference in attachment

height: heavy constituents will tend to attach high, and light constituents (e.g., a short relative clause as in (22b) or a prepositional phrase) will tend to attach low. This is the explanation for why LC can be overridden in the Spanish example shown in (20a), in which the relative clause is comparable in length (or weight) to the whole complex NP, and would not be well balanced against just the lower (second) NP.

The challenge is then to explain why, in English, relative clauses attach to the lower NP as shown in (20b), violating the same-size-sister principle (but obeying LC, apparently). Fodor proposes that this can be explained by the prosodic behavior of the relative pronoun in English. In English, there is often no pause at the beginning of a relative clause, and any prosodic break is likely to fall within the relative clause, e.g., after the relative pronoun "who" or even after the verb. Thus the prosodic phrasing in English has the effect of "gluing" the beginning of the relative clause to the lower noun. However, in Spanish (and most other languages), a pause or other prosodic mark of a major phrase boundary is typically present at the left edge of the relative clause, i.e., before the relative pronoun "que" in (20a). This discourages a close structural relation between the second noun and the relative clause. The complex noun phrase and the relative clause are thus processed separately, which permits the prosodic balance principle to come into play and results in an interpretation in which the relative clause modifies the whole complex noun phrase, e.g., "la sobrina del maestro" in (20a).

Fodor observes that intuitively the LC preference in relative clause attachment becomes even stronger when the relative clause is short, as shown in (22b), compared to (22a).

(22)

- a. Someone shot the maid of the actress who was on the balcony with her husband. (weak LC preference)
- b. Someone shot the maid of the actress who cried. (stronger LC preference)

In support of Fodor's proposal, Fernandez & Bradley (1999) provided experimental data showing that the constituent length of the relative clause affects its attachment site in English.

(23)

- a. My friend met the aides of the detective that was investigating the case. (forced Low)
- b. My friend met the aide of the detectives that was investigating the case. (forced High)

Fernandez & Bradley tested sentences with forced low attachment, e.g., (23a) and (24a), and with forced high attachment, e.g., (23b) and (24b). When the relative clause was long, as in (23), reading times for the two sentence types did not significantly differ, showing no evidence for LC preference. However, when the relative clause was short, as in (24), sentences with forced low attachment, e.g., (24a) were read significantly faster than those with forced high attachment, e.g., (24b).

(24)

- a. My friend met the aides of the detective that was fired. (forced Low)
- b. My friend met the aide of the detectives that was fired. (forced High)

Fodor suggests that an attachment difference related to relative clause length holds also in other languages, for example, in Spanish, the EC preference for long relative

clauses changes to a LC preference for short relative clauses. This is corroborated by Igoa (1999) for Spanish and by Pynte & Colonna (1999) for French.

Furthermore Fodor argued that the tendency towards prosodic balance applies also in Japanese and accounts for the intuitive observation reported in Inoue & Fodor (1995).

- (25) sin'setsuna gakusei-no imooto
 kind student-Gen sister
- a. [si'nsetsuna gakusei]-no imooto
 kind student-Gen sister
 "sister of a kind student"
- b. si'nsetsuna [gakusei-no imooto]
 kind student-Gen sister
 "kind sister of a student"
- (26) kyokuta'nni si'nsetsuna gakusei-no imooto
 extremely kind student-Gen sister
- a. [kyokuta'nni sin'setsuna gakusei]-no imooto
 extremely kind student-Gen sister
 "sister of an extremely kind student"
- b. kyokuta'nni sin'setsuna [gakusei-no imooto]
 extremely kind student-Gen sister
 "extremely kind sister of a student"

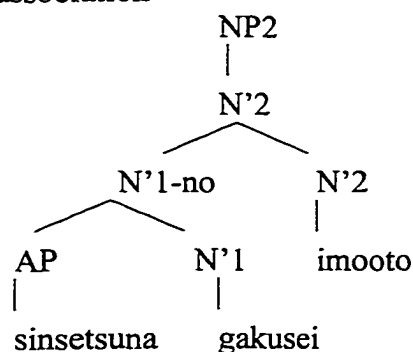
In (25), an AP “(Kyokutanni) sinsetuna” ((exremely) kind) precedes a complex NP consisting of “gakusee-no” (student-Gen) + “imooto” (sister). The position of the adjective is ambiguous and allows two interpretations: it may be associated with the lower genitive NP, or with the whole complex NP.¹⁶ In the structural analysis (25a), the

¹⁶ We choose to use “association”, rather than “attach” to describe the process by which the relation between the pronominal modifier and its modifyee is established in this construction, because (assuming incremental parsing) the modifier is encountered and incorporated into the CPPM first, and only then is the modifyee attached to the CPPM.

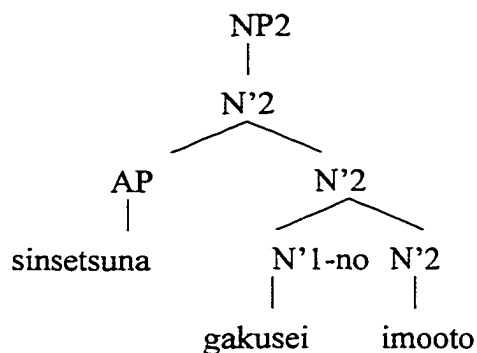
adjective is associated with the lower noun (N1); in (25b), it is associated with the higher noun (N2) which heads the whole complex NP, as illustrated in (27) below.

(27)

a. N1 (low) association



b. N2 (high) association



The former is conveniently referred to as “N1-association” while the latter may be called “N2-association”. However, note that the word order is different from English and Spanish, so “N1- association” means attachment to the lower (genitive) NP while “N2- association” means attachment to the whole complex NP. Inoue & Fodor report that low N1 association as shown in (25a) is intuitively the preferred reading, but that this

preference seems to change when the one-word AP is replaced with an adjective phrase consisting of two words, as shown in (27a). For the longer AP, the preference for high attachment (as shown in (27b)) increases.

A prosodic balance principle would favor dividing the four-word string in (26) into two two-word packages, “kyokuta’nni sin’setsuna” and “gakuei-no imooto”, rather than into the less balanced “kyokuta’nni sin’setsuna gakuei-no” and “imooto”. As in the case of English and Spanish, Fodor proposes that in reading the parser computes the most natural prosody for the word string, and then takes this prosodic pattern seriously as if it had been part of the input. In case of ambiguity, the parser chooses the syntactic structure which is most naturally associated with the prosodic phrasing. In the case of (26) this is the symmetrically branching structure $[[AB][CD]]$, rather than $[[[AB] C] D]$. With a one-word AP as in (25), there are only three words in the entire NP and hence no clear preference about how to divide them, therefore nothing overrides the on-line association of the adjective with the first noun, before the second noun is encountered. This provides a plausible account for the AP length effect in Japanese. The pressure toward balanced phrasing in (26) could also be attributed to an “absolute” length constraint (see section 6.2.3) such as Selkirk’s BinMin constraint.

While Bader’s data reveal an effect of implicit prosody on the difficulty of reanalysis following a first-pass misanalysis (a garden path), the various phenomena discussed by Fodor imply an effect of implicit prosody on the first-pass assignment of syntactic structure to ambiguous word strings.

We adopt the proposal of implicit prosody, and thus assume that in processing SR/SOR-ambiguous relative clause sentences, the parser computes prosody on-line

during the first-pass. The prosodic patterns are presumably similar to those observed in Experiment 6. Fully-parsed SR and SOR structures require a major phrase boundary that marks the left edge of the relative clause, but there is no way for the parser to know the correct structure during the initial parsing stage, thus there is every chance that the prosodic pattern computed during the first-pass is different from the one which is appropriate for the correct structure after reanalysis. Our proposal, outlined in more detail below, is that it is this initially computed prosodic pattern that controls the ambiguity resolution at the onset of reanalysis.

6.5 Conclusion

In the series of experiments presented in the previous chapter and the current chapter, we have established the following facts. In Experiments 4 and 5 in the preceding chapter, we discovered that the number of constituents in the subject NP affects the SR versus SOR choice: the SR preference was stronger when the NP-ga was conjoined. In the current chapter we reviewed some considerations suggesting that this might be an effect of the number of minor prosodic phrases in the subject phrase. In Experiment 6 we found that the two types of subject NP-ga do have an influence on the prosodic pattern when these phrases are spoken. Sentence fragments with a conjoined subject NP strongly attract a major phrase boundary immediately following the subject phrase, with no boundary following the object NP. In contrast, in simple subject fragments no major phrase boundary was observed following the subject NP. The prosodic pattern turned out to be either one in which no major phrase boundary is present through the adverb, or one

in which a boundary follows the object. These patterns are consistent with a number of theoretical proposals, including those of Selkirk and Kubozono.

These findings make sense together, if we assume that not only syntactic structure but also prosodic structure is processed in silent reading. In the SR and SOR type relative clauses, prosodic phrasing is initially computed based on the first-pass single-clause analysis, which (by assumption) is congruent with the prosodic pattern that would be produced if the single clause were spoken aloud. Then, once the prosodic pattern is established on the first-pass analysis, it becomes part of the information feeding any reanalysis that is subsequently necessary.

When the head noun is processed, it becomes evident to the parser that a relative clause must have begun at some point in the word string that was processed as a single clause. The linguistic knowledge of a native speaker specifies that the beginning of a relative clause should induce a major phrase boundary in the prosodic representation. So, the processing of a relative clause not only requires syntactic reanalysis creating a CP node and re-arranging the constituents that have already been processed as clausemates, but it also requires creating a major phrase boundary appropriately marking the left edge of the CP. Our proposal is that when there is a major phrase boundary already created in the first pass parse (although it was not originally created to mark a CP boundary), it is more economical to compute a syntactic structure whose required major phrase boundary coincides with the one which already exists, than to compute a syntactic structure for which a new major phrase boundary has to be created elsewhere. Therefore, instead of abandoning the prosodic phrasing computed in the first-pass analysis and re-computing new prosodic phrasing based on the reanalyzed syntactic structure, the parser would

maintain the prosodic phrasing that is already computed, and reanalyze the syntactic structure in a way that is consistent with the existing prosodic pattern. This may be because once the prosody has been computed in silent reading in the first-pass stage, the parser's short-term memory representation of the sentence may be indistinguishable from when the prosodic pattern is actually present in the input. That is, the representation system that evolved for spoken language may have no means to distinguish mentally computed prosody from heard prosody (Fodor, personal communication).

If an (implicit) prosodic input to relative clause reanalysis is assumed, the results of Experiments 4 and 5 can be connected to those of Experiment 6. Experiment 6 found a major phrase boundary following the subject NP-ga and none following the NP-o for fragments with a conjoined subject. If the parser prefers a reanalysis structure which has the CP boundary at the same position as the major phrase boundary that already exists, then an SR preference would result. This is consistent with the outcome of Experiments 4 and 5. For fragments with simple subjects, the result was mixed, but it was never the case that a major phrase boundary followed NP-ga; thus, there was no prosodic basis for an SR preference. In some cases we observed a major phrase boundary following the object position, which would make SOR the preferred structure because it would have the clause boundary at that position. For other cases in simple subject fragments, no major phrase boundary was found either following the subject or the object. In such cases, there is no prosodic ground that the parser can rely on when making its choice about plausible relative clause structure (non-argument relative clause readings are not plausible here); therefore the choice could be random, or influenced by some other factor. This is consistent with the fact that no strong bias toward either SR or SOR was found in

Experiment 4.

The contrasts being drawn here appear to follow from Bader's PCR, that is, "Revising a syntactic structure is difficult if it necessitates a concomitant reanalysis of the associated prosodic structure". Here, the PCR would translate to "Processing is difficult if the major phrase boundary required in the reanalysis structure does not coincide with the major phrase boundary that already exists in the first-pass analysis." Bader argues that a PCR violation leads to processing difficulty which is consciously detectable. However, if we adopt this proposal, we should predict conscious difficulty at the disambiguation point in most SR sentences with a simple subject, e.g., (28).

(28)	Mori'sita-ga Morisita-Nom	si'nyaku-o new medicine-Acc	kokoro'kara truly
	sinyoosita trusted	yuujin'tati-ni friends-Dat	a'tta. met

"Morisita met the friends who truly trusted the new medicine."

In Experiment 6, there was no major phrase boundary between the sentence-initial NP-ga "Mori'sita-ga" and NP-o "si'nyaku-o" in the first-pass reading. Since the relative clause boundary separates these two constituents in the SR reading, requiring a major phrase boundary at that position, this reanalysis would fall under Bader's PCR. However, this is not consistent with what we have seen (and what Mazuka & Itoh also observed), that is, that an SR structure such as (28) does not typically involve severe difficulty.

Let us reconsider, then, whether it is necessary to assume that a PCR violation must lead to conscious difficulty, since this does not seem to fit the Japanese data. Bader studied focal stress, which is a marked type of prosody, not present in all sentences.

Also, it has a clear influence on semantic interpretation. Focal stress is required when a certain phrase in a sentence carries semantic focus, and failing to assign stress to the focused phrase results in ill-formedness in the syntax-phonology interface and also in the semantics-phonology interface. It is conceivable that the severity of the garden path which Bader observed in German and explained as a consequence of a prosodic garden path, was an extremely severe one because focal stress is marked and has semantic consequences. Perceivers may become conscious of the mismatch between prosodic focus and semantic focus in the reanalyzed structure.

In addition to the potential overprediction of difficulty discussed above, there is another point for which we find the PCR does not quite fit our data. Bader's PCR predicts a prosodic effect on the difficulty of reanalysis of a structure following a first-pass misanalysis, but it does not go so far as to predict a prosodic effect on the parser's choice of a reanalysis. It is the latter that we have demonstrated in Japanese. The two phenomena are closely related of course, since a difficulty with one analysis normally implies a preference for the alternative analysis. Nevertheless, the difference is worth emphasizing because our data indicate a prosodic effect on the choice of reanalysis even for less highly marked prosodic phrasing of a kind routinely assigned throughout a sentence, in the absence of a severe garden path effect when prosody does have to be altered. Thus parsing appears to be sensitive even to quite modest aspects of implicit prosody.

It may not be necessary to posit the PCR or any prosody-based principle governing reanalysis. As long as we assume that relevant aspects of prosody (including phrasing and stress) are computed during the first-pass analysis, reluctance to alter an

already assigned prosodic pattern follows from the Minimal Revision Principle (Frazier, 1990), which can be seen as one facet of the Minimal Everything principle which defines the human sentence processing mechanism as a 'least-effort' device (Fodor & Inoue, 1994). Reanalysis which calls for revising prosody as well as structure would violate the Minimal Revision Principle either because it requires revision at more than one level of linguistic representation, or just because it increases the total amount of revision, whether syntactic or prosodic, which has to be made to arrive at the correct analysis. If prosody assignment is assumed to be part of parsing, then all that is needed to explain Bader's results and our results would be the Minimal Revision Principle, which encompasses prosody as well as syntactic structure and semantics. Fodor's suggestion that mentally computed prosody may not be distinguished from heard prosody is compatible with this. However, it is a strong claim. To account for the difference in the magnitude of the effect for German focal stress and Japanese major phrase boundaries, it would be necessary to assume that perceivers can sometimes override heard prosody when the lexical, syntactic or semantic information conflicts with it, and that this is easier to do for major phrase boundary cues than for focal stress. Overriding of input prosody does reportedly occur in conflict situations, but for Japanese the details remain to be worked out.

To summarize: we propose that the first-pass parsing of a sentence in silent reading includes not only building the syntactic structure but also constructing the relevant levels of prosodic phrasing. Construction of a prosodic contour is constrained by factors such as constituent size as well as syntactic structure, and the size factor often overrides syntactic phrasing in determining prosodic phrasing. The prosodic boundaries

created during the first-pass processing in turn influence ambiguity resolution in reanalysis, if the initial syntactic analysis turns out to be incorrect and more than one structural reanalysis is possible. If the reanalysis structure requires a certain kind of prosodic break, such as a major phrase boundary, the parser tries to make use of any comparable break that already exists in the first-pass structure, and chooses the reanalysis structure accordingly. This follows from the Minimal Revision principle, which prevents the parser from making any unnecessary revision — including removing one prosodic boundary and creating another one elsewhere. Thus, choice of revision can be influenced by prosody even in cases where the same prosodic revision, when necessary, is not strikingly difficult. Together, these points explain the enhanced SR preference in the Japanese sentences of central concern in this dissertation, when the initial subject NP-ga is a conjoined subject consisting of two minor phrases, compared to when the NP-ga is a single noun. It also accounts for apparent facilitation of the SOR analysis when the NP-ga is a single noun.

CHAPTER 7

CONCLUSIONS

7.1 Summary

The general goal of this dissertation has been to find out how the parser deals with structural ambiguity in garden path reanalysis. We focused on two specific constructions in Japanese, “Subject Reanalysis (SR)” and “Subject and Object Reanalysis (SOR)”. These constructions differ with respect to: (1) the role and the position of the gap (which is coindexed with the head noun) in the relative clause, and (2) the position of the left clause boundary which splits the matrix clause and the relative clause. Resolving either one of these two ambiguities often resolves the other at the same time. That is, once the position and the role of the relative clause gap is established, it determines which overt items in the word string there is room for, and a need for, in the relative clause; this amounts to determining where the clause boundary falls. Conversely, if the position of the clause boundary can be established, this may determine which positions in the relative clause lack lexical items, and thus it limits the possible role that the relative clause gap can play.

As we have discussed in Chapters 2 and 3, Japanese relative clauses are profoundly ambiguous. Japanese syntax allows ambiguity in the processing of these

constructions not only in the first pass but also in reanalysis. That is, even when it becomes evident that a relative clause structure must be built, there is no morpho-syntactic information which signals either the role/position of the gap or the position of the clause boundary. (Some information about the clause boundary may be supplied by morpho-syntactic properties of the matrix clause; but most of the matrix clause information including all the information in its head, is encountered only after the relative clause.) This has made us wonder how SR and SOR structures can be chosen at the point of ambiguity, and whether both structures can be successfully handled by the HSPM. In fact, it has been assumed by researchers that SOR creates substantial processing difficulty while SR does not. The reason for this varies across models. While some researchers argue that the difficulty of SOR is due to the parser's incapability of processing such a structure, some researchers propose that there is a structure-based preference principle that can resolve a reanalysis ambiguity, when no decisive syntactic information is available. However, the facts about difficulty of SR and SOR are discovered to be more variable than what these previous proposals predict. We have focused on two factors that appear to be influencing the SR/SOR ambiguity resolution: semantic/thematic (discussed in Chapter 4) and prosodic (discussed in Chapters 5 and 6). These two factors help or bias the parser to make a decision between SR/SOR but in different ways. The former contributes to identifying the role (and hence the position) of the relative clause gap; the latter determines the position of the clause boundary.

In Chapter 4 it was shown that an SOR sentence can be processed without any notable difficulty when its head noun is compatible only with the thematic role of

the object in the relative clause. While we found facilitation of an SOR by thematic resolution, we failed to find a significant difference in processing difficulty between SR and SOR sentences when thematic ambiguity did not intrude. Based on these results, we argued that SOR sentences can be easy to process when the information provided by the head noun uniquely specifies the possible thematic role of the gap in the relative clause (which determines the gap position, which in turn specifies where the matrix and relative clauses split in the word string). As a result, the parser selects the SOR structure at the head noun, and then has no trouble later in the sentence when the matrix verb demands the SOR structure. We further proposed that information about thematic compatibility is utilized as soon as it is available, and no later than any syntactic parsing preferences apply. Thus Japanese relative clause processing differs from English processing (at least as characterized by the familiar garden-path model) either in lacking structural preference principles or in giving them lower priority than thematic compatibility information. We have conjectured that this may be because the extreme lack of syntactic disambiguating information in Japanese relative clauses may make it less natural or less efficient to rely on syntactic preference principles, or because in reanalysis all sources of information are equally accessible.

In speech, relative clause ambiguity can often be resolved by means of prosodic information which signals the presence of a clause boundary. We argued that effects of prosody in resolution of syntactic ambiguities are not irrelevant to processing of written sentences, based on the following findings and reasoning. We observed that constituent length has an influence on SR/SOR ambiguity resolution: the preference was more strongly for SR when the subject NP was conjoined than when it was a single noun, as

indicated by the results of off-line and on-line experiments reported in Chapter 5. Data from a production experiment reported in Chapter 6 indicated that this constituent length factor influences the prosodic pattern in relative clauses read aloud: a conjoined subject was more often followed by a major prosodic boundary than a single noun subject was. Based on this, we ascribed the length effect on SR/SOR preference in reanalysis to the effect of implicit prosody mentally computed during silent reading concurrently with first-pass syntactic processing. We suggested that in resolving an ambiguity of reanalysis, a reader treats the implicitly assigned prosodic pattern as part of the input, and so chooses a syntactic analysis whose relative clause boundary coincides with the major break in that prosodic pattern. We have also discussed the idea that this might follow from the Minimal Revision principle, which prevents the parser from making any unnecessary revision — including erasing one prosodic boundary and creating another one elsewhere. When the initial subject NP-ga constitutes a major prosodic phrase, this has the effect of enhancing SR preference; when NP-ga is only one minor phrase, it would counteract any general SR preference (syntactic or thematic).

To conclude: SR/SOR ambiguity arises because of the lack of syntactic information to (1) identify the position of the gap in the relative clause, and/or (2) signal the position of the left clause boundary. The data reported in this dissertation suggest, contrary to what might have been expected from the study of English and other languages, that it is not structure-based preferences that control SR/SOR ambiguity resolution. Rather, it is strongly influenced by at least two non-syntactic factors which have an impact on different aspects of SR/SOR structure. Thematic compatibility information decides the identity of the relative clause gap, and the pattern of prosodic

phrasing computed in silent reading imposes a bias on the decision about the position of the relative clause left boundary.

7.2 Future research

The empirical research reported here could be extended in several directions. We focus on just one here, to explore the interaction between the two factors whose effects have so far been studied separately. We have argued that thematic compatibility information influences SR/SOR selection by signaling relative clause gap position. However, in our test materials in Experiments 1-3 the prosodic status of the constituents in the critical portion of the sentences was not systematically matched, so it was left uncontrolled whether there was any length/prosody bias concerning clause boundary position. We have also argued that the parser prefers to choose the syntactic analysis whose clause boundary coincides with the major prosodic phrase boundary assigned during the course of first-pass parsing. But observation of the prosodic effect on reanalysis resolution in Experiments 4-6 was limited to the case where thematic-compatibility information could not make a decision about the role or position of the relative clause gap. Now, when both of these information/biasing sources are present, each supporting a different structure, which one wins, and by what process is the conflict resolved?

(1) is an example of an SOR sentence from Mazuka & Itoh (1995) which they claim involves a conscious difficulty.

- (1) Ya'kuza-no ka'nbu-ga waka'i ko'bun-o sagasida'sita
 gang-Gen leader-Nom young member-Acc found
- kenzyuu-de utikoro'site simatta.
 gun-with shot to death

“The leader of the gang shot the young member to death with the gun he found.”

According to our proposal in Chapter 4, the correct SOR structure should be processed without difficulty by virtue of the thematic compatibility information: “kenzyuu” (gun) can be THEME but cannot be AGENT of “sagasidasita” (found). However, recall our finding in Chapter 6 that the sentence initial NP-ga consisting of two minor phrases had a robust tendency to induce a major phrase boundary following it, thus favoring SR. This effect seems to be applicable to (1). (It is reasonable to assume that a major phrase boundary would also be induced after the object, since this also consists of two minor phrases, but we do not have direct confirmation of this from production data.) This implies that the informally observed difficulty associated with (1) may be attributed to the persisting prosodic boundary following NP-ga, attempting to attract a clause boundary at that position in the revised structure, which conflicts with what the thematic compatibility information requires (i.e., to associate the gap to the object position and begin the relative clause following the object). Intuitively, the SOR reading becomes notably easier in (2) compared to (1), where the length of the subject and the object are modified so that no major phrase boundary will be induced following the subject position.

- (2) ka'nbu-ga ko'bun-o sagasida'sita kenzyuu-de utikoro'site simatta.
 leader-Nom member-Acc found gun-with shot to death

"The leader shot the member to death with the gun he found."

This merits further appropriately designed experimental work. Consider the following pair (modeled after the sentence pair (5) in Chapter 4, but modified so that the relevant part of the sentences consists of accented words):

(3)

a. Prosody and thematic compatibility agree:

ro'oba-ga kodo'mora-o ki'njo-de sagasita
 old woman-Nom children-Acc in the neighborhood looked for

bura'nko-ni to'otoo tsureteitta.
 swing-Dat finally took to

"The old woman finally took the children to the swing which they looked for in the neighborhood."

b. Prosody and thematic compatibility conflict:

onna'noko-to ro'oba-ga kodo'mora-o ki'njo-de sagasita
 girl-and old woman-Nom children-Acc in the neighborhood looked for

bura'nko-ni to'otoo tsureteitta.
 swing-Dat finally took to

"The girl and the old woman finally took the children to the swing which she looked for in the neighborhood."

Both (3a) and (3b) have a thematically unambiguous head noun compatible only with THEME; thus in order to achieve a coherent interpretation for the sentence, the SOR analysis must be chosen. The two sentences contrast with respect to the length of the initial subject NP. (3a) has a subject consisting of single minor phrase. We have

established that in the first-pass parsing of such sentences up to the first verb, an SOR-inducing prosodic phrasing is often assigned (although this is somewhat variable); SR-inducing prosodic phrasing is rarely assigned. Therefore, in (3a) the thematic and prosodic (if any) factors are biasing in the same direction and the processing of the head noun should be smooth. By contrast, (3b) has a conjoined subject, which has been found to induce SR-compatible prosody, so the thematic and prosodic factors bias toward opposite directions. This will cause a conflict in the processing of the head noun in (3b). In the end, it is reasonable to assume that prosodic bias must yield to thematic compatibility, in order to maintain a plausible interpretation. Yet, if prosodic bias has any impact on the SR/SOR reanalysis decision, and is not shut out by priority of the thematic decision, the parser is predicted to exhibit difficulty at the head noun due to the conflict.

If instead, thematic-compatibility information (when available) dominates any other source of bias, then SOR should be adopted effortlessly at the head noun in both (3a) and (3b). Unless conflicting prosody is ignored entirely, this will force revision of the first-pass prosodic phrasing in (3b), requiring the creation of an extra major phrase boundary after the object. This prosodic revision is not necessarily associated with severe processing difficulty. It would not be difficult according to the interpretation of the prosodic effect on reanalysis as an instance of Minimal Revision, which only prevents the parser from making unnecessary revisions. Hence this leads to the prediction that processing of the head noun in (3b) should also be smooth, and therefore no significant difference in cost will be observed at this position compared to that in (3a).

This is an empirical question awaiting an answer by an experimental test.

Intuitively, (3b) does appear to cause some sense of surprise at the head noun in response to the inanimate head noun, presumably because an SR-type relative clause is anticipated, suggesting that the prosodic contour has an early effect strong enough to compete with a powerful thematic bias. However, the conflict seems to be resolved quite quickly in favor of the thematically-required SOR analysis, and the subsequent matrix verb which demands SOR is thus not a surprise.

Additional data that would illuminate this issue include data for comparable sentences but with thematic resolution toward SR at the head noun (see section 4.2.6.4 in Chapter 4) and an implicit prosodic bias toward SOR. Also valuable would be data on prosodic/thematic conflict resolution in spoken sentences where the prosody is explicit; thus would provide a baseline for estimating the strength of implicit prosody effects. It would also be of interest to discover whether conflict resolution is influenced by the relative timing of prosodic and thematic processing, or by a difference in informativeness between the two types of disambiguating information, or by the fact that one relates to the clause boundary position while the other concerns the role of the gap. These are more questions for future research on reanalysis ambiguity in Japanese relative clause processing.

APPENDICES

- APPENDIX 1: Experimental Materials for Experiment 1 (Chapter 4)
- APPENDIX 2: Experimental Materials for Experiment 2 (Chapter 4)
- APPENDIX 3: Experimental Materials for Experiment 3 (Chapter 4)
- APPENDIX 4: Experimental Materials for Experiment 3b (Chapter 4)
- APPENDIX 5: Experimental Materials for Experiments 4 and 6
(Chapter 5 and Chapter 6)
- APPENDIX 6: Experimental Materials for Experiment 5 (Chapter 5)
- APPENDIX 7: Experiment: An effect of constituent length on modifier association

APPENDIX 1: Experimental Materials for Experiment 1

- 1a 真弓がさっちゃんを駅前で見つけた歯医者にさっそく連れていった
 Mayumi-ga Sacchan-o ekimae-de mituketa haisha-ni tsureteitta
 (name)-Nom (name)-Acc station-Loc saw dentist-Dat immediately took to
 "Mayumi took Sacchan immediately to the dentist which she saw at the station."
- 1b 真弓がさっちゃんを駅前で見つけた診療所にさっそく連れていった
 Mayumi-ga Sacchan-o ekimae-de mituketa sinryoosho-ni tsureteitta
 (name)-Nom (name)-Acc station-Loc saw clinic-Dat immediately took to
 "Mayumi took Sacchan immediately to the clinic which she saw at the station."
- 1c 真弓がさっちゃんを駅前で見つけた歯医者にさっそくおれをいった
 Mayumi-ga Sacchan-o ekimae-de mituketa haisha-ni orei-o itta
 (name)-Nom (name)-Acc station-Loc saw dentist-Dat immediately thanked
 "Mayumi thanked the dentist who saw Sacchan at the station immediately."
- 2a クラスメートが絵里子を昔から毛嫌いしていた美容師にとうとう紹介するはめになった
 kurasumeeto-ga Eriko-o mukasikara kegraisiteita biyoosi-ni tootoo shookaisuruhameninatta
 classmate-Nom (name)-Acc since before hated hairdresser-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the hairdresser whom s/he had hated since before."
- 2b クラスメートが絵里子を昔から毛嫌いしていた美容室にとうとう紹介するはめになった
 kurasumeeto-ga Eriko-o mukasikara kegraisiteita biyoositu-ni tootoo shookaisuruhameninatta
 classmate-Nom (name)-Acc since before hated hairsalon-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the hairsalon which s/he hated since before."
- 2c クラスメートが絵里子を昔から毛嫌いしていた美容師にとうとう交渉するはめになった
 kurasumeeto-ga Eriko-o mukasikara kegraisiteita biyoosi-ni tootoo kooshoosuru hameninatta
 classmate-Nom (name)-Acc since before hated hairdresser-Dat in the end ended up negotiating
 "The classmate ended up negotiating with the hairdresser in the end who hated Eriko since before."

- 3a 一郎が弟を公園で目にしただんだんご屋に今日もおおきざりにした
 Ichiroo-ga otooto-o kooen-de menisita dangoya-ni kyoomo okizarinisita
 (name)-Nom brother-Acc park-Loc spotted candy vendor-Dat today left alone
 "Today as well, Ichiro left his brother alone at the candy vendor which he spotted in the park."
- 3b 一郎が弟を公園で目にしたすべり台に今日もおおきざりにした
 Ichiroo-ga otooto-o kooen-de menisita suberidai-ni kyoomo-mo okizarinisita
 (name)-Nom brother-Acc park-Loc spotted swing-Dat today left alone
 "Today as well, Ichiro left his brother alone at the swing which he spotted in the park."
- 3c 一郎が弟を公園で目にしただんだんご屋に今日もことづけをした
 Ichiroo-ga otooto-o kooen-de menisita dangoya-ni kyoomo-mo kotoduke-o sita
 (name)-Nom brother-Acc park-Loc spotted candy vendor -Dat today left message
 "Today as well, Ichiro left a message to the candy vendor who spotted his brother in the park."
- 4a 伊藤がうわさの心靈写真を日本中探して見つけただした祈禱師にすぐさま送り付けた
 Ito-ga uwasa-no sinreishasin-o nihonjyuu sagasite mitukedasia kitoosi-ni sugusama okurituketa
 (name)-Nom famous ghost photo-Acc by searching throughout Japan discovered healer-DAT right away sent
 "Ito immediately sent the healer the ghost photo which he discovered by searching throughout Japan."
- 4b 伊藤がうわさの心靈写真を日本中探して見つけただした祈禱場をすぐさま送り付けた
 Ito-ga uwasa-no sinreishasin-o nihonjyuu sagasite mitukedasia kitoojyoo-ni sugusama okurituketa
 (name)-Nom famous ghost photo-Acc by searching throughout Japan discovered healing place-Dat right away sent
 "Ito immediately sent the healing place the ghost photo which he discovered by searching throughout Japan."
- 4c 伊藤がうわさの心靈写真を日本中探して見つけただした祈禱師にすぐさま言い訳した
 Ito-ga uwasa-no sinreishasin-o nihonjyuu sagasite mitukedasia kitoosi-ni sugusama iiwakeshita
 (name)-Nom famous ghost photo-Acc by searching throughout Japan discovered healer-Dat right away made an excuse
 "Ito immediately made an excuse to the healer who discovered the ghost photo by searching throughout Japan."

- 5a 顧問の先生が山本君をいちばん気に入っていた監督に最初に推薦した
 komonno sensei-ga Yamamotokun-o ichiban kimiitteita kantoku-ni saishoni suisensita
 supervisor-Nom (name)-Acc the best liked manager -Dat first recommended
 "The supervisor first recommended Yamamoto to the manager that he liked the best."
- 5b 顧問の先生が山本君をいちばん気に入っていた役職に最初に推薦した
 komonno sensei-ga Yamamotokun-o ichiban kimiitteita yakushoku-ni saishoni suisensita
 supervisor-Nom (name)-Acc the best liked position-Dat first recommended
 "The supervisor first recommended Yamamoto to the position that he liked the best"
- 5c 顧問の先生が山本君をいちばん気に入っていた監督に最初に打診した
 komonno sensei-ga Yamamotokun-o ichiban kimiitteita kantoku-ni saishoni dasinsita
 supervisor-Nom (name)-Acc the best liked manager -Dat first sounded
 "The supervisor first sounded the captain (for opinion) who liked Yamamoto the best."
- 6a 監督がフランス映画を本当は軽蔑していた女子大生になんとか売り込もうとした
 kantoku-ga furansueega-o hontoo-wa keibetussteita josidaisei-ni nantoka urikomoo to siteita
 director-Nom French movie-Acc actually looking down on female student-Dat somehow trying to promote
 "The director was trying to promote the French movie somehow to the female student that he was actually looking down on."
- 6b 監督がフランス映画を本当は軽蔑していた女子短大になんとか売り込もうとした
 kantoku-ga furansueega-o hontoo-wa keibetussteita jositandai-ni nantoka urikomootositeita
 director-Nom French movie-Acc actually looking down on female college-Dat somehow trying to promote
 "The director was trying to promote the French movie somehow to the female college that he was actually looking down on."
- 6c 監督がフランス映画を本当は軽蔑していた女子大生になんとか接近しようとした
 kantoku-ga furansueega-o hontoo-wa keibetussteita josidaisei-ni nantoka sekkinshiyootositeita
 director-Nom French movie-Acc actually looking down on female student-Dat somehow trying to approach
 "The director was trying to approach somehow to the female student who was actually looking down on the French movie."

- 7a 鈴木達が賞金をままえからねらっていた質屋にこっそり隠そうとしていた
 Suzukitai-ga shookin-o maemaekara neratteiru sitya-ni kossori kakusootositeita
 (name)and others-Nom prize money-Acc since long before targeting pawnshop-Dat sneakingly trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the pawnshop which they had been targeting since long before."
- 7b 鈴木達が賞金をままえからねらっていた空家にこっそり隠そうとしていた
 Suzukitai-ga shookin-o maemaekara neratteiru akiya-ni kossori kakusootositeita
 (name)and others-Nom prize money-Acc since long before targeting empty house-Dat sneakingly trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the empty house which they had been targeting since long before."
- 7c 鈴木達が賞金をままえからねらっていた質屋にこっそり話をしようとした
 Suzukitai-ga shookin-o maemaekara neratteiru sitya-ni kossori hanasootositeita
 (name)and others-Nom prize money-Acc since long before targeting pawnbroker-Dat sneakingly trying to talk to
 "Suzuki and others were trying to talk to the pawnbroker sneakingly who had been targeting the prize money since long before."
- 8a 山岡が隠し遺産をあの手この手で探し出したもぐりの弁護士にやむなく預けた
 Yamaoka-ga kakusiisan-o anotekonotede sagasidasita moguri-no bengosi-ni yamunaku azuketa
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed lawyer-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed lawyer who he discovered after great effort."
- 8b 山岡が隠し遺産をあの手この手で探し出したもぐりの貸金庫にやむなく預けた
 Yamaoka-ga kakusiisan-o anotekonotede sagasidasita moguri-no kasinko-ni yamunaku azuketa
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed safe-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed safe which he discovered after great effort."
- 8c 山岡が隠し遺産をあの手この手で探し出したもぐりの弁護士にやむなく謝った
 Yamaoka-ga kakusiisan-o anotekonotede sagasidasita moguri-no bengosi-ni yamunaku ayamatta
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed lawyer-Dat unwillingly apologized
 "Yamaoka unwillingly apologized to the unlicensed lawyer who discovered the hidden fortune after great effort."

- 9a 松田部長が若い秘書をかねてから軽視していた主任に最終的に任命した
 Matsuda buchoo-ga wakai hisho-o kanetekara karukumiteita shunin-ni saishuutekini ninneesita
 (name) manager-Nom young secretary-Acc since before neglecting chief-Dat in the end nominated
 "The manager Matsuda, in the end, nominated the young secretary to the chief which he was neglecting since before."
- 9b 松田部長が若い秘書をかねてから軽視していた職種に最終的に任命した
 Matsuda buchoo-ga wakai hisho-o kanetekara karukumiteita shokushu-ni saishuutekini ninneesita
 (name) manager-Nom young secretary-Acc since before neglecting position-Dat in the end nominated
 "The manager Matsuda, in the end, nominated the young secretary to the position which he was neglecting since before."
- 9c 松田部長が若い秘書をかねてから軽視していた主任に最終的に注意した
 Matsuda buchoo-ga wakai hisho-o kanetekara karukumiteita shunin-ni saishuutekini shuuisita
 (name) manager-Nom young secretary-Acc since before neglecting chief-Dat in the end warned
 "The manager Matsuda, in the end, warned the chief who was neglecting the young secretary since before."
- 10a 沢田が近所の老婆を昔から信頼していた看護婦にまずは慣らそうとした
 Sawada-ga kinjo-no rooba-o mukasikara sinraiteita kangofu-ni mazu-wa narasoo-to sita
 Sawada-Nom neighborhood-Gen old woman-Acc since old times had trusted nurse-Dat first-Top tried to familiarize
 "Sawada tried to familiarize the old woman in the neighborhood to the nurse that he had trusted since old times. "
- 10b 沢田が近所の老婆を昔から信頼していた治療法にまずは慣らそうとした
 Sawada-ga kinjo-no rooba-o mukasikara sinraiteita chilyosi-ni mazu-wa narasoo-to sita
 Sawata-Nom neighborhood-Gen old woman-Acc since old times had trusted remedy-Dat first-Top tried to familiarize
 "Sawata tried to familiarize the old woman in the neighborhood to the remedy that he had trusted since old times. "
- 10c 沢田が近所の老婆を昔から信頼していた看護婦にまずは慣れようとした
 Sawada-ga kinjo-no rooba-o mukasikara sinraiteita kangofu-ni mazu-wa nareyoo-to sita
 Sawata-Nom neighborhood-Gen old woman-Acc since old times had trusted nurse-Dat first-Top tried to familiarize
 "Sawata tried to get familiarized to the nurse who had trusted the old woman in the neighborhood since old times. "

- 11a 美佐子が息子を心の底ではばかにしていた塾講師に思い切って一任することにした
 Misako-ga musuko-o kokoro-no oko-de-wa baka-ni siteita jyukukoosi-ni omoikitte ichinin surukotoni sita
 Misako-Nom son-Acc at heart making a fool of instructor-Dat boldly decided to entrust
 "Misako boldly decided to entrust her son to the instructor whom she was making a fool of at heart."
- 11b 美佐子が息子を心の底ではばかにしていた公文式に思い切って一任することにした
 Misako-ga musuko-o kokoro-no soko-de-wa baka-ni siteita kumonsiki-ni omoikitte ichinin surukotoni sita
 Misako-Nom son-Acc at heart making a fool of Kumon method-Dat boldly decided to entrust
 "Misako boldly decided to entrust her son to the Kumon method which she was making a fool of at heart."
- 11c 美佐子が息子を心の底ではばかにしていた塾講師に思い切って抗議することにした
 Misako-ga musuko-o kokoro-no soko-de-wa baka-ni siteita jyukukoosi-ni omoikitte koogi surukotoni sita
 Misako-Nom son-Acc at heart making a fool of instructor-Dat boldly decided to protest
 "Misako boldly decided to protest against the instructor who was making a fool of her son at heart."
- 12a 佐藤が語学力のある人材をずっと要請していた課長について昇格させた
 Satoo-ga gogakuryoku-no aru jinzai-wo zutto yoosei siteita kachoo-ni tuini syookaku saseta
 Satoo-Nom skilled in foreign languages person-Acc long requesting section chief-Dat finally promoted to
 "Sato finally promoted the person skilled in foreign languages to the section chief that he had long been requesting."
- 12b 佐藤が語学力のある人材をずっと要請していた地位について昇格させた
 Satoo-ga gogakuryoku-no aru jinzai-wo zutto yoosei siteita tiini-nituini syookaku saseta
 Satoo-Nom skilled in foreign languages person-Acc long requesting position-Dat finally promoted to
 "Sato finally promoted the person skilled in foreign languages to the position that he had long been requesting."
- 12c 佐藤が語学力のある人材をずっと要請していた課長について直訴された
 Satoo-ga gogakuryoku-no aru jinzai-wo zutto yoosei siteita kachoo-ni tuini jūkiso saseta
 Satoo-Nom skilled in foreign languages person-Acc long requesting section chief-Dat finally make an appeal-Passive
 "Sato was finally appealed by the section chief who had long been requesting the person skilled in foreign languages."

APPENDIX 2: Experimental Materials for Experiment 2

("/" indicates segmentation.)

- 1a 真弓がさっちゃんを駅前で見つけた/歯医者に/さっそく/連れていった。
 Mayumi-ga Sacchan-o ekimae-de mituketa haisha-ni tsureteitta.
 (name)-Nom (name)-Acc station-Loc saw dentist-Dat took to
 "Mayumi took Sacchan right away to the dentist which she saw at the station."
- 1b 真弓がさっちゃんを駅前で見つけた/診療所に/さっそく/連れていった。
 Mayumi-ga Sacchan-o ekimae-de mituketa sinryoosho-ni tsureteitta.
 (name)-Nom (name)-Acc station-Loc saw clinic-Dat took to
 "Mayumi took Sacchan right away to the clinic which she saw at the station."
- 1c 真弓がさっちゃんを駅前で見つけた/歯医者に/さっそく/お礼をいった。
 Mayumi-ga Sacchan-o ekimae-de mituketa haisha-ni orei o itta.
 (name)-Nom (name)-Acc station-Loc saw dentist-Dat thanked
 "Mayumi thanked right away to the dentist who saw Sacchan at the station."
- 2a クラスメートが/絵里子を/昔から/怪しいと思っていた/公認会計士に/とうとう/紹介するはめになった。
 kurasumeeto-ga Eriko-o mukasikara ayasiito omotteita koonkaikeisi-ni tootoo shookaisuruhameninatta.
 classmate-Nom (name)-Acc since before suspected accountant-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the accountant whom s/he was suspecting since before."
- 2b クラスメートが/絵里子を/昔から/怪しいと思っていた/法律事務所に/とうとう/紹介するはめになった。
 kurasumeeto-ga Eriko-o mukasikara ayasiito omotteita hoorisujimusho-ni tootoo shookaisuruhameninatta.
 classmate-Nom (name)-Acc since before suspected law firm-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the law firm which s/he was suspecting since before."
- 2c クラスメートが/絵里子を/昔から/怪しいと思っていた/公認会計士に/とうとう/交渉するはめになった。
 kurasumeeto-ga Eriko-o mukasikara ayasiito omotteita koonkaikeisi-ni tootoo kooshoosuruhameninatta.
 classmate-Nom (name)-Acc since before suspected accountant-Dat in the end ended up negotiating
 "The classmate ended up negotiating with the accountant in the end who was suspecting Eriko since before."

- 3a 一郎が/弟を/公園で/目にした/花屋に/今日も/おきざりにした。
 Ichiroo-ga ototoo-o kooen-de menisita hanaya-ni kyoo-mo okizarinisita.
 (name)-Nom brother-Acc park-Loc spotted florist-Dat today also left alone
 "Today Ichiro left his brother alone at the florist which he spotted in the park."
- 3b 一郎が/弟を/公園で/目にした/噴水に/今日も/おきざりにした。
 Ichiroo-ga ototoo-o kooen-de menisita funsui-ni kyoo-mo okizarinisita.
 (name)-Nom brother-Acc park-Loc spotted fountain-Dat today also left alone
 "Today Ichiro left his brother alone at the fountain which he spotted in the park."
- 3c 一郎が/弟を/公園で/目にした/花屋に/今日も/ことづけをした。
 Ichiroo-ga ototoo-o kooen-de menisita hanaya-ni kyoo-mo kotodukeo sita.
 (name)-Nom brother-Acc park-Loc spotted florist-Dat today also left message
 "Today Ichiro left a message with the florist who spotted his brother in the park."
- 4a 伊藤が/うわさの心霊写真を/人里離れた/村で/見つけた/見つけた/超能力研究者に/すぐさま送り付けた。
 Ito-ga uwasa-no sinreishashin-o hitozato hanareta mura-de mitukedasita choonooryokukenkyuusha-ni sugusama okurituketa.
 (name)-Nom famous ghost photo-Acc remote village-Loc discovered ESP researcher-Dat immediately sent
 "Ito immediately sent the ghost photo to the ESP researcher who he discovered in the remote village."
- 4b 伊藤が/うわさの心霊写真を/人里離れた/村で/見つけた/見つけた/超能力研究所に/すぐさま送り付けた。
 Ito-ga uwasa-no sinreishashin-o hitozato hanareta mura-de mitukedasita choonooryokukenkyuusho-ni sugusama okurituketa.
 (name)-Nom famous ghost photo-Acc remote village-Loc discovered ESP research institute-Dat immediately sent
 "Ito immediately sent the ghost photo to the ESP research institute which he discovered in the remote village."
- 4c 伊藤が/うわさの心霊写真を/人里離れた/村で/見つけた/見つけた/超能力研究者に/すぐさま言い訳した。
 Ito-ga uwasa-no sinreishashin-o hitozato hanareta mura-de mitukedasita choonooryokukenkyuusha-ni sugusama iiwakeshita.
 (name)-Nom famous ghost photo-Acc remote village-Loc discovered ESP researcher-Dat immediately made an excuse
 "Ito immediately made an excuse to the ESP researcher who discovered the ghost photo in the remote village."

- 5a 顧問の先生が山本君をいちばん/気に入っていた/監督に/最初に/推薦した。
 komon-no sensei-ga Yamamotokun-o ichiban kimitteita kantoku-ni saishoni suisensita.
 supervisor-Nom (name)-Acc the best liked manager-Dat first recommended
- 5b 顧問の先生が山本君をいちばん/気に入っていた/役職に/最初に/推薦した。
 komon-no sensei-ga Yamamotokun-o ichiban kinitteita yakushoku-ni saishoni suisensita.
 supervisor-Nom (name)-Acc the best liked position-Dat first recommended
- 5c 顧問の先生が山本君をいちばん/気に入っていた/監督に/最初に/打診した。
 komon-no sensei-ga Yamamotokun-o ichiban kinitteita kantoku-ni saishoni dasinsita.
 supervisor-Nom (name)-Acc the most liked manager-Dat first sounded
- 6a 監督がフランス映画を/全く/知らない/女子大生に/なんとか/売り込もうとしていた。
 kantoku-ga furansueega-o mattaku siranai josidaisei-ni nantoka urikomoo to sitcita.
 director-Nom French movie-Acc at all know-Neg female student-Dat somehow was trying to sell
- 6b 監督がフランス映画を/全く/知らない/女子短大に/なんとか/売り込もうとしていた。
 kantoku-ga furansueega-o mattaku siranai jositandaini nantoka urikomootositeita.
 director-Nom French movie-Acc at all know-Neg female college-Dat somehow was trying to sell
- 6c 監督がフランス映画を/全く/知らない/女子大生に/なんとか/接近しようとしていた。
 kantoku-ga furansueega-o mattaku siranai josidaisei-ni nantoka sekkinshiyootositeita.
 director-Nom French movie-Acc at all know-Neg female student-Dat somehow was trying to approach

- 7a 鈴木達が賞金を/まえまえから/ねらっていた/質屋に/こっそり/隠そうとしていた。
 Suzukitai-ga shookin-o maemaekara neratteita sitya-ni kakusootositeita.
 (name) and others-Nom prize money-Acc since long before was aiming at pawnbroker -Dat sneakingly was trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the pawnbroker which they were aiming at since long before."
- 7b 鈴木達が賞金を/まえまえから/ねらっていた/空家に/こっそり/隠そうとしていた。
 Suzukitai-ga shookin-o maemaekara neratteita akiya-ni kakusootositeita.
 (name) and others-Nom prize money-Acc since long before aiming at empty house-Dat sneakingly was trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the empty house which they were aiming at since long before."
- 7c 鈴木達が賞金を/まえまえから/ねらっていた/質屋に/こっそり話をしようとした。
 Suzukitai-ga shookin-o maemaekara neratteita sitya-ni hanasiosiyootositeita.
 (name) and others-Nom prize money-Acc since long before aiming at pawnbroker-Dat sneakingly was trying to talk to
 "Suzuki and others are trying to talk to the pawnbroker sneakingly who were aiming at the prize money since long before."
- 8a 山岡が隠し遺産を/あの手この手で/探し出した/もぐりの弁護士に/やむなく/預けた。
 Yamaoka-ga kakusuisan-o anotekonotede sagasidasita moguri-no bengosi-ni yamunaku azuketa.
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed lawyer-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed lawyer that he discovered after great effort."
- 8b 山岡が隠し遺産を/あの手この手で/探し出した/もぐりの貸金庫に/やむなく/預けた。
 Yamaoka-ga kakusuisan-o anotekonotede sagasidasita moguri-no kasinko-ni yamunaku azuketa.
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed safe-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed safe that he discovered after great effort."
- 8c 山岡が隠し遺産を/あの手この手で/探し出した/もぐりの弁護士に/やむなく/謝った。
 Yamaoka-ga kakusuisan-o anotekonotede sagasidasita moguri-no bengosi-ni yamunaku ayamatta.
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed lawyer-Dat unwillingly apologized
 "Yamaoka unwillingly apologized to the unlicensed lawyer that discovered the hidden fortune after great effort."

- 9a 松田部長が若い秘書をかねてから軽視していた主任に最終的に任命した。
 Matsuda buchoo-ga wakai hisho-o kanetekara keisisiteita shunin-ni saishuutekini ninneesita.
 (name) manager-Nom young secretary-Acc since before was underestimating chief-Dat in the end appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the chief which he was underestimating since before."
- 9b 松田部長が若い秘書をかねてから軽視していた職種に最終的に任命した。
 Matsuda buchoo-ga wakai hisho-o kanetekara keisisiteita shokushu-ni saishuutekini ninneesita.
 (name) manager-Nom young secretary-Acc since before was underestimating position-Dat in the end appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the position which he was underestimating since before."
- 9c 松田部長が若い秘書をかねてから軽視していた主任に最終的に注意した。
 Matsuda buchoo-ga wakai hisho-o kanetekara keisisiteita shunin-ni saishuutekini shuisita.
 (name) manager-Nom young secretary-Acc since before was underestimating chief-Dat in the end warned
 "The manager Matsuda, in the end, warned the chief who was underestimating the young secretary since before."
- 10a 母親が昭彦を第一印象で気に入った女性にじつは/まかせたがっていた。
 hahaoya-ga Akihiko-o daiiinshoode kimiitta josei-ni jituwa makasetagatteita.
 mother-Nom (name)-Acc at the first sight liked woman-Dat in fact wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the woman whom she liked at the first sight."
- 10b 母親が昭彦を第一印象で気に入った学校にじつは/まかせたがっていた。
 hahaoya-ga Akihiko-o daiiinshoode kimiitta gakkoo-ni jituwa makasetagatteita.
 mother-Nom (name)-Acc at the first sight liked school-Dat in fact wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the school whom she liked at the first sight."
- 10c 母親が昭彦を第一印象で気に入った女性にじつは/いやがらせしていた。
 hahaoya-ga Akihiko-o daiiinshoode kimiitta josei-ni jituwa iyagaraseteita.
 mother-Nom (name)-Acc at the first sight liked woman-Dat in fact was harassing
 "The mother was in fact harassing the woman who liked Akihiko at the first sight."

- 11a 山本医師が自分の患者を/大通りで/見つけた/新聞屋に/すぐに/案内した。
 Yamamoto isi-ga jibun-no kanja-o oodoori-de mituketa sinbunya-ni suguni annaisita.
 (name) Dr. -Nom own patient-Acc main street-Loc found newspaper seller-Dat immediately directed
 "Dr. Yamamoto immediately directed his own patient to the newspaper seller which he found on the main street."
- 11b 山本医師が自分の患者を/大通りで/見つけた/郵便局に/すぐに/案内した。
 Yamamoto isi-ga jibun-no kanja-o oodoori-de mituketa yuubi nkyoku-ni suguni annaisita.
 (name) Dr. -Nom own patient-Acc main street-Loc found post office-Dat immediately directed
 "Dr. Yamamoto immediately directed his own patient to the post office which he found on the main street."
- 11c 山本医師が自分の患者を/大通りで/見つけた/新聞屋に/すぐに/質問した。
 Yamamoto isi-ga jibun-no kanja-o oodoori-de mituketa sinbunya-ni suguni situmonsita.
 (name) Dr. -Nom own patient-Acc main street-Loc found newspaper seller-Dat immediately questioned
 "Dr. Yamamoto immediately questioned the newspaper seller who found his own patient on the main street."
- 12a 村田が/新しい作品を/完璧に/信用している/友人達に/ただちに/送った。
 Murata-ga atarasii sakuhin-o kanpekini sinyoositeiru yuujintai-ni tadatini okutta.
 (name) -Nom new work-Acc completely trust friends-Dat immediately sent
 "Murata immediately sent his new work to friends whom he completely trusted."
- 12b 村田が/新しい作品を/完璧に/信用している/出版社に/ただちに/送った。
 Murata-ga atarasii sakuhin-o kanpekini sinyoositeiru shuppansha-ni tadatini okutta.
 (name) -Nom new work-Acc completely trust publisher-Dat immediately sent
 "Murata immediately sent his new work to the publisher which he completely trusted."
- 12c 村田が/新しい作品を/完璧に/信用している/友人達に/ただちに/謝った。
 Murata-ga atarasii sakuhin-o kanpekini sinyoositeiru yuujintai-ni ayamatta.
 (name) -Nom new work-Acc completely trust friends-Dat immediately apologized
 "Murata immediately apologized to the friends who completely trusted his new work."

- 13a 和也が珍しい子猫を/川べりで/目にとめた/魚屋に/夕方/預けて帰った。
 Kazuya-ga mezurasii koneko-o kawaberi-de menitometta azukete kaetta.
 (name) -Nom strange kitten-Acc by the river-Loc spotted left behind
 "In the evening, Kazuya left the strange kitten behind at the fishseller's which he found by the river."
- 13b 和也が珍しい子猫を/川べりで/目にとめた/民家に/夕方/預けて帰った。
 Kazuya-ga mezurasii koneko-o kawaberi-de menitometta azukete kaetta.
 (name) -Nom strange kitten-Acc by the river-Loc spotted left behind
 "In the evening, Kazuya left the strange kitten behind at somebody's house which he found by the river."
- 13c 和也が珍しい子猫を/川べりで/目にとめた/魚屋に/夕方/電話をかけた。
 Kazuya-ga mezurasii koneko-o kawaberi-de menitometta denwa-o kaketa.
 (name) -Nom strange kitten-Acc by the river-Loc spotted phoned
 "In the evening, Kazuya phoned the fishseller who found the strange kitten by the river."
- 14a 三田村氏が/新入生の一人を/密かに/有望視していた/サッカー/コーチに/去年/任せていた。
 Mitamura-ga sinnyuusei-no hitori-o hisokani yuuboosisiteita sakkaa kooti-ni
 (name) -Nom one of the new students-Acc secretly was counting on soccer coach-Dat
 "Last year Mitamura entrusted one of the new students to the soccer coach that he was secretly counting on."
- 14b 三田村氏が/新入生の一人を/密かに/有望視していた/サッカー/チームに/去年/任せていた。
 Mitamura-ga sinnyuusei-no hitori-o hisokani yuuboosisiteita sakkaa tiimu-ni
 (name) -Nom one of the new students-Acc secretly was counting on soccer team-Dat
 "Last year Mitamura entrusted one of the new students to the soccer team that he was secretly counting on."
- 14c 三田村氏が/新入生の一人を/密かに/有望視していた/サッカー/コーチに/去年/話をきいた。
 Mitamura-ga sinnyuusei-no hitori-o hisokani yuuboosisiteita sakkaa kooti-ni
 (name) -Nom one of the new students-Acc secretly was counting on soccer coach-Dat
 "Last year Mitamura interviewed the soccer coach that was secretly counting on one of the new students."

- 15a お母さんが晋平と弟をバス停の前で見つけた/ちり紙交換屋に/あとで行かせた。
 okaasan-ga Simpei-to ototoo-o basutei-no mae-de mituketa tirigami kookan ya-ni
 mother-Nom (name) and brother-Acc in front of bus stop found scrap dealer-Dat
 "Later the mother made Simpei and his brother go to the scrap dealer which she found in front of the bus stop." atode
 later
 ikaseta.
 go-Cause-Past
- 15b お母さんが晋平と弟をバス停の前で見つけた/子ども図書館に/あとで行かせた。
 okaasan-ga Simpei-to ototoo-o basutei-no mae-de mituketa kodomo toshokan-ni
 mother-Nom (name) and brother-Acc in front of bus stop found kid's library-Dat
 "Later the mother made Simpei and his brother go to the kid's library which she found in front of the bus stop." atode
 later
 ikaseta.
 go-Cause-Past
- 15c お母さんが晋平と弟をバス停の前で見つけた/ちり紙交換屋に/あとで礼をした。
 okaasan-ga Simpei-to ototoo-o basutei-no mae-de mituketa tirigami kookan ya-ni
 mother-Nom (name) and brother-Acc in front of bus stop found scrap dealer-Dat
 " Later the offered a reward to the scrap dealer who found Simpei and his brother in front of the bus stop." atode
 later
 rei o sita.
 rewarded
- 16a 叔母が春子を/はじめから/あとにしていた/祖父母に/無理に/預かってもらった。
 oba-ga Haruko-o hajimekara tayorinisiteita sofubo-ni murini
 aunt-Nom (name)-Acc from the beginning counting on grandparents-Dat forcibly
 "The aunt forcibly had her grandparents whom she was counting on from the beginning look after Haruko." azukatteromoratta.
 look after-Cause
- 16b 叔母が春子を/はじめから/あとにしていた/託児所に/無理に/預かってもらった。
 oba-ga Haruko-o hajimekara tayorinisiteita takujijo-ni murini
 aunt-Nom (name)-Acc from the beginning was counting on daycare center-Dat forcibly
 "The aunt forcibly had the daycare center which she was counting on from the beginning look after Haruko." azukatteromoratta.
 look after-Cause-Past
- 16c 叔母が春子を/はじめから/あとにしていた/祖父母に/無理に/話をつけてやった。
 oba-ga Haruko-o hajimekara tayorinisiteita sofubo-ni murini hanasi-o
 aunt-Nom (name)-Acc from the beginning was counting on grandparents-Dat forcibly
 "The aunt forcibly negotiated with her grandparents who was counting on Haruko from the beginning." tuketeyatta.
 negotiated

- 17a P T A 会長夫妻が一人娘をあまりよりは評価していない/担任教師に/なんとか/なじませる努力をした。
 PTA kaichoofusai-ga hitorimusume-o amani hyookasiteinai najimaseru doryokuosita.
 PTA president couple-Nom daughter-Acc somewhat underestimate teacher-Dat somehow tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the teacher whom they somewhat underestimated."
- 17b P T A 会長夫妻が一人娘をあまりよりは評価していない/私立高校に/なんとか/なじませる努力をした。
 PTA kaichoofusai-ga hitorimusume-o amani hyookasiteinai sirituokoo-ni nantoka najimaseru doryokuosita.
 PTA president couple-Nom daughter-Acc somewhat underestimate private school-Dat somehow tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the private school which they somewhat underestimated"
- 17c P T A 会長夫妻が一人娘をあまりよりは評価していない/担任教師に/なんとか/あゆみよる努力をした。
 PTA kaichoofusai-ga hitorimusume-o amani hyookasiteinai tanninkyoosi-ni nantoka ayumiyoru doryokuosita.
 PTA president couple-Nom daughter-Acc somewhat underestimate teacher-Dat somehow tried to compromise with
 "Mr. and Mrs. president of PTA somehow tried to compromise with the teacher who somewhat underestimated their daughter."
- 18a 沢田が近所の老婆を/昔から/信頼していた/看護婦に/まずは/慣らそうとした。
 Sawada-ga kinjo-no rooba-o mukasikara sinraiseita kangofu-ni mazu-wa narasoo-to sita.
 Sawata-Nom neighborhood-Gen old woman-Acc since old times has trusted nurse-Dat first-Top tried to familiarize
 "Sawata tried to familiarize the old woman in the neighborhood to the nurse that he had trusted since old times."
- 18b 沢田が近所の老婆を/昔から/信頼していた/治療法に/まずは/慣らそうとした。
 Sawada-ga kinjo-no rooba-o mukasikara sinraiseita hiryoohoo-ni mazu-wa narasoo-to sita.
 Sawata-Nom neighborhood-Gen old woman-Acc since old times has trusted remedy-Dat first-Top tried to familiarize
 "Sawata tried to familiarize the old woman to the remedy that he had trusted since old times."
- 18c 沢田が近所の老婆を/昔から/信頼していた/看護婦に/まずは/慣れようとした。
 Sawada-ga kinjo-no rooba-o mukasikara sinraiseita kangofu-ni mazu-wa nareyoo-to sita.
 Sawata-Nom neighborhood-Gen old woman-Acc since old times has trusted nurse-Dat first-Top tried to get familiarized
 "Sawata tried to get familiarized to the nurse who had trusted the old woman in the neighborhood since old times."

- 19a 中村教授が/教育実習生たちを/以前は/相手に/もして/いなかった/校長に/あとで/紹介した。
 Nakamura kyooju-ga kyooiku jissusei tachu-o izen-wa aitenimoshiteimakatta
 Nakamura professor-Nom intern-Acc before-Top has ignored
 "Professor Nakamura introduced the interns to the president whom he had ignored."
- 19b 中村教授が/教育実習生たちを/以前は/相手に/もして/いなかった/高校に/あとで/紹介した。
 Nakamura kyooju-ga kyooiku jissusei tachu-o izen-wa aitenimoshiteimakatta
 Nakamura professor-Nom intern-Acc before-Top has ignored
 "Professor Nakamura introduced the interns to the high school that he had ignored."
- 19c 中村教授が/教育実習生たちを/以前は/相手に/もして/いなかった/校長に/あとで/抗議した。
 Nakamura kyooju-ga kyooiku jissusei tachu-o izen-wa aitenimoshiteimakatta
 Nakamura professor-Nom intern-Acc before-Top has ignored
 "Professor Nakamura protested against the president who had ignored the interns."
- 20a 学年主任が/おちこぼれの生徒を/もとも/なめて/かかっていた/女教師に/案の定/押しつけた。
 gakunen syuinin-ga ochikobore-no seito-o student-Acc originally nametekakatteita
 chairman-Nom dropout-Gen student-Acc originally has despised
 "The chairman certainly forced the dropout students on the female teacher whom he had despised."
- 20b 学年主任が/おちこぼれの生徒を/もとも/なめて/かかっていた/学習塾に/案の定/押しつけた。
 gakunen syuinin-ga ochikobore-no seito-o student-Acc originally nametekakatteita
 chairman-Nom dropout-Gen student-Acc originally has despised
 "The chairman forced the dropout students on the cram school that he had despised."
- 20c 学年主任が/おちこぼれの生徒を/もとも/なめて/かかっていた/女教師に/案の定/腹をたてた。
 gakunen syuinin-ga ochikobore-no seito-o student-Acc originally nametekakatteita
 chairman-Nom dropout-gen student-Acc originally has despised
 "The chairman got angry with the female teacher who had despised the dropout students."
- 19a koocho-ni atode syookai sita.
 principal-Dat later introduced
- 19b kokoni-ni atode syookai sita.
 high school-Dat later introduced
- 19c koocho-ni atode koogi sita.
 principal-Dat later protested
- 20a onna kyoosi-ni annojyoo osituketa.
 woman teacher-Dat certainly forced on
- 20b gakusyujiku-ni annojyoo osituketa.
 cram school-Dat certainly forced on
- 20c onna kyoosi-ni annojyoo haraotateta.
 woman teacher-Dat certainly got angry with

- 21a 老人が捨て子を/あちこち聞いて/探して/探した/牧師に/とうとう/託すことにした。
 roojin-ga sutego-o achikochikiite sagasia bokusi-ni tootoo takusukotomisita.
 old man-Nom orphan-Acc asking at various places looked for priest-Dat finally decided to entrusted
 "The old man finally decided to entrust the orphan to the priest who he looked for by asking in various places."
- 21b 老人が/捨て子を/あちこち聞いて/探した/施設に/とうとう/託すことにした
 roojin-ga sutego-o achikochikiite sagasia sisetu-ni tootoo takusukotomisita.
 old man-Nom orphan-Acc asking at various places looked for orphanage-Dat finally decided to entrusted
 "The old man finally decided to entrust the orphan to the orphanage who he looked for by asking in various places."
- 21c 老人が捨て子をあちこち聞いて探した牧師にとうとう会うことにした。
 roojin-ga sutego-o achikochikiite sagasia bokusi-ni tootoo aukotonisita.
 old man-Nom orphan-Acc asking at various places looked for priest-Dat finally decided to see
 "The old man finally decided to meet the priest who looked for the orphan by asking in various places."
- 22a 松井が/新入社員を/普段なるべく/避けている/部長に/仕方なく/挨拶しに行かせた。
 Matui-ga shinnyu syain-o fudan narubeku saketeiru bucho-ni sikatanaku aisatusini ikaseta.
 Matui-Nom freshman-Acc usually if possible avoid director-Dat against one's will forced to visit
 "Matui forced the freshman against his will to visit the director that he had usually avoided as much as possible."
- 22b 松井が/新入社員を/普段なるべく/避けている/部署に/仕方なく/挨拶しに行かせた。
 Matui-ga shinnyu syain-o fudan narubeku saketeiru busyo-ni sikatanaku aisatusini ikaseta.
 Matui-Nom freshman-Acc usually if possible avoid department-Dat against his will forced to visit
 "Matui forced the freshman against his will to visit the department that he had usually avoided as much as possible."
- 22c 松井が/新入社員を/普段なるべく/避けている/部長に/仕方なく/挨拶をしに行った。
 Matui-ga shinnyu syain-o fudan narubeku saketeiru bucho-ni sikatanaku aisatu-o simiitta.
 Matui-Nom freshman-Acc usually if possible avoid director-Dat against his will visited
 "Matui, against his will, visited the director who had usually avoided the freshman as much as possible."

- 23a 直美が/年上の/恋人を/たまたま/知っていた/社長に/無理に/斡旋した。
 Naomi-ga tosiue-no koibito-o tamatama sitteita syachoo-ni murini assensita.
 Naomi-Nom older lover-Acc incidentally knew president-Dat forcibly mediated
 "Naomi forcibly mediated her older lover to the president whom she happened to know."
- 23b 直美が/年上の/恋人を/たまたま/知っていた/劇団に/無理に/斡旋した。
 Naomi-ga tosiue-no koibito-o tamatama sitteita gekidan-ni murini assensita.
 Naomi-Nom older lover-Acc incidentally knew troupe-Dat forcibly mediated
 "Naomi forcibly mediated her older lover to the troupe which she happened to know."
- 23c 直美が/年上の/恋人を/たまたま/知っていた/社長に/無理に/尋問した。
 Naomi-ga tosiue-no koibito-o tamatama siteita syachoo-ni murini jimmonshita.
 Naomi-Nom older lover-Acc incidentally knew president forcibly question
 "Naomi forcibly questioned the president who happened to know her older lover."
- 24a 軍曹が/女の/刺客たちを/所詮/なめてかかっていた/大臣に/すぐさま/差し向けた。
 gunsoo-ga onna no sikyakutai-o shosen namete kakatteita daijin-ni sugusama sasimuketa.
 officer-Nom female killer-Acc utterly made a fool of minister-Dat soon sent
 "The officer immediately sent the female killers to the minister whom he had utterly made a fool of."
- 24b 軍曹が/女の/刺客たちを/所詮/なめてかかっていた/小国に/すぐさま/差し向けた。
 gunsoo-ga onna no sikyakutai-o shosen namete kakatteita syookoku-ni sugusama sasimuketa.
 officer-Nom female killer-Acc utterly made a fool of small country-Dat soon sent
 "The officer immediately sent the female killers to the small country which he had utterly made a fool of."
- 24c 軍曹が/女の/刺客たちを/所詮/なめてかかっていた/大臣に/すぐさま/忠告した。
 gunsoo-ga onna no sikyakutai-o shosen namete kakatteita daijin-ni sugusama chuukokusita.
 officer-Nom female killer-Acc utterly made a fool of minister-Dat soon warned
 "The officer immediately warned the minister who had utterly made a fool of the female killers."

APPENDIX 3: Experimental Materials for Experiment 3

("P" indicates segmentation.)

- 1a 真弓が/さっちゃんを/駅前で/見つけた/あやしげな/歯医者に/さっそく/連れていった。
 Mayumi-ga Sacchan-o ekimae-de mituketa ayasigena haisha-ni tsureteitta.
 (name)-Nom (name)-Acc station-Loc saw strange dentist-Dat took to
 "Mayumi took Sacchan right away to the strange dentist which she saw at the station."
- 1b 真弓が/さっちゃんを/駅前で/見つけた/あやしげな/診療所に/さっそく/連れていった。
 Mayumi-ga Sacchan-o ekimae-de mituketa ayasigena sinryoosho-ni tsureteitta.
 (name)-Nom (name)-Acc station-Loc saw strange clinic-Dat took to
 "Mayumi took Sacchan right away to the strange clinic which she saw at the station."
- 2a クラスメートが/絵里子を/昔から/怪しいと思っていた/無名の/公認会計士に/とうとう/紹介するはめになった。
 kurasumeeto-ga Eriko-o mukasikara ayasiito omotteita numeeno kooninkaikaisi-ni tootoo shookaisuruhameninatta.
 classmate-Nom (name)-Acc since before suspected unknown accountant-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the unknown accountant whom s/he was suspecting since before."
- 2b クラスメートが/絵里子を/昔から/怪しいと思っていた/無名の/法律事務所に/とうとう/紹介するはめになった。
 kurasumeeto-ga Eriko-o mukasikara ayasiito omotteita numeeno hooritsujimusho-ni tootoo shookaisuruhameninatta.
 classmate-Nom (name)-Acc since before suspected unknown law firm-Dat in the end ended up introducing
 "The classmate ended up introducing Eriko in the end to the unknown law firm which s/he was suspecting since before."
- 3a 一郎が/弟を/公園で/目にした/例の/花屋に/今日も/おきざりにした。
 Ichiroo-ga ototoo-o reino kooen-de menisita hanaya-ni kyoo-mo okizarinisita.
 (name)-Nom brother-Acc usual park-Loc spotted florist-Dat today also left alone
 "Today Ichiro left his brother alone at the usual florist which he spotted in the park."
- 3b 一郎が/弟を/公園で/目にした/例の/噴水に/今日も/おきざりにした。
 Ichiroo-ga ototoo-o kooen-de menisita reino funsui-ni kyoo-mo okizarinisita.
 (name)-Nom brother-Acc park-Loc spotted usual fountain-Dat today also left alone
 "Today Ichiro left his brother alone at the usual fountain which he spotted in the park."

- 4a 伊藤が/うわさの心霊写真を/人里離れた/村で/見つけた/した/有名な/超能力研究者に/すぐさま送り付けた。
 Ito-ga uwasa-no sinreishasin-o hitozato hanareta mura-de mitukedasia yuumeena choonooryokukenkyuusha-ni sugusama okurituketa.
 (name)-Nom famous ghost photo-Acc remote village-Loc discovered famous ESP researcher-Dat immediately sent
 "Ito immediately sent the ghost photo to the famous ESP researcher who he discovered in the remote village."
- 4b 伊藤が/うわさの心霊写真を/人里離れた/村で/見つけた/した/有名な/超能力研究所に/すぐさま送り付けた。
 Ito-ga uwasa-no sinreishasin-o hitozato hanareta mura-de yuumeena mitukedasia choonooryokukenkyuusho-ni sugusama okurituketa.
 (name)-Nom famous ghost photo-Acc remote village-Loc discovered famous ESP research institute-Dat immediately sent
 "Ito immediately sent the ghost photo to the famous ESP research institute which he discovered in the remote village."
- 5a 顧問の先生が/山本君を/いちばん/気に入っていた/いた/ある/監督に/最初に/推薦した。
 komon-no sensei-ga Yamamotokun-o ichiban kinitteita aru kantoku-ni saishoni suisensita.
 supervisor-Nom (name)-Acc the best liked certain manager-Dat first recommended
 "The supervisor first recommended Yamamoto to the certain manager that he liked the best."
- 5b 顧問の先生が/山本君を/いちばん/気に入っていた/いた/ある/役職に/最初に/推薦した。
 komon-no sensei-ga Yamamotokun-o ichiban kinitteita aru yakushoku-ni saishoni suisensita.
 supervisor-Nom (name)-Acc the best liked certain position-Dat first recommended
 "The supervisor first recommended Yamamoto to the certain position that he liked the best."
- 6a 監督が/フランス映画を/全く/知らない/お上品な/女子大生に/なんとか/売り込もうとしていた。
 kantoku-ga furansueega-o mattaku siranai ojohinna josidaisei-ni nantoka urikomoo to siteita.
 director-Nom French movie-Acc at all know-Neg elegant female student-Dat somehow was trying to sell
 "The director was trying to promote the French movie to the elegant female student he did not know at all."
- 6b 監督が/フランス映画を/全く/知らない/お上品な/女子短大に/なんとか/売り込もうとしていた。
 kantoku-ga furansueega-o mattaku siranai ojohinna jositandaini nantoka urikomootositeita.
 director-Nom French movie-Acc at all know-Neg elegant female college-Dat somehow was trying to sell
 "The director was trying to promote the French movie to the elegant female college he did not know at all."

- 7a 鈴木達が/賞金を/ままえから/ねらっていた/古い/質屋に/こっそり/隠そうとしていた。
 Suzukitai-ga shookin-o prize money-Acc maemaekara neratteita funui sitiya-ni kossori kakusootositeita.
 (name) and others-Nom prize money-Acc since long before was aiming at old pawnbroker-Dat sneakingly was trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the old pawnbroker which they were aiming at since long before."
- 7b 鈴木達が/賞金を/ままえから/ねらっていた/古い/空家に/こっそり/隠そうとしていた。
 Suzukitai-ga shookin-o prize money-Acc maemaekara neratteita funui akiya-ni kossori kakusootositeita.
 (name) and others-Nom prize money-Acc since long before aiming at old empty house-Dat sneakingly was trying to hide
 "Suzuki and others were trying to hide the prize money sneakingly in the old empty house which they were aiming at since long before."
- 8a 山岡が/隠し遺産を/あの手この手で/探し出した/もぐりの/弁護士に/やむなく/預けた。
 Yamaoka-ga kakuisisan-o anotekonotede sagasidasita moguri-no bengosi-ni yamunaku azuketa.
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed lawyer-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed lawyer that he discovered after great effort."
- 8b 山岡が/隠し遺産を/あの手この手で/探し出した/もぐりの/貸金庫に/やむなく/預けた。
 Yamaoka-ga kakuisisan-o anotekonotede sagasidasita moguri-no kasinko-ni yamunaku azuketa.
 (name)-Nom hidden fortune-Acc after great effort discovered unlicensed safe-Dat unwillingly entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed safe that he discovered after great effort."
- 9a 松田部長が/若い秘書を/かねてから/軽視していた/へん/な/主任に/最終的に/任命した。
 Matsuda buchou-ga wakai hisho-o kanetekara keisiteita henna shumin-ni saishuutekini ninmeesita.
 (name) manager-Nom young secretary-Acc since before was underestimating weird chief-Dat in the end appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the weird chief which he was underestimating since before."
- 9b 松田部長が/若い秘書を/かねてから/軽視していた/へん/な/職種に/最終的に/任命した。
 Matsuda buchou-ga wakai hisho-o kanetekara keisiteita henna shokushu-ni saishuutekini ninmeesita.
 (name) manager-Nom young secretary-Acc since before was underestimating weird position-Dat in the end appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the weird position which he was underestimating since before."

- 10a 母親が昭彦を/第一印象で/気に入った/どこかの/女性に/じつは/まかせたがっていた。
 hahaoya-ga Akihiko-o daiitiinshoode kiniitta dokoka-no josei-ni jituwa makasetagatteita.
 mother-Nom (name)-Acc at the first sight liked unfamiliar woman-Dat in fact wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the unfamiliar woman whom she liked at the first sight."
- 10b 母親が昭彦を/第一印象で/気に入った/どこかの/学校に/じつは/まかせたがっていた。
 hahaoya-ga Akihiko-o daiitiinshoode kiniitta dokoka-no gakkoo-ni jituwa makasetagatteita.
 mother-Nom (name)-Acc at the first sight liked unfamiliar school-Dat in fact wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the unfamiliar school whom she liked at the first sight."
- 11a 山本医師が/自分の患者を/大通りで/見つけた/新しい/新聞屋に/すぐに/案内した。
 Yamamoto isi-ga jibun-no kanja-o oodoori-de mituketa atarasii sinbunya-ni suguni annaisita.
 (name) Dr. -Nom own patient-Acc main street-Loc found new newspaper seller-Dat immediately directed
 "Dr. Yamamoto immediately directed his own patient to the newspaper seller which he found on the main street."
- 11b 山本医師が/自分の患者を/大通りで/見つけた/新しい/郵便局に/すぐに/案内した。
 Yamamoto isi-ga jibun-no kanja-o oodoori-de mituketa atarasii yuubinkyoku-ni suguni annaisita.
 (name) Dr. -Nom own patient-Acc main street-Loc found new post office-Dat immediately directed
 "Dr. Yamamoto immediately directed his own patient to the post office which he found on the main street."
- 12a 村田が/新しい作品を/完璧に/信用している/親しい/友人達に/ただちに/送った。
 Murata-ga atarasii sakuhin-o kanpekini completely sinyoositeiru sitasii yuujintati-ni okutta.
 (name) -Nom new work-Acc completely trust familiar friends-Dat immediately sent
 "Murata immediately sent his new work to familiar friends whom he completely trusted."
- 12b 村田が/新しい作品を/完璧に/信用している/親しい/出版社に/ただちに/送った。
 Murata-ga atarasii sakuhin-o kanpekini completely sinyoositeiru sitasii shuppansha-ni okutta.
 (name) -Nom new work-Acc completely trust familiar publisher-Dat immediately sent
 "Murata immediately sent his new work to the familiar publisher which he completely trusted."

- 13a 和也が珍しい子猫を川べりで目にとめた/小汚い/魚屋に/夕方/預けて帰った。
 Kazuya-ga mezurasii koneko-o kawaberi-de menitometa kogitanai sakanaya-ni yuugata azukete kaetta.
 (name) -Nom strange kitten-Acc by the river-Loc spotted dirty fishseller-Dat in evening left behind
 "In the evening, Kazuya left the strange kitten behind at the dirty fishseller's which he found by the river."
- 13b 和也が珍しい子猫を川べりで目にとめた/小汚い/民家に/夕方/預けて帰った。
 Kazuya-ga mezurasii koneko-o kawaberi-de menitometa kogitanai minka-ni yuugata azukete kaetta.
 (name) -Nom strange kitten-Acc by the river-Loc spotted dirty private house-Dat in evening left behind
 "In the evening, Kazuya left the strange kitten behind at somebody's dirty house which he found by the river."
- 14a 三田村氏が新入生の一人を/密かに/有望視していた/若い/サッカー/コーチに/去年/任せていた。
 Mitamura-ga sinnyuusei-no hitori-o hisokami yuuboositeita wakai sakkaa kooi-ni makaseteita.
 (name) -Nom one of the new students-Acc secretly was counting on young soccer coach-Dat entrusted
 "Last year Mitamura entrusted one of the new students to the young soccer coach that he was secretly counting on."
- 14b 三田村氏が新入生の一人を/密かに/有望視していた/若い/サッカー/チームに/去年/任せていた。
 Mitamura-ga sinnyuusei-no hitori-o hisokami yuuboositeita wakai sakkaa tiimu-ni makaseteita.
 (name) -Nom one of the new students-Acc secretly was counting on young soccer team-Dat entrusted
 "Last year Mitamura entrusted one of the new students to the young soccer team that he was secretly counting on."
- 15a お母さんが/晋平と弟を/バス停の前で/見つけた/近くの/ちり紙交換屋に/あとで/行かせた。
 okaasan-ga Simpei-to ootoo-o basutei-no mae-de mituketa tikakuno tirigami kookan ya-ni ikaseta.
 mother-Nom (name) and brother-Acc in front of bus stop found close scrap dealer-Dat go-Cause-Past
 "Later the mother made Simpei and his brother go to the close scrap dealer which she found in front of the bus stop."
- 15b お母さんが/晋平と弟を/バス停の前で/見つけた/近くの/子ども図書館に/あとで/行かせた。
 okaasan-ga Simpei-to ootoo-o basutei-no mae-de mituketa tikakuno kodomo toshokan-ni atode ikaseta.
 mother-Nom (name) and brother-Acc in front of bus stop found close kid's library-Dat later go-Cause-Past
 "Later the mother made Simpei and his brother go to the close kid's library which she found in front of the bus stop."

- 16a 叔母が/春子を/はじめから/あてにしていた/ひまそうな/祖父母に/無理に/預かってもらった。
 oba-ga Hanuko-o hajimekara tayorinisiteita himasoona sofubo-ni murini azukattemoratta.
 aunt-Nom (name)-Acc from the beginning counting on unoccupied grandparents-Dat forcibly look after-Cause
 "The aunt forcibly had her unoccupied grandparents whom she was counting on from the beginning look after Haruko."
- 16b 叔母が/春子を/はじめから/あてにしていた/ひまそうな/託児所に/無理に/預かってもらった。
 oba-ga Haruko-o hajimekara tayorinisiteita himasoona takujjo-ni murini azukattemoratta.
 aunt-Nom (name)-Acc from the beginning was counting on unoccupied daycare center-Dat forcibly look after-Cause-Past
 "The aunt forcibly had the unoccupied daycare center which she was counting on from the beginning look after Haruko."
- 17a P T A 会長夫妻が/一人娘を/あまりよくは/評価して/いない/きどった/担任教師に/なんとか/なじませる努力をした。
 PTA kaichoofusai-ga hitorimusume-o amari hyookasiteinai kidotta nninkyooosi-ni nantoka najimaseru doryokuosita.
 PTA president couple-Nom daughter-Acc somewhat underestimate affected teacher-Dat somehow tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the affected teacher whom they somewhat underestimated."
- 17b P T A 会長夫妻が/一人娘を/あまりよくは/評価して/いない/きどった/私立高校に/なんとか/なじませる努力をした。
 PTA kaichoofusai-ga hitorimusume-o amari hyookasiteinai kidotta sinitukookoo-ni nantoka najimaseru doryokuosita.
 PTA president couple-Nom daughter-Acc somewhat underestimate affected private school-Dat somehow tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the affected private school which they somewhat underestimated"
- 18a 沢田が/近所の老婆を/昔から/信頼していた/平凡な/看護婦に/まずは/慣らそうとした。
 Sawada-ga kinjo-no rooba-o mukasikara sinraiteita heebonna kangofu-ni mazu-wa narasoo-to sita.
 Sawata-Nom neighborhood-Gen old woman-Acc since old times has trusted ordinary nurse-Dat first-Top tried to familiarize
 "Sawata tried to familiarize the old woman in the neighborhood to the ordinary nurse that he had trusted since old times."
- 18b 沢田が/近所の老婆を/昔から/信頼していた/平凡な/治療法に/まずは/慣らそうとした。
 Sawada-ga kinjo-no rooba-o mukasikara sinraiteita heebonna hiryoohoo-ni mazu-wa narasoo-to sita.
 Sawata-Nom neighborhood-Gen old woman-Acc since old times has trusted ordinary remedy-Dat first-Top tried to familiarize
 "Sawata tried to familiarize the old woman to the ordinary remedy that he had trusted since old times."

- 19a 中村教授が教育実習生たちを/以前は/相手にもして/いなかった/いけすかない/校長に/あとで/紹介した。
 Nakamura kyooju-ga kyooiku jissusei tachi-o izen-wa aitenimoshiteimakatta ikesukanai koocho-ni syookai sita.
 Nakamura professor-Nom intern-Acc before-Top has ignored disgusting principal-Dat later introduced
 "Professor Nakamura introduced the interns to the disgusting principal whom he had ignored."
- 19b 中村教授が教育実習生たちを/以前は/相手にもして/いなかった/いけすかない/高校に/あとで/紹介した。
 Nakamura kyooju-ga kyooiku jissusei tachi-o izen-wa aitenimoshiteimakatta ikesukanai kokoni-ni syookai sita.
 Nakamura professor-Nom intern-Acc before-Top has ignored disgusting high school-Dat later introduced
 "Professor Nakamura introduced the interns to the disgusting high school that he had ignored."
- 20a 学年主任がおちこぼれの生徒を/もと/なめてかかっていた/とんでもない/女教師に/案の定/押しつけた。
 gakunen syuinin-ga ochikobore-no seito-o motomoto nametekakatteita tondemonai onna kyooisi-ni osituketa.
 chairman-Nom dropout-Gen student-Acc originally has despised awful woman teacher-Dat certainly forced on
 "The chairman certainly forced the dropout students on the awful female teacher whom he had despised."
- 20b 学年主任がおちこぼれの生徒を/もと/なめてかかっていた/とんでもない/学習塾に/案の定/押しつけた。
 gakunen syuinin-ga ochikobore-no seito-o motomoto nametekakatteita tondemonai gaksuyujiku-ni osituketa.
 chairman-Nom dropout-Gen student-Acc originally has despised awful cram school-Dat certainly forced on
 "The chairman forced the dropout students on the awful cram school that he had despised."
- 21a 老人が/捨て/子を/あちこち聞いて探した/良心的な/牧師に/とうとう/託すことにした。
 roojin-ga sutego-o achikochikiite sagasita ryoosintekina bokusi-ni tootoo takusukotonisita.
 old man-Nom orphan-Acc asking at various places looked for good priest-Dat finally decided to entrusted
 The old man finally decided to entrust the orphan to the good priest who he looked for by asking in various places."
- 21b 老人が/捨て/子を/あちこち聞いて探した/良心的な/施設に/とうとう/託すことにした
 roojin-ga sutego-o achikochikiite sagasita ryoosintekina sisetu-ni tootoo takusukotonisita.
 old man-Nom orphan-Acc asking at various places looked for good orphanage-Dat finally decided to entrusted
 "The old man finally decided to entrust the good orphan to the orphanage who he looked for by asking in various places."

- 22a 松井が/新入社員を/普段なるべく/避けている/おかたの/部長に/仕方なく/挨拶しに行かせた。
 Matui-ga shinnyu syain-o fudan narubeku saketeiru okatai bucho-ni sikatanaku aisatusini ikaseta.
 Matui-Nom freshman-Acc usually if possible avoid conservative director-Dat against one's will forced to visit
 "Matui forced the freshman against his will to visit the conservative director that he had usually avoided as much as possible."
- 22b 松井が/新入社員を/普段なるべく/避けている/おかたの/部署に/仕方なく/挨拶しに行かせた。
 Matui-ga shinnyu syain-o fudan narubeku saketeiru okatai busyo-ni sikatanaku aisatusini ikaseta.
 Matui-Nom freshman-Acc usually if possible avoid conservative department-Dat against his will forced to visit
 "Matui forced the freshman against his will to visit the conservative department that he had usually avoided as much as possible."
- 23a 直美が/年上の/恋人を/たまたま/知っていた/たよりなさそう/社長に/無理に/斡旋した。
 Naomi-ga tosiue-no koibito-o tamatama siteita tayorinasoona syachoo-ni murini assensita.
 Naomi-Nom older lover-Acc incidentally knew unreliable president-Dat forcibly mediated
 "Naomi forcibly mediated her older lover to the unreliable president whom she happened to know."
- 23b 直美が/年上の/恋人を/たまたま/知っていた/たよりなさそう/劇団に/無理に/斡旋した。
 Naomi-ga tosiue-no koibito-o tamatama siteita tayorinasoona gekidan-ni murini assensita.
 Naomi-Nom older lover-Acc incidentally knew unreliable troupe-Dat forcibly mediated
 "Naomi forcibly mediated her older lover to the unreliable troupe which she happened to know."
- 24a 軍曹が/女の/刺客たちを/所詮/なめてかかって/いた/裕福な/大臣に/すぐさま/差し向けた。
 gunsoo-ga onna no sikyakuatari-o shosen namete kakatteita yuufukuna daijin-ni sugusama sasimuketa.
 officer-Nom female killer-Acc utterly made a fool of wealthy minister-Dat sent
 "The officer immediately sent the female killers to the wealthy minister whom he had utterly made a fool of."
- 24b 軍曹が/女の/刺客たちを/所詮/なめてかかって/いた/裕福な/小国に/すぐさま/差し向けた。
 gunsoo-ga onna no sikyakuatari-o shosen namete kakatteita syookoku-ni sugusama sasimuketa.
 officer-Nom female killer-Acc utterly made a fool of wealthy small country -Dat soon sent
 "The officer immediately sent the female killers to the wealthy small country which he had utterly made a fool of."

APPENDIX 4: Experimental Materials for Experiment 3b

(“/” indicates segmentation.)

- 1a 真弓が/あやしげな/歯医者に/さっそく/さっちゃんを/連れていった。
 Mayumi-ga ayasigena haisha-ni sassoku Sacchan-o tsureteita.
 (name)-Nom strange dentist-Dat right away (name)-Acc took to
 "Mayumi took Sacchan right away to the strange dentist."
- 1b 真弓が/あやしげな/診療所に/さっそく/さっちゃんを/連れていった。
 Mayumi-ga ayasigena sinryoo sho-ni sassoku Sacchan-o tsureteita.
 (name)-Nom strange clinic-Dat right away (name)-Acc took to
 "Mayumi took Sacchan right away to the strange clinic."
- 2a クラスメートが/無名の/公認会計士に/とうとう/絵里子を/紹介するはめになった。
 kurasumeeto-ga mumeeno kooninkaikeisi-ni tootoo Eriko-o shookaisuruhameninatta.
 classmate-Nom unknown accountant-Dat in the end (name)-Acc ended up introducing
 "The classmate ended up introducing Eriko in the end to the unknown accountant."
- 2b クラスメートが/無名の/法律事務所に/とうとう/絵里子を/紹介するはめになった。
 kurasumeeto-ga mumeeno hoorisujimusho-ni tootoo Eriko-o shookaisuruhameninatta.
 classmate-Nom unknown law firm-Dat in the end (name)-Acc ended up introducing
 "The classmate ended up introducing Eriko in the end to the unknown law firm."
- 3a 一郎が/例の/花屋に/今日も/弟を/おきざりにした。
 Ichiroo-ga reino hanaya-ni kyoo-mo ototoo-o okizarinisita.
 (name)-Nom usual florist-Dat today also brother-Acc left alone
 "Today Ichiro left his brother alone at the usual florist."

- 3b 一郎が/例の/噴水に/今日も/弟を/おきざりにした。
 Ichiroo-ga reino funsui-ni kyoo-mo ootoo-o okizarinisita.
 (name)-Nom usual fountain-Dat today also brother-Acc left alone
 "Today Ichiro left his brother alone at the usual fountain"
- 4a 伊藤が/有名な/超能力研究者に/うわさの/心靈写真を/すぐさま送り付けた。
 Ito-ga yuumeena choonoooryokukenkyuusha-ni sugusama uwasa-no sinreishasin-o okurituketa.
 (name)-Nom famous ESP researcher-Dat immediately famous ghost photo-Acc sent
 "Ito immediately sent the ghost photo to the famous ESP researcher."
- 4b 伊藤が/有名な/超能力研究所に/うわさの/心靈写真を/すぐさま送り付けた。
 Ito-ga yuumeena choonoooryokukenkyuusho-ni sugusama uwasa-no sinreishasin-o okurituketa.
 (name)-Nom famous ESP research institute-Dat immediately famous ghost photo-Acc sent
 "Ito immediately sent the famous ESP research institute."
- 5a 顧問の先生が/ある/監督に/最初に/山本君を/推薦した。
 komon-no sensei-ga aru kantoku-ni saishoni Yamamotokun-o suisensita.
 supervisor-Nom certain manager-Dat first (name)-Acc recommended
 "The supervisor first recommended Yamamoto to the certain manager."
- 5b 顧問の先生が/ある/役職に/最初に/山本君を/推薦した。
 komon-no sensei-ga aru yakushoku-ni saishoni Yamamotokun-o suisensita.
 supervisor-Nom certain position-Dat first (name)-Acc recommended
 "The supervisor first recommended Yamamoto to the certain position."
- 6a 監督が/お上品な/女子大生に/なんとか/フランス映画を/売り込もうとしていた。
 kantoku-ga ojohinna josidaisei-ni nantoka furansueega-o urikomoo to siteita.
 director-Nom elegant female student-Dat somehow French movie-Acc was trying to sell
 "The director was trying to promote the French movie to the elegant female student."

- 6b 監督がお上品な/女子短大に/なんとか/フランス映画を/売り込もうとしていた。
 kantoku-ga ojouhinna jostandaini nantoka furansueega-o urikomoo to siteita.
 director-Nom elegant female college-Dat somehow French movie-Acc was trying to sell
 "The director was trying to promote the French movie to the elegant female college."
- 7a 鈴木達が/古い/質屋に/こっそり/賞金を/隠そうとしていた。
 Suzukitai-ga furui sitya-ni kossori shookin-o kakusootositeita.
 (name) and others-Nom old pawnbroker-Dat sneakingly prize money-Acc was trying to hide
 "Suzuki and others are trying to hide the prize money sneakingly in the old pawnbroker."
- 7a 鈴木達が/古い/質屋に/こっそり/賞金を/隠そうとしていた。
 Suzukitai-ga furui kiya-ni kossori shookin-o kakusootositeita.
 (name) and others-Nom old empty house-Dat sneakingly prize money-Acc was trying to hide
 "Suzuki and others are trying to hide the prize money sneakingly in the old empty house."
- 8a 山岡が/もぐりの/弁護士に/やむなく/隠し遺産を/預けた。
 Yamaoka-ga moguri-no bengosi-ni yamunaku kakuisan-o azuketa.
 (name)-Nom unlicensed lawyer-Dat unwillingly hidden fortune-Acc entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed lawyer."
- 8a 山岡が/もぐりの/貸金庫に/やむなく/隠し遺産を/預けた。
 Yamaoka-ga moguri-no kasinko-ni yamunaku kakuisan-o azuketa.
 (name)-Nom unlicensed safe-Dat unwillingly hidden fortune-Acc entrusted
 "Yamaoka unwillingly entrusted the hidden fortune to the unlicensed safe."
- 9a 松田部長が/へんな/主任に/最終的に/若い秘書を/任命した。
 Matsuda buchou-ga henna shunin-ni saishuutekini wakai hisho-o ninmeesita.
 (name) manager-Nom weird chief-Dat in the end young secretary-Acc appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the weird chief."

- 9b 松田部長が/へんな主任に/最終的に/若い秘書を/任命した。
 Matsuda buchou-ga henna shokushu-ni saishuutekini wakai hisho-o ninmeesita.
 (name) manager-Nom weird position-Dat in the end young secretary-Acc appointed to
 "The manager Matsuda, in the end, appointed the young secretary to the weird position."
- 10a 母親が/どこかの女性に/じつは/昭彦を/まかせたがっていた。
 hahaoya-ga dokoka-no josei-ni jituwa Akihiko-o makasetagatteita.
 mother-Nom unfamiliar woman-Dat in fact (name)-Acc wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the unfamiliar woman."
- 10b 母親が/どこかの学校に/じつは/昭彦を/まかせたがっていた。
 hahaoya-ga dokoka-no gakkoo-ni jituwa Akihiko-o makasetagatteita.
 mother-Nom unfamiliar school-Dat in fact (name)-Acc wanted to entrust
 "The mother in fact wanted to entrust Akihiko to the unfamiliar school."
- 11a 山本医師が/新しい新聞屋に/自分の患者を/すぐに/案内した。
 Yamamoto isi-ga atarasii sinbunya-ni suguni jibun-no kanja-o annaisita.
 (name) Dr. -Nom new newspaper seller-Dat immediately own patient-Acc directed
 "Dr. Yamamoto immediately directed his own patient to the newspaper seller."
- 11b 山本医師が/新しい郵便局に/自分の患者を/すぐに/案内した。
 Yamamoto isi-ga atarasii sinbunya-ni suguni jibun-no kanja-o annaisita.
 (name) Dr. -Nom new yuubinkyoku-ni immediately own patient-Acc directed
 "Dr. Yamamoto immediately directed his own patient to the post office."
- 12a 村田が/親しい/友人達に/ただちに/新しい作品を/送った。
 Murata-ga sitasii yuujintati-ni tadatini atarasii sakuhin-o okutta.
 (name)-Nom familiar friends-Dat immediately new work-Acc sent
 "Murata immediately sent his new work to familiar friends."

- 12b 村田が親しい/友人達に/ただちに/新しい作品を/送った。
 Murata-ga sitasii shuppansha-ni tadatani atarasii sakuhin-o okuita.
 (name) -Nom familiar publisher-Dat immediately new work-Acc sent
 "Murata immediately sent his new work to familiar publisher."
- 13a 和也が/小汚い/魚屋に/夕方/珍しい子猫を/預けて/帰った。
 Kazuya-ga kogitanai sakanaya-ni yuugata mezurasii koneko-o azukete kaetta.
 (name) -Nom dirty fishseller-Dat in evening strange kitten-Acc left behind
 "In the evening, Kazuya left the strange kitten behind at the dirty fishseller's."
- 13b 和也が/小汚い/民家に/夕方/珍しい子猫を/預けて/帰った。
 Kazuya-ga kogitanai minka-ni yuugata mezurasii koneko-o azukete kaetta.
 (name) -Nom dirty private house-Dat in evening strange kitten-Acc left behind
 "In the evening, Kazuya left the strange kitten behind at the dirty house."
- 14a 三田村氏が/若い/サッカーコーチに/去年/新入生の一人を/任せていた。
 Mitamura-ga wakai sakkaa kooti-ni kyonen sinnyuusei-no hitori-o makaseteita.
 (name) -Nom young soccer coach-Dat last year one of the new students-Acc entrusted
 "Last year Mitamura entrusted one of the new students to the young soccer coach."
- 14b 三田村氏が/若い/サッカーチームに/去年/新入生の一人を/任せていた。
 Mitamura-ga wakai sakkaa kooti-ni kyonen sinnyuusei-no hitori-o makaseteita.
 (name) -Nom young soccer team-Dat last year one of the new students-Acc entrusted
 "Last year Mitamura entrusted one of the new students to the young soccer team."
- 15a お母さんが/近い/近くの/ちり紙交換屋に/あとで/晋平と弟を/行かせた。
 okaasan-ga tükakuno tirigami kookan ya-ni atode Simpei-to ototoo-o ikaseta.
 mother-Nom close scrap dealer-Dat later (name) and brother-Acc go-Cause-Past
 "Later the mother made Simpei and his brother go to the close scrap dealer."

- 15b お母さんが//近くの/子ども図書館に/あとで/晋平と弟を/行かせた。
 okaasan-ga tōkaku no kodomo toshokan-ni ato de Simpei-to ototoo-o ikaseta.
 mother-Nom close kid's library-Dat later (name) and brother-Acc go-Cause-Past
 "Later the mother made Simpei and his brother go to the close kid's library."
- 16a 叔母が/ひまそうな/祖父母に/無理に/春子を/頼かってもらった。
 oba-ga himasoona sofubo-ni murini Hanuko-o azukatteromoratta.
 aunt-Nom unoccupied grandparents-Dat forcibly (name)-Acc look after-Cause
 "The aunt forcibly had her unoccupied grandparents."
- 16b 叔母が/ひまそうな/託児所に/無理に/春子を/頼かってもらった。
 oba-ga himasoona takujijo-ni murini Haruko-o azukatteromoratta.
 aunt-Nom unoccupied daycare center-Dat forcibly (name)-Acc look after-Cause
 "The aunt forcibly had her unoccupied center."
- 17a P T A 会長夫妻が/きどった/担任教師に/なんとか/一人娘を/なじませる努力をした。
 PTA kaichoofusai-ga kidottata ninkyooosi-ni nantoka hitorimusume-o najimaseru doryokuosita.
 PTA president couple-Nom affected teacher-Dat somehow daughter-Acc tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the affected teacher."
- 17b P T A 会長夫妻が/きどった/私立高校に/なんとか/一人娘を/なじませる努力をした。
 PTA kaichoofusai-ga kidottata ninkyooosi-ni nantoka hitorimusume-o najimaseru doryokuosita.
 PTA president couple-Nom affected sinitukookoo-ni somehow daughter-Acc tried to familiarize
 "Mr. and Mrs. president of PTA somehow tried to familiarize their daughter to the affected private school."
- 18a 沢田が/平凡な/看護婦に/まずは/近所の老婆を/慣らそうとした。
 Sawada-ga heebonna kangofu-ni mazu-wa kinjo-no rooba-o narasoo-to sita.
 Sawata-Nom ordinary nurse-Dat first-Top neighborhood-Gen old woman-Acc tried to familiarize
 "Sawata tried to familiarize the old woman in the neighborhood to the ordinary nurse."

- 18b 沢田が平凡な治療法にまずは近所の老婆を慣らそうとした。
 Sawada-ga heebonna luryoohoo-ni mazu-wa kinjo-no narasoo-to sita.
 Sawata-Nom ordinary remedy-Dat first-Top neighborhood-Gen old woman-Acc tried to familiarize
 "Sawata tried to familiarize the old woman in the neighborhood to the ordinary remedy."
- 19a 中村教授がいきすかない校長にあとで教育実習生たちを紹介した。
 Nakamura kyooju-ga ikesukanai koocho-ni atode kyooiku jissusei tachi-o syookai sita.
 Nakamura professor-Nom disgusting principal-Dat later intern-Acc introduced
 "Professor Nakamura introduced the interns to the disgusting principal whom he had ignored."
- 20a 学年主任がりとんでもない女教師に案の定おちこぼれの生徒を押しつけた。
 gakunen syuinin-ga toondemonai onna kyooosi-ni annojyoo ochikobore-no seito-o osituketa.
 chairman-Nom awful woman teacher-Dat certainly dropout-Gen student-Acc forced on
 "The chairman certainly forced the dropout students on the awful female teacher."
- 20b 学年主任がりとんでもない学習塾に案の定おちこぼれの生徒を押しつけた。
 gakunen syuinin-ga toondemonai gakusyujiku-ni annojyoo ochikobore-no seito-o osituketa.
 chairman-Nom awful cram school-Dat certainly dropout-Gen student-Acc forced on
 "The chairman certainly forced the dropout students on the awful cram school."
- 21a 老人が良心的な牧師にとうとう捨て子を託すことにした。
 roojin-ga ryoosintekina bokusi-ni tootoo sutego-o takusukotonisita.
 old man-Nom good priest-Dat finally orphan-Acc decided to entrusted
 The old man finally decided to entrust the orphan to the good priest."
- 21b 老人が良心的な施設にとうとう捨て子を託すことにした。
 roojin-ga ryoosintekina sisetu-ni tootoo sutego-o takusukotonisita.
 old man-Nom good orphanage-Dat finally orphan-Acc decided to entrusted
 The old man finally decided to entrust the orphanage to the good orphanage."

- 22a 松井がおかたいたい部長に/仕方なく/新入社員を/挨拶しに行かせた。
 Matui-ga okatai bucho-ni sikatanaku shinnyu syain-o aisatusini ikaseta.
 Matui-Nom conservative director-Dat against one's will freshman-Acc forced to visit
 "Matui forced the freshman against his will to visit the conservative director."
- 22b 松井がおかたいたい部署に/仕方なく/新入社員を/挨拶しに行かせた。
 Matui-ga okatai busyo-ni sikatanaku shinnyu syain-o aisatusini ikaseta.
 Matui-Nom conservative department-Dat against one's will freshman-Acc forced to visit
 "Matui forced the freshman against his will to visit the conservative department."
- 23a 直美がたよりなさそうな/社長に/無理に/年上の/恋人を/斡旋した。
 Naomi-ga tayorinasoona syachoo-ni murini tosiue-no koibito-o assensita.
 Naomi-Nom unreliable president-Dat forcibly older lover-Acc mediated
 "Naomi forcibly mediated her older lover to the unreliable president."
- 23b 直美がたよりなさそうな/劇団に/無理に/年上の/恋人を/斡旋した。
 Naomi-ga tayorinasoona gekidan-ni murini tosiue-no koibito-o assensita.
 Naomi-Nom unreliable troupe-Dat forcibly older lover-Acc mediated
 "Naomi forcibly mediated her older lover to the unreliable troupe."
- 24a 軍曹が/裕福な/大臣に/すぐさま/女の刺客たちを/差し向けた。
 gunsoo-ga yuufukuna daijin-ni sugusama onna no sikyakutati-o sasimuketa.
 officer-Nom wealthy minister-Dat soon female killer-Acc sent
 "The officer immediately sent the female killers to the wealthy minister-Dat."
- 24b 軍曹が/裕福な/小国に/すぐさま/女の刺客たちを/差し向けた。
 gunsoo-ga yuufukuna syookoku-ni sugusama onna no sikyakutati-o sasimuketa.
 officer-Nom wealthy small country -Dat soon female killer-Acc sent
 "The officer immediately sent the female killers to the wealthy small country."

APPENDIX 5: Experimental materials (sentence fragments) used in Experiments 4 and 6. Fragments were either in the simple subject condition without the NP-to presented in the parenthesis, or in the conjoined subject condition with the NP-to in the parenthesis.

1. 酒井と秘書が絵里子を前から怪しんでいた会計士にとうとう
(Sakai-to) husho-ga Eriko-o maekara ayasindeita kaikeisi-ni tootoo
(Sakai-and) secretary-Nom Eriko-Acc since before suspected accountant-Dat finally
2. 横山と吉岡が財産をとうとう探し出した弁護士にやむなく
(Yokoyama-to) Yosioka-ga zaisan-o tootoo sagasidasita bengosi-ni yamunaku
(Yokoyama-and) Yosioka-Nom fortune-Acc finally found lawyer-Dat re luctantly
3. 祖父と両親が昭彦を一目で気に入った女性にじつは
(sofubo-to) ryoosin-ga Akihiko-o hitome-de kiniitta josei-ni jituwa
(grandparents-and) parents-Nom Akihiko-Acc at the first glance liked woman-Dat in fact
4. 兄と正樹が家族を一通りで見かけた友達にすぐに
(ani -to) Masaki-ga kazoku-o toori-de mikaketa tomodachi-ni suguni
(brother-and) Masaki-Nom family member-Acc street-Loc saw friend-Dat right away
5. 細川と森下が新薬を心から信用した友達にとうとう
(Hosokawa -to) Morisita-ga sinyaku-o kokorokara sinyoosita tomodachi-ni tootoo
(Hosokawa-and) Nirusuta-Nom new medicine-Acc truly trusted friend-Dat finally
6. 母さんと父さんが春彦をかなり頼りにしていた祖母にとまかく
(kaasan-to) toosan-ga Haruhiko-o kanari tayoriniseiteita so fubo-ni tomokaku
(mother -and) father-Nom Haruhiko-Acc heavily was counting on grandparents-Dat anyway
7. 理事長と学校長が学部生を以前からなめていた女教師に案の定
(rijicho-to) gakkoocho-ga izenkara nameteita jokyousi-ni annojoo
(c hair of trustee-and) school president-Nom since before made little of female teacher-Acc as expected

8. 千佳ちゃんと健次くんが伝書鳩をさつき発見した獣医にとにかく
 (Tikachan-to) Kenji kun-ga denshobato-o sakki tonikaku
 (Tika-and) Kenji-Nom carrier pegeon-Acc earlier veterinarian-Dat anyway
9. 農夫と老婆が子供らを急いで連れてきた神父にととうとう
 (noofu-to) rooba-ga kodomora-o isoide tootoo
 (peasant-and) old woman-Nom children-Acc in a hurry priest-Dat finally
10. チーフと専務が秘書をあきらかに避けている係長に仕方なく
 (chiifu-to) sennu-ga hisho-o akirakani saketeiru sikatanaku
 (chief-and) manager-Nom secretary-Acc obveously is avoiding section chief-Dat unwillingly
11. 佐藤と原田が薬物をなんとか見つけたら研究者にすぐさま
 (Sato-to) Harada-ga yakubutu-o nantoka mitukedasita sugusama
 (Sato-and) Harada-Nom drug-Acc somehow discovered researcher-Dat immediately
12. お姉さんとお母さんが正彦を町内で見つけた本屋にあとで
 (onecsan-to) okaasan-ga Masahiko-o chonai-de honya-ni atode
 (sister-and) mother-Nom Masahiko-Acc neighborhood-Loc bookseller-Dat later

APPENDIX 6: Experimental materials used in Experiment 5. Sentences were either in the simple subject condition without the NP- to presented in the parenthesis, or in the conjoined subject condition with the NP-to in the parenthesis.

1. 幸子と真由子がさっちゃんを商店街で見た外人に母親をひきあわせた。
 (Yukiko-to) Mayuko-ga shootengai-de mita gajjin-ni hahaya-o hikiawaseta.
 (Yukiko-and) Mayuko-Nom Sacchan-Acc shooppig street-Loc saw foreigner-Dat mother-Acc introduced
 "(Yukiko and) Mayuko introduced the mother to the foreigner who saw Sacchan on the shopping street."
2. 酒井と秘書が絵里子を以前怪しんでいた会計士に顧客を探してきてやった。
 (Sakai-to) hisho-ga Eriko-o izen ayasindeita kaikeisi-ni kokyaku-o sagasitekiteyatta.
 (Sakai-and) secretary-Nom Eriko-Acc before suspected accountant-Dat client-Acc found
 "(Sakai and) the secretary found a client for the accountant who suspected Eriko before."
3. 婦長と院長が看護婦を先月やとった外科医に患者をまわした。
 (fuchoo-to) incho-ga kangofu-o sengetu yatotta gekai-ni kanja-o mawasita.
 (chief nurse-and) hospital director-Nom nurse-Acc last month hired surgeon-Dat patient-Acc transferred to
 "(The chief nurse and) the director of the hospital transferred a patient to the surgeon who hired a nurse last month."
4. 兄夫妻と佐川夫妻が一人息子を一目で気に入りにかけた女性に家族全員を紹介した。
 (ani fusai-to) Sagawa fusai-ga hitori musuko-o hitome-de kiniirikaketa josei-ni kazokuzen'in-o shookaisita.
 (brother and the wife-and) Mr./s. Sagawa-Nom only son-Acc at the first glance about to love woman-Dat whole family-Acc introduced
 "(The brother and his wife and) Mr. and Mrs. Sagawa introduced the only son to the woman who was about to like him at the first glance."
5. 細川と森下が新薬を心から信用した友人達に処方箋を送った。
 (Horokawa-to) Morisita-ga sinyaku-o kokorokara sinyoosita yuujintai-ni shoosen-o okutta.
 (Hosokawa-and) Morisita-Nom new medicine truly trusted friends-Dat prescription-Acc sent
 "(Hosokawa-and) Morisita sent the prescription to the friends who truly trusted the new medicine."
6. 母さんと父さんが春彦をかなり頼りにしていた祖父母に看護婦をつけてみたらしい。
 (kaasan-to) toosan-ga Haruhiko-o kanari tayonisuiteita sobfubo-ni kangofu-o tuketemitarasii.
 (mother-and) father-Nom Haruhiko-Acc heavily counting on grandparents-Dat helper-Acc hired for
 "(Mother and) Father hired a helper for the grandparents who were heavily counting on Haruhiko."

7. 講師と副主任が実習生をそれまで無視していた事務員に警告書をわたした。
 (kooisi-to) fukushuinin-ga jisshuusei-o soremade musisiteita jimuin-ni keikokusho-o watasita.
 (instructor-and) sub director-Nom intern-Acc until then ignored office worker-Dat warning letter-Acc handed
 "(The instructor and) the sub director handed a warning letter to the office worker who was ignoring the intern until then."
8. チーフと専務が秘書をあきらかに避けていた係長に鈴木女史を同行させた。
 (chiifu-to) senmu-ga hisho-o akirakani saketeita kakarichoo-ni Suzuki josi-o dookoosaseta.
 (chief-and) manager-Nom secretary-Acc obviously section chief-Dat Ms. Suzuki-Acc accompany-Cause-Past
 "(The chief and) the manager had Ms. Suzuki accompany the section chief who was obviously avoiding the secretary."
9. 佐藤と原田が薬物をなんとか見つけただけだした研究者に紹介状を書いてよこした。
 (Sato-to) Harada-ga yakubutu-o nantoka mitukedasia kenkyuusha-ni shookajoo-o kaiteyokosita.
 (Sato-and) harada-Nom drug-Acc somehow discovered researcher-Dat letter-Acc sent in
 "(Sato and) harada sent in the letter to the researcher who somehow discovered the drug."
10. コーチと顧問が村瀬君をけっこう重要視していた副主将に牧野くんを推薦した。
 (kooti-to) komon-ga Murasekun-o kekkoo juuyoosi siteita fukushushoo-ni Makinokun-o suisensita.
 (coach-and) supervisor-Nom Murase-Acc quite regard as important sub captain-Dat Makino-Acc recommended
 "(The coach and) the supervisor recommended Makino to the sub captain who regarded Murase as important."
11. 佐川と香取が大家をあっさり信じた不動産業者にお客を送りこんだ。
 (Sagawa-to) Katori-ga ooya-o assari sinjita fudoosanya-ni okyaku-o okurikonda.
 (Sagawa-and) Katori-Nom landroad-Acc easily trusted realtor-Dat customer-Acc sent
 "(Sagawa and) Katori sent the customer to the realtor who easily trusted the landroad."
12. 達也とヒロシが委員長を裏通りでなぐった中学生に空手部員を監視役につけた。
 (Tatsuya-to) Hirosi-ga iincho-o uradoori-de nagutta chuugakusei-ni karatebunin-o kansini tuketa.
 (Tatsuya-and) Hirosi-Nom class representative-Acc backstreet-Loc beat middleschol kid-Dat member of Karate club-Acc place as a guard
 "(Tatsuya and) Hirosi placed a member of Karate club to the middle school kid who beat the class representative on the backstreet."
13. 神谷氏と教習生が経営者がかつて告訴した教官に助言をうけていた。
 (Kamiya si-to) kyoooshuusei-ga keiisha-o katsute kokusosita jogen-o uketeita.
 (Mr. Kamiya-and) trainee-Nom owner-Acc before sued instructor-Dat advice-Acc was receiving
 "(Mr. Kamiya and) the trainee were receiving advice from the instructor who sued the owner before."

14. 宮地と理事が推薦入学をかなり期待していた卒業生に外部受験をすすめた。
 (Miyaji-to) riji-ga suisennyuugaku-o kanari kitaiteita sotugyosei-ni. gaibujuken-o susumeta
 (Miyaji-and) chair of trustee-Nom re commended admission-Ac quite was expecting graduate-Dat regular admission-Acc recommended
 "(Miyaji and) the chair of trustee recommended regular admission to the graduate who was expecting recommended admission."
15. 進藤と藤田がテキストをどこかで見つけてきたアメリカ人に解説書を紹介した。
 (Sindoo-to) Fujita-ga tekisuto-o dokokade mituketekita amerikajin-ni shookaisita.
 (Sindoo-and) Fujita-Nom text-Acc somewhere found American-Dat manual-Acc introduced
 "(Sindoo and) Fujita introduced the manual to the American who found the text somewhere."
16. 佐久間と沢木がりさを理科室によびだした男子学生に仲間をけしかけた。
 (Sakuma-to) Sawaki-ga Risako-o rikasitu-ni yobidasita dansi gakusei-ni kesikaketa.
 (Sakuma-and) Sawaki-Nom Risako-Acc lab-to called out male student-Dat friend-Acc set on
 "(Sakuma and) Sawaki set the friend on the male student who called Risako on to the lab."

APPENDIX 7

Experiment: An effect of constituent length on modifier association

This experiment provides evidence for an effect of length on a processing preference other than the one reported in Chapter 5 induced by the contrast between a single versus conjoined subject reported in relative clauses. The current experiment tests Inoue & Fodor's observation of an influence of constituent length on the parser's first-pass decision, concerning adjunct-noun relations, discussed in section 5.4 above. Reading time data were collected for four types of Japanese sentences that were presented frame-by-frame. The experimental sentences all included an [AP + N1-Gen + N2] constituent, which varied in AP length and AP association type.

Length of the AP was manipulated by the type of adverb that preceded the adjective: a short AP, as in (1a,b), consisted of a bare adjective without a modifier: and a long AP, as in (1c,d), consisted of an adjective modified by a preceding adverb (e.g., "nantonaku", somewhat). In short AP sentences, the position immediately preceding the adjective (which was filled by an adjective-modifying adverb inside a long AP) was filled by an adverbial phrase which was unambiguously a *sentential* modifier (e.g., "nishuukan mae", two weeks ago) which could not be a part of the AP.

The manipulation of AP association type contrasted two kinds of adjectives. In one association type, illustrated in (1a) and (1c), the adjective (e.g., "usugurai", dim, poorly lit) was semantically compatible with N1 and incompatible with N2, and thus the sentence was disambiguated toward an N1-association interpretation. This will be referred to as *unambiguous*. In the other type, illustrated in (1b) and (1d), the adjective

(e.g., "hinnonai", unsophisticated) was compatible with both N1 (e.g., "sunakku", bar) or N2 (e.g., "hosutesu", hostess): this AP type will be referred to as *ambiguous*.

(1)

- a. nishuukan ma'e usugura'i suna'kku-no ho'sutesu-o
two weeks ago dim bar-Gen hostess-Acc

Satoru-ga bujokushita
Satoru-Nom insulted

N1-association interpretation only:

"Two weeks ago Satoru insulted the hostess of the dim bar."

- b. nishuukan ma'e hinnona'i suna'kku-no ho'sutesu-o
two weeks ago unsophisticated bar-Gen hostess-Acc

Satoru-ga bujokushita
Satoru-Nom insulted

N1-association interpretation: "Two weeks ago Satoru insulted the hostess of the unsophisticated bar."

N2-association interpretation: "Two weeks ago Satoru insulted the unsophisticated hostess of the bar."

- c. nantona'ku usugura'i suna'kku-no ho'sutesu-o
somewhat dim bar-Gen hostess-Acc

Satoru-ga bujokushita
Satoru-Nom insulted

N1-association interpretation only:

"Satoru insulted the hostess of the somewhat dim bar."

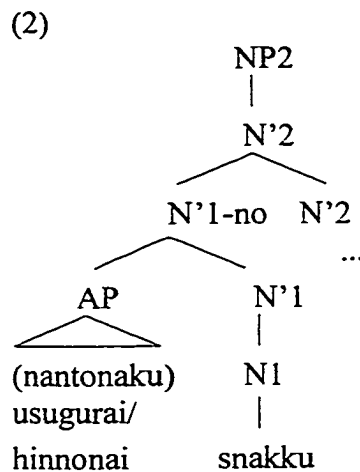
- d. nantona'ku hinnona'i suna'kku-no ho'sutesu-o
somewhat unsophisticated bar-Gen hostess-Acc

Satoru-ga bujokushita
Satoru-Nom insulted

N1-association interpretation: "Satoru insulted the hostess of the somewhat unsophisticated bar."

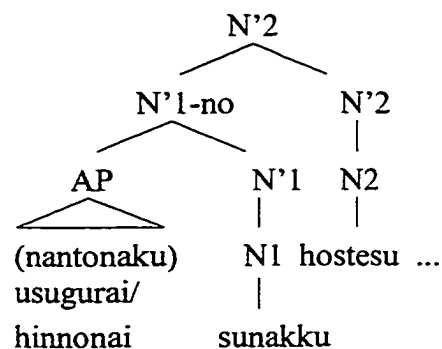
N2-association interpretation: "Satoru insulted the somewhat unsophisticated hostess of the bar."

When the AP is processed, a noun is expected which the AP will modify, and the N1-Gen encountered immediately following the AP is a possible candidate. Following Inoue & Fodor (1995) and Kamide & Mitchell (1997), it is reasonable to assume that a phrase-marker is constructed as in (2); i.e., N'1 immediately attaches as a sister constituent of AP (since they are semantically compatible, for both ambiguous and unambiguous adjectives), with the genitive marker attaching to the higher N' node dominating the AP and N1.

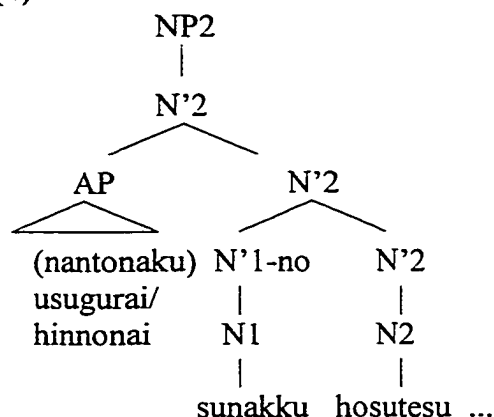


What is of interest is what happens when N2 is processed. After N2-Acc is encountered, two structures are possible. In (3), the relationship between the AP and N1 remains unchanged, and thus it is called N1-association.





(4)



In (4), an alternative analysis, the AP modifies the whole complex N' (N1-Gen N2) headed by N2, and is thus referred to as N2-association. Kamide & Mitchell (1997) concluded from their data that even though the parser builds the structure such as (2) when N1 is initially encountered, (4) is the eventually preferred structure. (Whether arriving at this structure after first building a structure such as (2) violates the Minimal Revision principle is an issue under debate: see Kamide & Mitchell, 1997; Fodor & Inoue, 1998.) If (4) is preferred when the N2 is processed, then when the AP is headed by an adjective which is not semantically compatible with N2 (i.e., the unambiguous adjectives of this experiment), the N2-association structure (4) has to be revised to (3) to recover a plausible interpretation. On the basis of Kamide & Mitchell's findings,

therefore, a garden path effect is expected in the present experiment for unambiguous APs, in contrast to the ambiguous APs (compatible with both N1 and N2) for which no anomaly arises at N2.

Method

Subjects. Fifty six undergraduate students from Nagoya University, naive with respect to the purpose of the experiment, participated successfully in the experiment. All were native speakers of Japanese. The experimental session typically took 25 to 30 minutes.

Materials and Design. The experimental sentences were constructed as quadruples, and distributed in a counterbalanced design to form an experiment in four versions. Each of 24 such quadruples was generated based on a sentence containing an [AP + N1-Gen + N2-Acc] sequence as a fronted direct object of a sentence-final transitive verb; see (5) below. For presentation in the self-paced reading task, the sentences were divided into seven frames (Frames 1 to 7), as illustrated in (5); note that the design varied the contents of Frames 1 and 2 but had identical lexical content in Frames 3 through 7. Frame 1 was a sentential adverb for short AP sentences and an adverb modifying the following adjective for long AP sentences; Frame 2 was an adjective, always a possible modifier of the genitive-marked noun (N1-Gen) following in Frame 3, but either an impossible or a possible modifier of the noun case-marked as accusative (N2-Acc) in Frame 4. Frame 5 was a nominative NP which served as the subject of the whole sentence, and Frame 6 was the transitive verb. Frame 7 was a "maru" (period).

(5)

a.	Frame 1 nishuukan ma'e two weeks ago	Frame 2 usugura'i ... dim			
b.	Frame 1 nishuukan ma'e two weeks ago	Frame 2 hinnona'i ... unsophisticated			
c.	Frame 1 nantona'ku somewhat	Frame 2 usugura'i ... dim			
d.	Frame 1 nantona'ku somewhat	Frame 2 hinnona'i ... unsophisticated			
	Frame 3 ... suna'kku-no bar'-Gen	Frame 4 ho'sutesu-o hostess-Acc	Frame 5 Satoru-ga Satoru-Nom	Frame 6 bujokushita insulted	Frame 7 °

Frequency within adjective pairs was not matched, as there was no appropriate source of information. A norming test of semantic compatibility (reported below) showed that the intended manipulation of AP association type was successful. The length of adjectives was matched across sentences in a quadruple, whether length was measured in number of characters (kanji and kana), or in mora.

The materials design of this experiment makes Frame 4, the position for N2-Acc, the position of primary interest: it was intended to detect any garden path effect in the unambiguous conditions, e.g., (5a) and (5c), compared to the ambiguous conditions, e.g., (5b) and (5d), respectively, as would be expected if the parser preferentially associates AP to N2. Crucially, however, if the association preference is affected by the AP length, we should expect an interaction between AP association type and AP length at this position. Specifically, if N2 association is induced more often (or more strongly) when

the AP is long, as observed informally by Inoue & Fodor (1995), then we should find a stronger garden path effect in (5c) than in (5a) in Frame 4.

An additional 66 sentences were constructed as fillers, and interspersed among the experimental items so that two experimental items were never presented adjacently. Since the experimental materials (24 quadruples, thus 96 items) were distributed over four versions of the experiment in a counterbalanced design, the 24 experimental items within any version were made up of 6 instances of each of 4 conditions, without repetition of sentential content. The filler items and the order of presentation of sentences were identical across all four versions, and each version of the experiment presented 90 items in total, 24 experimental and 66 filler. Since half of the experimental items in each version required an N1-association reading in an [AP + N1-Gen + N2] construction, it was necessary to avoid a bias toward N1-association. Therefore, 12 of the 66 filler sentences had the same [AP + N1-Gen + N2] construction (without overlapping sentential context with any of the experimental items) but required an N2-association reading of the AP (i.e., the AP was compatible only with N2). The remainder of the fillers were pure fillers, varying in length and construction. Five additional warm-up items were prepared for the practice session preceding the experimental session proper.

For all sentences used in the experiment (including the fillers), comprehension questions were prepared. The purpose and the characteristics of the comprehension questions were the same as in Experiments 1, 2, and 3, 3b, and 5.

Norming study. In a questionnaire study, the naturalness of the combination of Frame 2's adjectives with the nouns used in Frames 3 and 4 of the experimental sentences was checked in a ratings test. The informants were three members of the Linguistics program

at CUNY Graduate Center, none of whom participated in the experiment proper; all three were native speakers of Japanese. The informants were asked to rate the naturalness of the combination of an adjective and a noun (not in a sentential context) using a 5-point scale (1: very natural, 5: very unnatural). The average ratings for the four combinations are summarized in Table A.

An ANOVA revealed a significant interaction between AP association type (unambiguous/ambiguous) and noun (N1/N2), $F_2(1,23) = 182.78$, $p < 001$. A subanalysis comparing the fit for N1 against the two types of adjectives showed no significant difference, $F_2(1, 23) = 1.53$, $p > .10$. Another analysis comparing the fit for N2 against the two types of adjectives revealed a significant difference, $F_2(1, 23) = 699.93$, $p < .001$.¹

¹ A subanalysis comparing the rated fit for the unambiguous adjectives against N1 and against N2 yielded a highly significant difference, $F_2(1, 23) = 414.50$, $p < .001$ while a subanalysis comparing the fit for the ambiguous adjective against N1 and against N2 showed no significant difference, $F_2(1, 23) < 1$.

Table A. Mean rating score

	Rated fit with	
	N1	N2
AP association type		
Unambiguous	1.19	4.58
Ambiguous	1.42	1.47

Procedure. The procedure and apparatus were the same as in Experiments 2, 3, and 3b.

Data treatment. In total, 63 subjects participated in the experiment, of whom 7 were rejected because of poor performance characteristics. Five subjects were excluded because they produced more than 15% errors in their responses to YES/NO comprehension questions. Two further subjects were rejected for abnormally speedy performance: on experimental sentences, one subject produced 17 reaction times less than 100 msec out of 120 possible data points (i.e., 14.2%; the other produced 27 (22.5%)).

Reaction times greater than 3000 msec (1.0% of the data) were rejected, as was any data point less than 100 msec. Finally, values falling beyond cutoffs established for each subject at mean plus-or-minus two standard deviations were replaced with those cutoff values, as in Experiments 1 to 3 and 5.

Results

Table A below shows the mean reading times for Frames 2 through 6, for all sentence types.

Table A. Mean reading times (in milliseconds) per frame, as a function of AP length

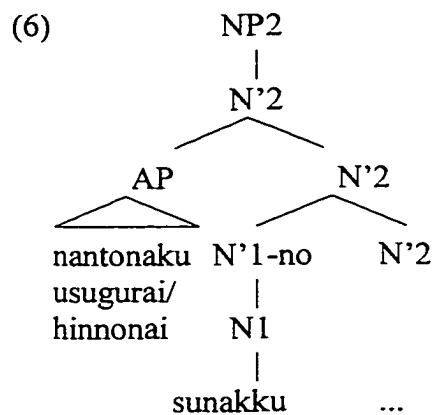
Frame	2 Adjective	3 N1-Gen	4 N2-Acc	5 NP-Nom	6 Verb
Short AP					
Unamb.	609	628	663	721	562
Amb.	554	665	677	695	521
Long AP					
Unamb.	565	650	715	687	577
Amb.	525	631	620	656	543

The primary point of interest in this experiment is Frame 4 (N2-Acc). An ANOVA performed over reading times for Frame 4 showed a significant interaction between the length of AP and AP association type, $F_1(1,52) = 6.77$, $p < .025$, $F_2(1,20) = 17.09$, $p < .001$. A subanalysis at Frame 4 comparing the two AP association types for long AP sentences yielded a highly significant difference, $F_1(1,52) = 8.85$, $p < .005$, $F_2(1,20) = 17.88$, $p < .001$. This is the predicted garden path effect, and reflects a cost for sentences in which the AP is compatible only with N1 and is not a possible modifier of N2. For the short AP conditions, by contrast, comparison of the two attachment types did not yield any significant difference, $F_1 < 1$ in both analyses.

No significant interaction between the length of AP and the AP association type was found at any other frame ($F < 1$ for both subject and item analyses), except that a strong trend was found at Frame 3, $F_1(1,52) = 3.91$, $.05 < p < .10$, $F_2(1,20) = 4.31$, $.05 < p < .10$. For Frame 3, the subanalysis comparing the two AP association types for long AP sentences yielded no significant difference, $F_1 < 1$ for both subject- and item-based analyses, whereas the same comparison for short AP sentences did reveal a difference that was significant in the subject analysis $F_1(1,52) = 4.25$, $p < .05$, though not in the

item-based analysis, $F_2(1,20) = 2.50$, $p > .10$. That is, the reading time tended to be slower for N1-Gen when it was preceded by a short AP compatible both with N1 and N2, rather than one which was compatible with N1 only. This may reflect the slight (but non-significant) difference observed in the norming study, in which the combination with N1 was rated as being more natural for unambiguous adjectives than for ambiguous adjectives that were compatible with both N1 and N2.

The interaction of such plausibility effect with length still appears to be a puzzle, but suggests an interesting possibility. That is, the parser was less sensitive to the compatibility between the adjective and N1 when the AP was long than when the AP was short. This may be because for long APs, when only N1 is encountered, initial association to N1 as shown in (2) may not be an option. The analysis at the point when the N1 is encountered may thus be (6). Note that the genitive marker accompanying N1 assures appearance of another possible modifyee N2.



To test this hypothesis, the fit between the adjective and N1 could be deliberately varied. It would be necessary to examine another set of quadruples, in which the factors are the

length of the AP, and AP association type where the contrast is between N2-only (instead of N1-only) versus ambiguous (compatible with both N1 and N2) adjectives. For the N2-only adjective sentences, it is predicted that the long APs are less sensitive to the semantic incompatibility with the N1 compared to short APs, and thus that reading should be faster for the N1 when it is preceded by a long AP than when preceded by a short AP.

Let us return now to the contrast at Frame 4, which is the focus of the experiment. Overall, the results were largely consistent with the idea that long modifiers are more likely to be associated with N2. The evidence of N2-association of the AP was present in this experiment only when APs were made up of two-word phrases. This confirms the informal observation of an NP-length effect by Inoue & Fodor (1995), and possibly provides support for the explanation in terms of implicit prosody proposed by Fodor (1998; discussed in 6.4 in this dissertation) based on Kubozono (1988; discussed in 6.2.3 in this dissertation).

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