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Processing of Japanese and Korean

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The Ohio State University, 1994
PROCESSING OF JAPANESE AND KOREAN

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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To My Grandparents
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1. Introduction

Not long ago, East Asian languages such as Japanese and Korean were considered as "mysterious" or "exotic" languages. There were many myths and misconceptions about these languages, shared by both native and non-native speakers of the language. For instance, one of the myths about Japanese, as noted by Shibatani (1990a), was that the language was "illogical and/or vague" compared to Western languages.

Fortunately, studies in modern linguistics have revealed that what made Japanese appear illogical or vague was nothing but a superficial comparison of the language with Western languages. One of the reasons Japanese appeared so illogical is that the language conveys ideas in a heavily discourse-dependent way (e.g., Huang, 1984). Japanese word-order, which made the language seem exotic, turned out to be not so uncommon in other languages in the world. Furthermore, extensive studies, especially those based on the government and binding framework (e.g.,
Chomsky, 1981), revealed that Japanese and Korean actually consisted of a set of systematic rules which were linguistically motivated. It was shown that the syntactic structures of these languages share many common aspects with English, except there is a "parametric" difference which is unique to each language (e.g., Kuroda, 1988; Fukui, 1986).

Modern linguistics, however, gave rise to another mystery to East Asian languages. The syntactic structures and other grammatical characteristics of Japanese and Korean became clear; but now people were puzzled about how the sentences in these languages, whose structures were different from English, were "processed" (understood by adult native speakers). Human sentence processing models have traditionally been developed mainly through studies based on Western languages, especially English (e.g., Bever, 1970; Kimball, 1973; Frazier, 1978). When these models were applied to investigate the mechanism of the processing of languages with different syntactic structures and grammatical characteristics such as Japanese or Korean, it became clear that no model can be directly applied without predicting extraordinary processing costs.

This further led to a question whether all languages are processed in the same way; i.e., whether there is "universality" in human language processing across languages. It is only natural that the processing of Japanese is currently attracting a lot of attention (e.g.,
A. Inoue, 1991; Inoue & Fodor, in press; Mazuka & Lust, 1990; Pritchett, 1991; Weinberg, 1993). The investigation of the processing of Japanese and Korean plays a significant role in deepening the understanding of not only these specific languages, but human language in general.

Unfortunately, the investigation of how Japanese and Korean are processed still lacks experimental study, because the issue started to attract attention only relatively recently. Most urgent is the experimental study of a "processing model" of Japanese and Korean. This is due to the fact that different processing models predict different outcomes for the experiments testing a hypothesis, as well as different implications of results. Without experimental evidence, there is much that must be assumed in the investigation of the processing of these languages; in fact, there is a tendency among researchers to simply assume the "serial model" of processing in conducting research in these languages.

The aim of the current research is to examine the processing models of Japanese and Korean experimentally. More specifically, it examines which of three classic models ("serial," "parallel," and "delay (head-driven)" models) better captures the processing of these languages than the others. Since a direct application of any of the models predicts an unreasonable processing cost, some modification will be proposed as well.
The organization of the study is as follows. Chapter 2 summarizes the characteristics of the proposed serial, parallel, and delay models, as well as the assumptions made in conducting the current research. In Chapter 3, the grammatical characteristics of Japanese and Korean and their implications for the processing of each language will be summarized. At the same time, problems which arise with the direct application of each of the three proposed models will be discussed. Chapter 4 reports the experiments conducted in Japanese and Korean. In Chapter 5, the results of the experiments and their implications for the processing models of Japanese and Korean are discussed. Since many further questions arise from the current research, future research issues and possible experimental strategies are proposed as well. By revealing more of the processing mechanism of Japanese and Korean in this dissertation, I wish to contribute to the investigation of the universality of language processing.

The current investigation focuses entirely on the processing of written language. This does not mean that phenomena observed in processing of spoken language are neglected. It has been reported that prosodic information is utilized in sentence processing in English (e.g., Beach, 1991; Straub & Bever, 1992), as well as in Japanese (Venditti & Yamashita, 1994; in press). The contribution of prosodic information in spoken language is of extreme interest by itself. The issue is not considered here
simply because it is an independent issue and beyond the scope of the current research.
CHAPTER II
THREE PROCESSING MODELS

2.0. Introduction

In this chapter, three proposed processing models based primarily on English data will be introduced. The models discussed here are "serial," "parallel," and "delay" models. Along with each model, some experimental evidence which supports it will also be discussed. Prior to the discussion of the models, the assumptions related to processing models discussed in the current study are summarized. They are the issues of modularity of the processor and autonomous/interactive processing.

2.1. Assumptions of Models

2.1.1. Modularity in the Language Processing Mechanism

In creating a model which represents the mechanisms of human language processing, two issues must be addressed. One is modularity and the other is the independence of each module (autonomy).

One view of the human language processing mechanism is that it is a "seamless" mechanism in which various types of
information (such as lexical and syntactic information) merge (e.g., Marslen-Wilson & Tyler, 1989). The other view is that each type of information is processed by a distinct subdomain ("module") of an entire language processing mechanism. For instance, lexical information is processed in the lexical module and syntactic processing is handled in the syntactic module. This hypothesis is called the "modularity" hypothesis (Fodor, 1983).

In the current study, the modularity hypothesis is assumed. In particular, it is assumed that there are linguistic modules (levels), each of which processes lexical information, syntactic information, and semantic/pragmatic information.

2.1.2. Autonomy of Processing

Along with the issue of modularity, how each module functions in relation to others in the processing of a language has attracted much attention (e.g., Clifton & Ferreira, 1989; Crain & Steedman, 1985; Forster, 1979; Frazier, 1987a; Rayner, et al., 1983; Steedman & Altmann, 1989). One view is that modules can interact with each other to the extent that one module can influence the process within another module (the "interactive" hypothesis). Steedman & Altmann (1989) support this view by demonstrating that contextual information, the information from a semantic/pragmatic module, may actually guide selection of syntactic representation. On the other
hand, Rayner, et al. (1983) argue that there is a "thematic module," where initial syntactic structures are screened by a pragmatically plausible thematic frame. This in turn gives support to the hypothesis that each module is independent and it may have access only to the output of the lower module. By the same token, the independence of lexical access from higher levels such as semantic or syntactic modules is claimed by Seidenburg et al. (1984) among others (cf. Meyer and Schvaneveldt, 1971).

Although the issue of autonomous vs. interactive processing is very interesting, it is beyond the scope of the current study. In the current study, I assume that there are distinct modules in the language processing mechanism, and each module only has access to the output of the module prior to it. In particular, I assume that the syntactic processor is independent of the semantic/pragmatic processor. Following Inoue & Fodor (in press), I assume that in on-line processing, the syntactic module plays a major role and that the semantic/pragmatic information is not sufficiently informative to resolve all the ambiguities in Japanese and Korean. I also assume the autonomy of lexical processing.¹

¹ In the first main experiment in both Japanese and Korean discussed in Chapter 4, the lexical decision task is used to reveal the syntactic computation. This is not incongruent with the autonomy of lexical processing, since such a task reflects a "post-lexical access" effect, which is the operation of integrating a recognized lexical item into the syntactic context. See Gorrell (1987) for a detailed discussion.
Furthermore, it is assumed that the syntactic structure computed in human language processing is analogous or very similar to the one developed in syntactic theories. That is, the syntactic structure computed in the processing and the syntactic structure in theory are closely connected, if not identical.

2.2. Serial, Full Attachment Model

Now let us discuss the three proposed models. The first model is called the "serial, full-attachment" model, in which a single structure is hypothesized according to certain principles.

A fragment of a sentence like (1) below is "temporarily ambiguous" because there is more than one possible interpretation for the string. It may possibly be concluded in two ways, as shown in (2).

(1) John knew the girl ...
(2) a. John knew the girl.
   b. John knew the girl was from New York.

The fragment may be a part of an SVO simplex sentence, in which the phrase the girl is an object of a verb, as in (2a). The phrase may be a part of the subordinate structure, a part of a sentential complement as in (2b). The serial model hypothesizes only one possible initial syntactic structure ((2a) or (2b)). In determining which structure to compute, a principle called "minimal
attachment" is used, in which a new constituent is attached to the syntactic structure creating the smallest possible number of non-terminal nodes (Frazier, 1978; Frazier & Fodor, 1978).

Following Inoue & Fodor (in press), the serial model described here is a "full-attachment" model, in which all the nodes are attached to a mother node without delay. In other words, as soon as John in (1) appears, it is attached to the matrix subject position (the spec of IP in the government and binding framework (Chomsky, 1981)). The next word knew is attached to the VP in the matrix clause, in which John is the subject. As mentioned in the previous subsection, I assume that the syntactic module independently processes the string and sends its output to the semantic/pragmatic module.

The model proposed by Frazier and Fodor (1978) assumes a serial model. Their model is called the "sausage machine," in which the two-staged parser follows processing strategies to pursue one syntactic structure at the point of ambiguity in a sentence. In this model, the first parser (the "Preliminary Phrase Packer") groups together the adjacent words, forming phrasal (non-terminal) nodes, and forwards them to the higher parser (the "Sentence Structure Supervisor"). The minimal attachment accounts for the preference of PP attachment (PP attached to VP) in the following sentence.
(3) Joe bought the book for Susan.
   a. Joe [\text{VP} [\text{v bought} \ [\text{NP} the\ book] \ [\text{PP} for\ Susan]]]
   b. Joe [\text{VP} [\text{v bought} \ [\text{NP} [\text{NP} the\ book] \ [\text{PP} for\ Susan]]]]

In (3), the preferred attachment of the PP for Susan is to the VP, as in (3a). The attachment of the PP to the object NP as in (3b) is not preferred. The preference is accounted for by the node that is increased by attaching the PP. Attaching PP to an existing VP in (3a) does not increase the number of nodes. On the other hand, the attachment of PP in (3b) increases the number of nodes by one: the NP that dominates the NP the book and the PP for Susan. The structural preference in an ambiguous sentence such as (3) can be accounted for by minimal attachment.

In English, there has been experimental evidence reported supporting serial processing (e.g., Frazier, 1978; Frazier & Rayner, 1982; Ferreira & Clifton, 1986). Recording eye movements during the reading of temporarily ambiguous sentences, Frazier and Rayner (1982) found that temporarily ambiguous sentences inconsistent with minimal attachment took longer to read than the temporarily ambiguous sentences which were in accord with minimal attachment. The fact that sentences which were against minimal attachment took longer to read suggests that the parser initially computed only the minimal attachment structures on both sentence types, and had to reanalyze the sentences in the non-minimal attachment sentences. This resulted in the increased processing cost in the non-
minimal attachment sentences.

Since only one structure is built at a time, the serial model is a cost-efficient model in terms of the memory load. However, if an initial analysis is incorrect, the structure must undergo "reanalysis." Reanalysis is a process which is assumed to involve a considerable processing cost (e.g., Frazier and Rayner, 1982). This is because no structure other than the first hypothesis had been pursued until the time when the structure was proven to be incorrect. The increased processing cost associated with the reanalysis is referred to as the "garden-path" phenomenon.  

2.3. Parallel Model

Parallel models assume the computation of multiple grammatical structures when there is syntactic ambiguity. Here, two types of parallel models are discussed: the strict parallel model and the ranked parallel model.

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2 Throughout the thesis, I assume, for simplicity, that all the alternative clauses occur equally frequently in natural languages. This means that choosing a minimal attachment structure does not necessarily increase the chance of getting the structure correct the first time.

3 Following Frazier & Rayner (1982), I assume that the parser is deterministic on a structure once it is computed. In other words, reanalysis of a structure computed by a parser involves a considerable processing cost.

4 The phenomenon is called such since it is believed that on encountering the words which necessitate the reanalysis, the parser goes back to information which had appeared previously.
2.3.1. Strict Parallel Model

The most strict parallel model hypothesizes that all possible structures are computed with equal speed and "weight," and sent to the semantic module (e.g., Altmann & Steedman, 1988). This type of model assumes that when the parser encounters an ambiguous sentence such as (1), both (2a) and (2b) are computed. When disambiguating information becomes available (the verb was in (2b), for instance), the inconsistent structure is dropped from the possible structures and selection will be made.

In the strict parallel model, presumably all possible grammatical structures are computed and stay active until the disambiguating information becomes available. Thus it is assumed that there is neither reanalysis or the cost related to reanalysis. There are, however, possible costs in computing and maintaining multiple structures. Among the experimental results supporting the cost for maintaining multiple structures, Foss (1970) found that subjects are slower and less accurate in a phoneme monitoring task embedded in an ambiguous sentence. In his experiment, the subjects were asked to press a button when they heard a particular phoneme such as /b/ in businessman in sentences such as (4).

(4) a.(ambiguous)

When I purchased the hat for my friend, the businessman seemed very grateful.
b. (unambiguous)

When I purchased the hat with my friend, the businessman seemed very grateful.

The sentence fragment in (4a) is ambiguous because there are two possible ways to attach the PP for my friend in (4a): attachment to the verb or to the NP the hat. In one meaning, the I is doing a favor by purchasing the hat instead of his friend. The other interpretation is that the I purchased the hat to give to his friend, thus it is independent of friend's purchasing of the hat. There is no such ambiguity in (4b).

If the parser computes all possible structures and keeps them activated in an ambiguous string, the secondary task of phoneme monitoring should experience interference, resulting in a slower and less accurate performance. This is exactly what was found; the reaction times to detect the phoneme /b/ in ambiguous strings were slower than in the unambiguous sentence in (4b). Also, the accuracy of detecting the phoneme in ambiguous sentences was lower than in the unambiguous sentences. The difference in the reaction times and the accuracy of the detection of /b/ in businessman between ambiguous and unambiguous sentences may be accounted for if the parser is computing multiple structures in ambiguous regions in (4a) and maintaining them. Assuming that processing difficulty of the ambiguous sentence interferes with the performance of phoneme monitoring, the poor performance in the ambiguous sentences
suggests that ambiguous sentences are more difficult to process than unambiguous sentences. 5

Other studies also support the claim that there is an increased processing load for ambiguous sentences. More recently, MacDonald et al. (1989) found evidence supporting a parallel model, and further found that the maintenance of the parallel structures is affected by the working memory capacity of readers. Using a word-by-word, self-paced presentation, they found that reading an ambiguous section of a sentence took longer than reading the corresponding section of an unambiguous sentence, and the larger the working memory capacity a person has, the larger the effect of ambiguity. One of their test sentences is as follows:

(5) The experienced soldiers [warned about the dangers] Region: 1 [before the midnight][raid]. 2 3

Regions 1 and 2 are ambiguous regions, and Region 3 is the disambiguating region. They found a main effect of ambiguity in Region 2 in the reading times. They also found that high span readers took more time than low span readers in reading Region 3. MacDonald et al. (1989) claimed that the results support multiple structures being

5 According to Garrett (1970), studies which support the computation of multiple structures tend to come from experiments which measured the effects on-line. On the other hand, reports which do not support parallel models tend to come from experiments using the measurements at the end of the sentence (but see Frazier & Rayner 1983). These conflicting experimental results may be accounted for if multiple structures are posited initially but are resolved by the end of the sentence.
built at ambiguous sections, and that how long the multiple structures remain active depends on the subjects' working memory capacity.

If indeed a language is processed in a strictly parallel fashion, memory overload is a potential problem. If the disambiguating information does not become available soon, the computation and maintenance of all possible grammatical structures can cause memory overload. As noted in Kurzman (1985), a modification which limits the duration of activating the multiple structures will make the strict parallel model a more workable hypothesis.

2.3.2. Ranked Parallel Model

Even if multiple structures are computed, if there is a decision principle to choose from alternatives, the parser does not have to wait until the syntactically disambiguating information. The "ranked parallel" model, proposed by Gorrell (1987), takes this approach. In his model, there is a "ranking" among alternative structures, which is determined by the complexity of a syntactic structure and the speed of its computation. According to this model, both syntactic structures in (2a) and (2b) are

---

Kurzman (1985) was the first to propose a ranked parallel model. In his model, "conceptual selection" plays a major role in selecting a structure among multiply hypothesized structures. While the parallel ranking in the model proposed in Gorrell (1987) is based upon the complexity of the syntactic structure, the ranking in Kurzman (1985) is based on what is "conceptually preferred." Although the statistical analyses did not always reach significance, Kurzman (1985) provided experimental evidence that the resolution adopted for an ambiguity is one that permits the sentence to express the conceptual information that is expected.
built in an ambiguous sentence shown in (1). However, (2a) is ranked higher than (2b) due to the fact that it is a minimal attachment structure and therefore the speed of its computation is faster.7

The evidence for Gorrell’s ranked parallel model comes from two experiments which present *prima facie* conflicting results: the results of the lexical decision task and the grammatical decision task.8 While the lexical decision test resulted in evidence supporting the computation of multiple structures, the grammatical decision task results supported the serial model.

The sentences below represent the test stimuli in the lexical decision test in Gorrell (1987).

(6) a. The old man was shaved in bed /is/ whenever he was ill.

b. The old man shaved in bed /is/

c. The old man they shaved in bed /is/ was very

---

7 The ranking among alternatives in the model by Gorrell (1987) is based on the complexity of the sentence structure, i.e., a "simple" structure is ranked higher than a "complex" structure. The definition of "simple" is not stated explicitly; Gorrell calls a simplex sentence analysis "simpler" than reduced relatives, and a sentence with a direct object simpler than a sentence with a sentential complement.

8 The lexical decision task is one in which subjects are asked to judge whether a word (i.e., a target word) presented at a given point (usually at an ambiguous point) is a word or a non-word. In experiments using this task, real targets are mixed with non-word targets. The grammatical decision task is the one in which subjects are asked judge whether a sentence fragment they read is "grammatical" or "make sense." For a detailed description of the lexical decision task and grammatical decision task, see Chapter 4.
In (6b), the verb *is* grammatically continues the sentence fragment only when the less-preferred structure, the interpretation of *the old man (who was) shaved in bed*, is computed. The verb *is* in (6c), another non-minimal but unambiguous structure, continues the sentence grammatically. On the other hand, the target *is* in (6a), a minimal attachment structure, does not continue the structure grammatically. Generally, the response times for lexical decision for the target words which grammatically continue the presented sentence is faster than for the ones that do not. In the experiment in Gorrell (1987), the lexical decision at the target was faster in (6b) and (6c) than in (6a). This is evidence supporting the hypothesis that in an ambiguous structure (6b), the less-preferred structure (the complex NP reading) is computed.

While the results of the lexical decision task in Gorrell (1987) supported the computation of the less-preferred structure in an ambiguous structure, the grammatical decision task constituted evidence supporting the hypothesis that only the preferred structure (minimal attachment structure) is being computed in an ambiguous

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*The boldfaced word, *is*, is the lexical decision target. Gorrell's other targets included modals: *has* and *must*. In (6a) and (6c), the sentence continued after the subjects completed the lexical decision task. The sentences were complete without the inclusion of the target. It is not clear, however, why (6b) did not continue until the end.*
The ambiguous sentence was judged grammatical as quickly as the preferred (minimal attachment) sentence. For example, the sentence (7b), an ambiguous structure, was judged as quickly as (7a), a minimal attachment structure. On the other hand, (7c), a non-minimal structure, was judged as grammatical more slowly than (7a) and (7b). The error rate of (7c) (i.e., judging the sentence as "ungrammatical") was higher than in the other two conditions.

(7) a. The old man was shaved in the small ****
b. The old man shaved in the small ****

In either experiment, Gorrell (1987) did not give evidence that both preferred and less-preferred structures were actually being computed in an ambiguous sentence due to the nature of his experimental material and the task. According to Garrett (1984), the priming effects in the lexical decision task occur only when the target is "predicted" by the previously computed structure. The ambiguous test sentences by Gorrell can predict the appearance of target words in the less-preferred structure, but it cannot in the preferred structure. His sentence is shown below.

(i) John said his wife claimed most of the money (is....)

In the less-preferred structure, the target word is is predicted as the subordinate verb. On the other hand, the preferred structure (simplex clause with a direct object) ends the sentence at money, and therefore nothing may be predicted to continue the sentence grammatically. Since there is no target word which can test the preferred structure, Gorrell (1987) could not test the computation of the preferred structure. Gorrell's claim that multiple structures are being computed is based on the crucial assumption that whenever a less-preferred structure is computed, a preferred structure is also computed.

An experiment in an SOV language such as Japanese or Korean avoids this type of problem. Since the verb is in the clause final position, a verb as the decision target word may be used to examine the computation of both preferred and less-preferred structures. See Chapter 4 for the experimental design using Japanese and Korean and the examination of parallel computation.

The subjects made a grammatical decision as soon as they saw **** on the screen. The presentation was a cumulative word-by-word, automatic presentation (300 msec.).
From this, Gorrell (1987) concluded that multiple structures were being computed in ambiguous sentences, but that there was a ranking among the alternatives. In other words, the lexical decision task taps the stage of processing where multiple structures are computed; the grammatical decision task, on the other hand, taps the stage where the structure which is computed the fastest is completed. The structure computed the fastest is most likely the minimal attachment structure.

Besides giving evidence supporting multiple structures and how they are organized in memory, there are other factors which call for further investigation. For instance, how many possible structures are computed when the choice is more than binary, and how long each of them is kept are two factors which await further extensive study. The number of possible representations may seem trivial in English, in which ambiguous verb information creates a finite set of possible structures. However, it becomes an important issue in the processing of head-final languages, in which there are more possible structures than in an SVO language. This issue will be discussed in detail in Chapter 3.
2.4. Delay Model

Delay models in general hypothesize that no syntactic structures are computed until enough information is provided (e.g., Knuth, 1965; Marcus, 1980; Nicol and Pickering, 1993). The most strict form of this model, which is called the "strict delay" model here, is wholly "bottom-up" (a tree is built from the lowest part and build upward) and does not build any dominating node until all the daughter nodes are identified. This model assumes that in reading (1), the parser does not build a matrix S, or VP, since the portion in (1) is not enough to make a decision on which of (2) is the right structure. Until further information provides the parser with enough confidence in choosing one structure over the other, the decision is not made as to which structure is the correct one.

The strict delay model does not assume costly reanalysis, since no structure is built until the parser is confident. This type of model, however, also has potential problems in describing human language processing. The model predicts that a syntactic structure may never be built in a globally ambiguous sentence, and thus no semantic interpretation is available in such a case. For instance, the PP in a bar in a sentence such as John

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In this dissertation, it is assumed that at least a minimum node (to label the lexical category) which specifies the syntactic category such as N, will be built as soon as the parser encounters each word.
talked to the girl who he met earlier in a bar is ambiguous even when the sentence is finished at a bar. Against the prediction, the computation of semantic interpretation is possible, and one usually comes up with a single interpretation. This means that at some time a syntactic structure is completed and an interpretation becomes available. The strict delay model must account for this phenomenon. A further problem is that totally bottom-up models including a delay model predict that there should be no garden-path phenomenon, which is against numerous reports (e.g., Frazier & Rayner, 1982; Rayner, et al., 1983).

Although a total delay model may not be workable, a modified delay model may possibly be implemented. For instance, the partial delay model, in which the parser delays building a structure up to a certain point is a possibility. The partial delay is a more relaxed version of delay model, in which the delay is not infinite but the duration is limited. Frazier and Rayner (1987) gives experimental evidence supporting the partial delay model in English. An experiment recording eye movements on lexically ambiguous sentences as in (8) suggested that subjects delayed syntactic analysis on categorically ambiguous words until disambiguation took place in a few words.

(8) a.I know that the / desert trains / young people to be especially tough.
b. I know that the / desert trains / are especially tough on young people.

c. I know that this / desert trains / young people to be especially tough.

d. I know that these / desert trains / are especially tough on young people.

The italic words in (8a) and (8b) are ambiguous between the noun phrase followed by a verb in third person singular and the noun phrase with modifier. In contrast, the underlined words in (8c) and (8d) are unambiguous, due to the determiners which specify the number feature of the head noun. The sentences in (8c) and (8d) are the control. In reading time per character, subjects took longer to read desert trains in (8c) and (8d) than (8a) and (8b), respectively. On the other hand, for the remainder of the sentence, subjects took longer to read (8a) and (8b) than in (8c) and (8d), respectively. The results are accounted for if subjects delayed syntactic analysis when there is categorical ambiguity at desert train in (8a) and (8b), and started analysis at the remainder of the sentence, when disambiguating information became available.

Across languages, the head, such as a verb in a VP, is a rich source of processing information. The verb contains subcategorization and thematic information. Since there is one verb or predicate in each clause, it may be worthwhile to delay computing syntactic structures just until the appearance of the verb. The "head-driven" parser proposed
by Pritchett (1988, 1991, 1992) is based on this idea. In this model, the head "projects" or builds the structure up to its maximal projection. In English, the head appears before the complement(s), so the projection takes place clause-initially. On the other hand, in head-final language such as Japanese and Korean, the projection presumably takes place clause-finally. This means that in Japanese, the attachment decisions are delayed and thus the numerous initial misanalyses which are predicted in serial models are not a problem in the head-driven model. This will be discussed in detail in Chapter 3.

2.5. Applicability to Other Languages

It is important to note that most of the theoretical discussion and experimental evidence supporting the models discussed above come from data based on English: a right-branching, head-first language with fairly fixed word-order. Despite the fact that the studies have been in English, which of the three models represents the true processing mechanism of English itself has yet to be decided.

At the same time, the issue of the universality of human language processing demands further investigation. The questions are as follows: (1) whatever the true processing model is for English, does it account for the processing of any other language? and (2) is each language
processed differently?

In order to answer these questions, evidence not only for English processing models is necessary but also for other languages as well. It is only after various languages are examined that the universality of a human processing model can be revealed. Unfortunately, the studies of processing models in other languages are still too few in number and lacking in diversity. Studies have revealed some aspects of pro-drop languages such as Italian and Spanish, and a "verb-second (V2)" language with topic and scrambling construction such as German, and Dutch, a head-final, V2 language (e.g., Bayer, 1992; Cuetos & Mitchell, 1988; De Vincenzi, 1991; Frazier, 1993). However, there is very little experimental work exclusively focusing on the processing models of left-branching head-final languages such as Japanese and Korean (e.g., Mazuka 1991; Mazuka et al., 1989).\(^\text{13}\)

One of the objectives of this dissertation is to offer experimental evidence supporting a particular processing model for Japanese and Korean. In particular, the study offers us which of the serial, parallel, or delay models most closely describes the processing of these languages. Although the investigation may leave many unsolved questions, the results contribute a step toward revealing the universality of language processing.

\(^\text{13}\) There is some theoretical (non-experimental) work on the models of processing Japanese (Inoue, 1991; Inoue & Fodor, in press; Mazuka & Lust, 1990). See Chapter 3 for a detailed discussion of the theoretical work on the processing models of Japanese.
CHAPTER III
SYNTACTIC PROPERTIES OF JAPANESE AND KOREAN
AND PROCESSING MODELS

3.0. Introduction

In Chapter two, three previously proposed models based on English were introduced. In this chapter, the applicability of any of the three models to Japanese and Korean will be discussed. It will be shown that no matter which model is employed, some modification will be necessary to account for the processing of Japanese and Korean. Before the discussion of applicability, I will briefly summarize the syntactic properties of Japanese and Korean and their implications to language processing.

3.1. Syntactic Properties of Japanese

In this section, four properties of Japanese which distinguish themselves from those of English will be discussed. They are (i) head position, (ii) Case marking,
(iii) word-order, and (iv) existence of null arguments.¹

3.1.1. Position of the Head

Japanese is a strict head-final language. Noun phrases have all the modifiers before the head noun. This is shown in (1a). Sentential modifiers, such as a relative clause or adnominal clause, also precede the head noun. This is shown in (1b). The verb follows all argument phrases and adjunct phrases in both tensed and non-tensed clauses. This is shown in (1c)-(1d) (EC stands for an "empty category" or a "gap"). The complementizer, to, which is the head of a sentential complement clause ("CP" in the government and binding framework (e.g., Chomsky, 1981)), follows the verb. (1e) demonstrates this.

(1) a. [NP[NP John-no [N oneesan]]-no [[AP kawaii] [N inu]]]
   John-gen sister -gen cute dog
   'John's sister's cute dog'

   b. [NP[CP John-ga honya-de EC_i mikaketa] syoo setu\_i]]
   John-nom bookstore-at saw novel
   'the novel which John saw at a bookstore'

   c. [IP John-ga[VP honya-de [NP omosiroi hon-o ]
   John-nom bookstore-at interesting book-acc
   [y katta]].
   bought
   'John bought an interesting book at a bookstore.'

d. John-ga \( \text{VP}_{IP} \) EC Mary-ni hon-o watasi-ni kita].
  John-nom Mary-to book-acc hand -to came
  ‘John came to hand a book to Mary.’

e. John-ga \( \text{CP}_{IP} \) Mary-ga asita kuru to] itta.
  John-nom Mary-nom tomorrow come comp said
  ‘John said that Mary would come tomorrow.’

In Japanese, the clausal and non-clausal adjunct phrases precede the matrix verb. Typically, the adjunct clauses in Japanese are adjoined to the matrix S or matrix VP (e.g., Koizumi, 1991). The matrix verb is the verb that appears at the end of the whole sentence, except for sentence final particles including a question marker.\(^2\) It is not possible for an adjunct clause to appear post-verbally. This is shown below.

(2) a. [[Mary-ga gakkoo-kara kaeru mae] John-ga uti-o
  Mary-nom school-from return before John-nom house-acc
  soozi-sita.
  cleaned
  ‘John cleaned the house before Mary came home.’

b. *John-ga uti-o soozi-sita, [[Mary-ga gakkoo-kara
  John-nom house-acc cleaned Mary-nom school-from

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\(^2\) Martin (1975) notes that the Japanese sentence final particles are attached after the tense inflected verb in order to express the speaker’s attitude toward the utterance, such as doubt, confirmation, inquiry and so on. For instance, when the speaker wants to confirm his opinion, the particle \( \text{ne}(e) \) is attached as follows.

(i) Fujisan-wa kireida \( \text{ne}(e) \).
  Mt. Fuji-top beautiful PT
  ‘Mt. Fuji is beautiful, isn’t it?’

See Nakayama (1993) for the description of sentence final particles in more current linguistic framework.
return before
‘John cleaned the house before Mary came home.’
c. Otoosan-ga [[Mary-ga gakkoo -o sabotta] kara]
father-nom Mary-nom school-acc skipped because
totemo okotta.
very got angry
‘Father got very angry because Mary skipped school.’
d. Otoosan-ga totemo okotta, [[Mary-ga gakkoo -o
father-nom very got angry Mary-nom school-acc
sabotta] kara].
skipped because
‘Father got very angry because Mary skipped school.’
(2a) shows that the clausal adjunct phrase headed by mae,
‘before,’ precedes the matrix clause. (2c) shows that the
reason adjunct phrase appears before the matrix VP. Both
(2b) and (2d) demonstrate that clausal adjuncts may not
appear after the matrix verb.3

The fact that the head is in the phrasal final
position in Japanese means that the end of a constituent is
clearly marked by its head; the end of an NP is the head N,
the end of a complex NP such as the relative clause
construction is also marked by the head N, and any sentence
is marked by a V. In contrast, there is nothing which
marks the beginning of a clause. Thus, the ambiguity in
Japanese occurs as to when the new clause starts. This is

3 The only time a constituent appears after the verb is the case of
"afterthoughts" (Kuno, 1978), which appears in spoken language.
the opposite of English, a head-initial language, in which the beginning of the clause is marked by the head. In English, it is the end of a constituent that is not marked. Thus the attachment of a constituent is sometimes ambiguous. Observe that the adjunct PP in the English sentence below is ambiguous between attachment to the matrix verb and the relative clause.

(3) John saw the girl whom Mary was talking about in the restaurant.

The phrase in the restaurant may modify the matrix verb see or verb in the relative clause, talk. Since nothing marks where the relative clause ends, the attachment of the PP is ambiguous.

3.1.2. Case Marking

In Japanese, Case markers such as ga, o, ni, and no are directly attached to NPs. Typically, ga is attached to an NP which has the nominative Case, o for the NP with the accusative Case, ni for the NP with the Dative Case, and no for the one with the Genitive Case. In colloquial Japanese, the accusative o and Dative ni may be deleted. The following sentences represent sentences with all overt particles.

   John-nom pizza-acc ate
   'John ate pizza.'

b. John-ga Mary-ni pizza-o ageta.
   John-nom Mary-to pizza-acc gave
'John gave pizza to Mary.'

However, a particle and the grammatical relation of the NP it is attached to are not in one-to-one correspondences (Shibatani, 1977). For instance, *ga* marks an object of certain type of predicate as well as a subject (cf. Kuno, 1973, Shibatani, 1977). The object marked by *ga* occurs with the stative constructions (desiderative, potential, feeling ('like' or 'hate'), etc.) (Kuno, 1973). This is shown below.

(5) a. (desiderative construction)

*Watasi-wa meron-ga tabe-tai.*

*I-top melon-acc eat want to

'I want to eat some melon.'

b. (potential construction)

*John-wa gitaa-ga hik-eru.*

*John-top guitar-acc play-can

'John can play guitar.'

c. ("feeling" construction)

*John-wa meron-ga suki-da.*

*John-top melon-acc like cop

'John likes melon.'

The Case marker *no* is not limited to marking the Genitive Case either. Case marking in the relative clause construction in Japanese is unique in the sense that the subject of a relative clause may be either marked by *ga* or

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*It is important, however, to note that the frequency of *ga* as the subject marker is higher than as the object marker. This is because the occurrence of *ga* as the object marker is limited to the verbs listed here.*
no. This is shown below.

(6) a. Kinoo Mary-ga [[John-ga/no EC₁ kaita]
yesterday Mary-nom John-nom wrote
ronbun₁]-o yonda.
paper-acc read
‘Yesterday, Mary read the paper which John wrote.’

b. Kinoo [[Mary-ga/no hon-o katta] mise]-ga
yesterday Mary-nom book-acc bought store-nom
seeru-o siteita.
sale-acc was doing
‘Yesterday, the store where Mary had bought a book
had a sale.’

Even though there is no exact one-to-one
correspondence between the Case and the grammatical
relation of the NP, certain expectations can be built up as
to what type of predicate will follow the Case marked NPs.
For instance, in (4b), the presence of the NP with Dative
Case ni as well as the NP with accusative Case o suggests
that a verb which subcategorizes an indirect object is
likely to follow; thus, it is likely that a ditransitive
verb is the predicate of the clause dominating the NP.®

Note, however, the combination of NP-ga NP-ni NP-o
does not always guarantee the expected results; for two

® See Miyagawa (1993) for the assignment of ga and no in relative
clause constructions.

® However, ni itself is ambiguous. It may be the Dative Case
marker, the postposition indicating the destination, direction,
benefactor, and the copula (Sadakane, 1992). Thus the appearance of
the NP with ni does not always guarantee the existence of the
ditransitive verb in the same clause.
reasons. First is the lack of on-to-one correspondence between the Case markers and grammatical functions.
Second, due to the fact that the beginning of the clause is not marked, the three NPs marked with ga, ni, and o may not belong to the same clause (i.e., not the co-arguments of the verb). The information on the forthcoming verb offered by the particles is only an approximation. It is necessary to examine the role Case markers play in the processing of Japanese. More specifically, when and how case information is used must be investigated.

3.1.3. Word-order and Scrambling

Hoji (1985) gives syntactic evidence supporting the hypothesis that basic Japanese word-order in a clause is NP-ga (Nominative), NP-ni (Dative), NP-o (Accusative), and the verb. The three NPs do frequently appear in this order

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7 This problem is further complicated by the fact that some arguments can be phonologically "null" (see section 3.1.4.).

8 Currently, I am conducting an independent study which investigates whether information provided by Case-markers plays a role in the on-line syntactic processing of Japanese. It compares two semantically equivalent relative clauses such as those below.

(i) [[John-ga honya-de katta]hon]-ga nakunatta.
(ii) [[John-no honya-de katta]hon]-ga nakunatta.
'The book which John bought at the bookstore was lost.'

There is ambiguity between simplex and relative clause construction in (i) until the appearance of head noun hon 'book', while there is no such ambiguity in (ii), because subjects in subordinate clauses only may be marked by either Genitive marker no or ga. If Japanese is processed serially and if Case information is utilized on-line, there should be increased processing cost observed at the head noun in (i), and not in (ii).

This is an on-going project whose results are not ready at this point. Also note that this study assumes the serial model in Japanese, and the examination of processing model in Japanese must be made explicit prior to the drawing of any conclusions from this Case marker study.
when they belong to the same clause with a ditransitive verb. However, the arguments may be displaced from the original position by a syntactic operation called "scrambling" (e.g., Saito, 1985). Any of the combinations of three arguments shown in (7) is possible.

(7) John gave pizza to Mary.

a. John-ga Mary-ni pizza-o ageta. (S, IO, DO, V)
   John-nom Mary-to pizza-acc gave
b. John-ga pizza-o Mary-ni ageta. (S, DO, IO, V)
c. Pizza-o John-ga Mary-ni ageta.
   (DO, S, IO, V)
d. Mary-ni John-ga pizza-o ageta. (IO, S, DO, V)
e. Pizza-o Mary-ni John-ga ageta.
   (DO, IO, S, V)
f. Mary-ni pizza-o John-ga ageta. (IO, DO, S, V)

The sentences in (7b-f) show that the arguments in a sentence may change their places anywhere in the clause (expect the post-verbal position), while keeping the same

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*This, of course, assumes that the basic word-order in Japanese is NP-ga NP-ni NP-o.*
meaning as in (7a).\textsuperscript{10,11}

An argument can be fronted outside a clause also.

This is shown in (8).

(8) *John said that Mary bought a pizza.*

\begin{itemize}
  \item[(a)] John-ga [Mary-ga pizza-o katta]-to itta.
  \hspace{1em} John-nom Mary-nom pizza-acc bought-comp said  
  \item[(b)] Pizza-o John-ga [Mary-ga katta]-to itta.
  \hspace{1em} pizza-acc John-nom Mary-nom bought-comp said
\end{itemize}

In (8b), *pizza*, the object in a subordinate clause, is placed in front of the matrix subject *John*. The sentence (8b) has basically the same meaning as (8a). The phenomena in (7) and (8) are both instances of scrambling.

Although arguments are freely scrambled, verbs in Japanese may never be scrambled. They are always at the clause-final position. If a verb is located in any other position, the sentence results in ungrammaticality.

\textsuperscript{10} There is, however, a sense of "focus" on the fronted NP.

\textsuperscript{11} Shibatani (1990b) points out that cases like (7c) and (7f), in which two arguments are scrambled, are awkward. Indeed those two sentences are less natural than the others. It is not clear what the nature of awkwardness is; the reason may not be syntactic (i.e., the grammatical rules do not permit such a structure), since the awkwardness disappears when the clauses are put in the subordinate clause, as shown below.

\begin{itemize}
  \item[(i)] [[[Pizza-o Mary-ni John-ga ageta] koto]-wa minna sitte-iru.
  pizza-acc Mary-to John-nom gave fact-top everyone knows
  \item[(ii)] [[[Mary-ni pizza-o John-ga ageta] koto]-wa minna sitte-iru.
  Mary-to pizza-acc John-nom gave fact-top everyone knows
\end{itemize}

*Everyone knows that John gave a pizza to Mary*. If the awkwardness is due to the scrambling of the two arguments, then sentences (i) and (ii) should also be ungrammatical. On the contrary, the sentences are fine. Therefore it is not a syntactic problem. Recall that scrambling is associated with focus; the focus by two scrambled arguments could have a strange effect in the simplex clause.
(9) a. *Ageta John-ga Mary-ni pizza-o.
   c. *John-ga Mary-ni ageta pizza-o.

   The fact that constituents may be reorganized rather freely makes the information provided by Case marking even less effective in parsing. A. Inoue (1991) claims that the nominative Case marked NP would be a good clue identifying where a clause begins. However, due to scrambling, it is not possible to assume this in any sentences. For instance, when arguments other than the subject NP are scrambled and fronted as in (7c)-(7f), the beginning of a clause is not the nominative NP. This means the nominative NP cannot guarantee the marking of the beginning a clause. It appears that A. Inoue’s principle must be applied only to the sentence with canonically Case-marked arguments.

3.1.4. Phonomogically Null Arguments

   In Japanese, not all the arguments classified by the verb have to be overtly present. For instance, The verb taberu, ‘to eat,’ takes the arguments shown in (10). The arguments <Agent> and <Theme> may both be overtly present, but their absence does not make the sentence ungrammatical. This is shown in (11).

(10) taberu ‘to eat’ <Agent <Theme>>

(11) a. Taro-ga pizza-o tabeta.
    Taro-nom pizza-acc ate
    ‘Taro ate a pizza.’
b. Taroo-ga EC tabeta.
   Taro-nom ate
   'Taro ate (it).'

c. EC pizza-o tabeta.
   '(I/You/He/She/We/They/It) ate a pizza.'

d. EC EC tabeta.
   ate
   '(I/You/He/She/We/They/It) ate (it).'

In the government and binding framework, it is hypothesized that there is a phonologically null argument present in the place where the overtly constituent can appear (Hoji, 1985; Nakamura, 1990; but cf. Hasegawa, 1984-5). This empty argument is called a (phonetically) null argument.\[^{12}\] Since null arguments are pronouns, they are more naturally used in a context in which their referents are either understood or easily "accommodated" (Thomason, 1987).

Null arguments may occur in a subordinate clause as well as in the matrix clause. (12) shows that null arguments can occur in a subordinate clause and a relative clause.

\[^{12}\] The null arguments in Japanese (and Korean) are different from arguments with an "open theta-role" (Carlson & Tanenhaus, 1988) in English, as shown below. 

(i) John gives blood regularly.

In (i), the NP which may receive <goal> is not overtly present. The null arguments mentioned here are different from implicit arguments because the null argument is not implicit but it must have a referent. Thus, in (11), the context must supply the information regarding the referents of the null arguments. In this sense, null arguments in Japanese and Korean are similar to English pronouns.
In (12a), there is a null argument in the subordinate clause, which is coindexed with the matrix subject. The subject in the relative clause in (12b) is a null argument that is coindexed with the matrix subject.\footnote{The subject can be overtly present as shown below.}

The fact that a null argument is possible in both matrix clauses and subordinate clauses, added to relatively free word-order, further obscures the beginning of a new clause. Since any of the arguments classified by a verb may be null, a string of NPs which appear to be in the same clause may not actually be co-arguments. Compare the following sentence with (12a-b).

(13) John-ga hon-o katta.

'John bought a book.'

The two arguments John-ga hon-o in (13) belong to the same

\footnote{The subject can be overtly present as shown below.}

(i) ??John-ga [[John-ga hon-o katta] to] itta.


'John said that (he) bought a book.'

The null argument or reflexive zibun "oneself" is preferred due to the nature of Japanese names and pronouns. See Aikawa (1993).
clause. Notice that on the surface, the first three words in (12a-b) are identical to the simplex clause in (13). In contrast to (13), the two NPs in both (12a) and (12b) belong to two separate clauses.

3.1.5. Complex Noun Phrases

Complex noun phrases in Japanese are formed by an NP preceded by a clause which modifies it. There are neither relative pronouns nor complimentizers (Kuno, 1973). According to the relation between the head noun and the relative clause, the complex noun phrases (relative clauses) may be classified in three types: "Regular (gapped) relative constructions," "Gapless relative constructions," and "PP relative constructions."

(14) gives an example of a Regular relative.

(14) <Regular relative construction>

[[John-ga EC\textsubscript{i} tabeta] pizza\textsubscript{i}]

John-nom ate pizza

'the pizza which John ate'

In the Regular relatives, there is a "gap" in the relative clause, which is obligatorily coindexed with the head NP.

The second kind of complex NP does not contain a gap in the relative clause. The head NP and the relative clause are related by certain pragmatic constraints such as "cause and result" (see Matsumoto, 1988, 1992).\textsuperscript{14} I will refer to this type as a "Gapless relative." This is shown

\textsuperscript{14} "Cause and result" are not the only pragmatic constraints governing the Gapless relative in Japanese. See Kuno (1973) and Matsumoto (1988).
below.

(15) <Gapless relative construction>

[[John-ga hon-o utta] okane]

John-nom book-acc sold money

'the money (which John received as a result) of
John’s selling books'

It is generally assumed that this Gapless relative
clause is not formed syntactically, and the head noun and
the relative clause hold some pragmatic "relation." There
is a certain pragmatic constraint for the well-formedness
of this type of complex NP.

The third type of relative clause contains no obvious
gap either. This type of relative clause will be referred
to as an "adjunct PP relative." This is shown below.

(16) <Adjunct PP relative construction>

[[John-ga EC₁ hon-o katta] miseᵢ]

John-nom book-acc bought store

'the store where John bought a book'

In (16), both arguments with <Agent> and <Theme> roles are
overtly present. Thus, the relative clause seems to
contain no gap. However, the head NP, mise, 'the store,'
is actually coindexed with the adjunct gap: the store which
specifies the location of the action (cf. Saito et al.,
1988; Murasugi, 1991; Yamashita, 1992). Presumably, the
simplex sentence corresponding to the PP relative in (16)
is as below.

(17) John-ga mise-de hon-o katta.

John-nom store-at book-acc bought
'John bought a book at a store.'

All three types of relative clauses are identical to the simplex sentence. Compare (18) to the Gapless and PP relatives in (15) and (16).

(18) a. John-ga hon-o utta.
    John-nom book-acc sold
    'John sold a book.'

b. John-ga hon-o katta.
    John-nom book-acc bought
    'John bought a book.'

The simplex sentences in (18) are identical on the surface to the relative clauses in (15) and (16). The relative clause in the Regular relative construction is also ambiguous between the simplex clause and relative clause, since Japanese allows null arguments. A simplex sentence in (19) is identical to the relative clause shown in (14) on the surface.

(19) John-ga EC tabeta.
    John-nom ate
    'John ate (it).'

The absence of a relative pronoun and the temporal ambiguity between a relative clause and a simplex clause make it difficult for the parser to detect the relative clause construction in Japanese. Since the simplex sentence and the relative clause are identical in the surface phonological string, the appearance of a verb does not solve the ambiguity of the simplex clause and the relative clause constructions. It is what follows the verb
that disambiguates. If a clause is followed by a head NP, the clause is a part of the relative clause construction. If a clause is followed by a period or a conjunction, the clause is not a relative clause construction. The disambiguation between a simplex clause and a relative clause does not take place until one word after the verb (A. Inoue, 1991).

3.2. Japanese Orthography

So far the syntactic characteristics of Japanese has been discussed. Now let us turn to the discussion of Japanese orthography.

Japanese can be written vertically (from the upper right to the left) or horizontally (from left to right). There are customary ways based on the type of written material. Traditional reading materials such as books and newspapers are written vertically. Writing from left to right is common in the social science and science articles; writing horizontally is also preferred by many young Japanese.

There are three types of characters in modern Japanese: Kanji (Chinese characters), which are ideograms used for content words; Hiragana, the phonograms used in grammatical function words such as particles, inflectional endings and some native content words; and Katakana, the phonograms for foreign (non-Chinese) names and
onomatopoetic expressions.\textsuperscript{15} Each character of Hiragana and Katakana represents a mora, a combination of consonant and a vowel (CV) or a vowel alone (V). By the end of secondary education, Japanese students learn all the Kanas and 1,945 daily Kanjis, following the recommendation by the Ministry of Education.

It is possible to use any of the three systems to write Japanese words, but there are some customs. For example, nouns referring to abstract ideas are often Sino-Japanese (words originating in the Chinese language), which are usually written in Kanji. Words such as seesin 'spirit,' hoogaku 'direction,' keekaku 'plan,' are therefore usually written in Kanji. If Hiragana were used in writing these Sino-Japanese words, the native readers would feel that the words are written in such a way to assist the reading of Kanji. Foreign names (except the ones originate from Chinese) and loan words such as amerika 'America' and naisu 'nice' are always written in Katakana. Many context words are partially written out in Kanji.

Some words, however, may be written in Hiragana or Kanji with equal frequency. For instance, the word hen, 'strange,' is equally natural in Hiragana or Kanji, and sometimes even in Katakana. There are also numerous context words that are partially written out in Kanji. Thus the verb taberu, 'to eat,' for instance, is written

\textsuperscript{15} See Shibatani (1990b: 125-131) for detailed discussion of the historical development of the three types.
using the Kanji for ta, and Hiragana is used for the rest of the word. Function words such as postpositions, Case markers and verb inflection morphemes are all written in Hiragana.

3.3 Syntactic Properties of Korean

Korean syntactic properties present striking similarities to those of Japanese. First, Korean is a strict head-final language. The head noun is preceded by all the modifiers, and in the relative clause construction the head noun follows the relative clause. This is shown below.

(20) a. John-uy chingwu-uy yepp-un kay
    John-gen friend-gen pretty dog
    'John's friend's pretty dog'

b. [[John-i honcase ssu-n] chayk]
    John-nom alone wrote book
    'the book which John wrote by himself'

The basic word-order of Korean is SOV. There is also a phenomenon of scrambling, which parallels the one in Japanese. The Case is marked by particles. The nominative Case is typically marked by i/ka, accusative Case by ul/lul, Dative Case by eykey or hante. In colloquial speech, it is common to drop ul/lul. Shown below are

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16 For detailed description of characteristics of Korean, see Baek (1984), Comrie (1990) and Lee (1989).

17 The second particles after the slash are used when the preceding NP ends with a vowel.
Korean sentences with fully-attached Case markers.

    John-nom bookstore-at book-acc bought
    'John bought a book at a bookstore.'

    Mary-nom John-to apple-acc gave
    'Mary gave an apple to John.'

As in the case of Japanese, there is no exact one-to-one correspondence between Case marking and the grammatical function of the word. For instance, the object of a verb choa-ha-ta 'to like' is marked by a nominative marker i/ka, instead of an accusative marker ul/lul. Some subjects in a relative clause are marked by genitive Case, although it is not as systematic as in Japanese. As in the case of Japanese, a Case marker gives a good approximation of the grammatical function of the word it is attached to, although there is no one-to-one correspondence between the two.

Korean also has phonologically null arguments, just like Japanese. This is shown below.

    John-nom pizza-acc ate
    'John ate pizza.'

    John-nom ate
    'John ate (it).'

c. EC Pica-lul meke-ss-ta.
    pizza-acc ate
'(I/You/We/He/She/They/It) ate pizza.'

d. EC EC Meke-ss-ta.

ate

'(I/You/We/He/She/They/It) ate (it/them).'

The sentences in (22) demonstrate that phonologically null arguments are possible in a simplex sentence. The sentences below show that null arguments are possible in the subordinate clause, as in Japanese.


promised

'John promised that (he) will make dinner.'


telephone call-did

'John called the bookstore where (he) bought that book.'

In (23a), the subject of the subordinate clause is a null argument which is coindexed with the matrix subject. In (23b), the subject of the relative clause is a null argument. It is coindexed with the matrix subject.

Korean adjunct subordinate clauses and relative clause constructions have many aspects in common with Japanese. Adjunct subordinate clauses such as temporal clauses or reason clauses precede the matrix verb, and the relative clauses precede the head nouns. There are no relative
pronouns in relative clause constructions.

The difference between Korean and Japanese in adjunct subordinate clauses and relative clause constructions is that in Korean the verbs in relative clauses and subordinate clauses are marked morphologically differently from the matrix verb. The verbs in relative clauses are unambiguously marked: suffix nun for a present tense relative verb, un/n, for the past, and ul/1 for the future tense. The following sentences show relative clauses with different tenses with respect to the event described by the matrix verb.

John-nom Mary-to apple-acc give rel child-acc powa-ss-ta.

saw

'John saw the child who gave Mary an apple.'

b.John-i [[ Mary-eykey sakwua-lul chwu-nun] ai]-lul
John-nom Mary-to apple-acc give rel child-acc powa-ss-ta.

saw

'John saw the child who gives Mary an apple.'

c.John-i [[ Mary-eykey sakwua-lul chwu-l] ai]-lul
John-nom Mary-to apple-acc give rel child-acc powa-ss-ta.

saw

'John saw the child who will give Mary an apple.'

The verbs in a simplex sentence have different morphological markings from those of relative clauses.
Compare (24) with (25).

    John-nom Mary-dat apple-acc gave
    'John gave an apple to Mary.'

    John-nom Mary-dat apple-acc gives/will give
    'John gives/will give an apple to Mary.'

By the same token, the verbs in adjunct subordinate clauses
are marked differently than the matrix verb. For example,
the verb in the adjunct clause headed by hwue, 'after,' is
marked by un/n, and the verb in a 'when' clause must be
marked by u1/l. Compare (25) with (26).

(26) a. [John-i Mary-eykey sakwua-lul chwu-n hwue]
    John-nom Mary-dat apple-acc gave after
    emeni-ka tto sa-owa-ss-ta.
    mother-nom more bought
    'After John gave an apple to Mary, mother bought
    some more.'

b. [John-i Mary-eykey sakwua-lul chu-ɬ ttay] Mary-nun
    John-nom Mary-dat apple-acc gave when Mary-top
    kamsa-bae-ss-ta.
    thanked
    'Mary thanked (John) when John gave her an apple.'

Due to the morphological difference between the matrix verb
and the subordinate verb, a Korean subordinate clause is
easier to detect than the one in Japanese. This may affect
the point of "closure," a point at which a parser decides a
clause is completed. That is, while a Korean parser makes
a decision at the verb whether a clause it is currently processing is a subordinate clause or matrix clause, a Japanese parser must wait until one word after the verb. In the following chapter, the issue of closure in the two languages will be investigated. Due to head-finality, null arguments and scrambling, however, the difficulty of detecting the beginning of a clause remains as problematic in Korean as in Japanese.

3.4. Korean Orthography

In writing, the Korean alphabet, "Hangul," is used. Hangul has 24 letters. They are arranged syllabically. Thus, one character has one syllable having a CV, CVC or CVCC structure. There are legal and illegal phonological combinations.

In the past, both Hangul and Chinese characters ("Hanja") were mixed in the same text. Numerous Sino-Korean words were, of course, written in Chinese characters. Since 1970, all textbooks in elementary schools, junior high schools and high schools have used only Hangul. Most newspapers, however, still use both Hangul and Chinese characters.

Using only Hangul in writing sometimes causes lexical ambiguity, especially when writing Sino-Korean words. For example, more than 21 Chinese characters, such as 'true,' 'fix,' 'silent,' 'precise,' 'sympathy,' and 'government,' are pronounced ceng. Thus, a reader of a text written in
Hangul must interpret the meaning of ceng from the context; while there is no ambiguity when Chinese characters are used, writing in Hangul requires the readers to solve the ambiguity using the lexical and sentential context.18

3.5. Processing Models for Japanese and Korean:
Prediction by Strict Serial, Parallel, and Delay Models

Imagine that Japanese and Korean are processed in a serial fashion, in which only one structure is hypothesized and pursued. Syntactic properties such as head-finality, null arguments, and scrambling make choosing the correct syntactic structure extremely difficult. There are simply too many possibilities to complete a fragment of a sentence. Recall, for instance, that a string of NPs may or may not be in the same clause. This is repeated below.

(27) John-ga Mary-ni pizza-o...
      John-nom Mary-to pizza-acc gave
      'John gave Mary a pizza.'
      John-nom Mary-dat pizza-acc gave comp said
      'John said that (he) gave Mary a pizza.'
      John-nom Mary-dat pizza-acc gave comp said
      '(I/You/We/He/She/They/It) said that John gave Mary a

18 In the current study, such words which lead to ambiguity at the lexical level were avoided. See Chapter 4 for methodological issues in creating stimuli in Hangul.
The string of John-ga Mary-ni pizza-o may be completed in any of the ways shown in (27). The sentences in (27) do not exhaust all the possible sentence types in which the NPs may be completed.

Serial models hypothesize the building of only one structure at a time. Therefore, a reanalysis takes place if the first structure turns out to be incorrect. One may claim that hypothesizing a single structure in Japanese is not a problem, if the parser always selects the structure which appears most frequently in the language. If a preferred structure is a minimal attachment structure, especially a simplex sentence, the parser does not have to reanalyze frequently. Many Japanese sentences, however, are not those of preferred structures (simplex sentences). I have analyzed the sentences in the articles in a magazine and a newspaper; the results reveal that more than half of the Japanese sentences in a text include some kind of less-preferred structure such as the subordinate clause and the
relative clause constructions. In three articles in LEE (1993), a woman's magazine published in Japan, 42.3% of total sentences (N=142) were simplex structures, which included no subordinate or relative clause construction. As much as 57.7% included some type of complex structure, and they were ambiguous between simplex and complex structures at the beginning of those sentences. In Yomiuri newspaper (November 21, 1993), one of the three major national daily newspapers in Japan, 40.7% were simplex sentences, whereas 59.3% were complex sentences (N=91). This shows that if the parser adopts the minimal attachment strategy, Japanese readers are forced to reanalyze the initial hypothesis more than half of the time. Since reanalysis is assumed to be costly, the serial model in the strictest sense predicts that processing Japanese (and presumably Korean) is difficult. This contrasts with the case of English. The similar informal survey in the English-language magazine Biblical Archaeology Review (November 1993), 40.5% of total sentences surveyed (N=84) were simplex sentences. 59.5% of sentences included some type of subordinate clause, sentential adjunct clause or relative clause. This ratio is approximately the same as in the Japanese-language.

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19 This probability may change slightly if there is information used by a parser to hypothesize non-minimal attachment initially. There is a possibility that Case information may be used initially to aid a parser in hypothesizing non-minimal attachment in certain cases, such as consecutive use of o. At this point, however, whether Case information or possibly other information contributes in such a way is totally speculative. Even if Case information contributes in such a way, such cases would be limited to a few constraints such as double o or double ga.
magazine and newspaper. However, most of the structures
which involved subordinate or relative clause in this
English magazine had overt marking, such as when, that, and
who. In fact, only 8% of all the sentences surveyed
included some type of deleted relative pronoun or
complementizer which caused ambiguity. This means that
parsing English according to minimal attachment may cause
as many misanalyses as Japanese, but the overt marking of
subordinate clauses or relative clauses further aids the
parser not making wrong hypotheses.

If Japanese and Korean are processed according to a
parallel model, the number of possible structures
simultaneously computed is higher than in English. English
syntactic ambiguity often is a result of multiple
subcategorizations and/or multiple argument structures of
the verb, or a morphological ambiguity such as past
Thus, the number of possible structures in English is
relatively limited. The ambiguity in Japanese and Korean
often is a result of the left-branching nature of the
language, along with null arguments and relatively free
word-order. Every NP can potentially start a new clause.
Just how many possible structures there are depends on the
forthcoming words.

It has been demonstrated that processing ambiguous
structures is more costly than unambiguous structures
(e.g., Foss, 1970; MacKay, 1966). The fact that the possible structures in Japanese and Korean are numerous would mean that Japanese and Korean are more difficult to process than English. The strict parallel model, therefore, predicts that processing Japanese and Korean is more costly than English. A parallel model with a ranking among alternatives, as proposed by Gorrell (1987), may be a workable model. If the ranked parallel model is correct, what kinds of criteria are used in ranking must be investigated.

If Japanese and Korean are processed in a delay fashion, the question is at which point the parser judges that enough information has been received and at which point a structure is built. It has been claimed that storing unstructured items is harder than storing structured items (Miller, 1956). This suggests that storing an unanalyzed (pre-attachment to a syntactic tree) lexical string is very costly, compared with storing information organized in a clause (or a sentence). If the delay model is proposed, clarification is needed as to when the syntactic structure is created. If there is some delay in syntactic processing, it must not be an unlimited delay; memory overload should limit the length of delay.

The strict delay model in Japanese presents a more severe memory overload problem than it does in English, due to the head-final, SOV nature of Japanese. In the so-

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20 Studies by both Foss (1970) and MacKay (1966) do not distinguish between the computation of multiple syntactic structures and interpreting multiple meanings in an ambiguous string.
called "center-embedded" sentences shown below, sometimes several NPs may appear before the first verb. Moreover, the first verb does not perfectly disambiguate the structure. After all, the final structure does not become clear until the very sentence-final verb.


   John-nom Mary-to apple-acc gave child -acc saw

   'John saw the child who gave Mary an apple.'

At the head NP kodomo, it becomes clear that the first three NPs do not belong to the same clause. In order to interpret kodomo as the head NP of the relative clause construction, one argument, most likely John-ga, must be expelled. However, whether or not Mary-ni is expelled from the relative clause will not become clear until the end of the sentence. Since the matrix verb is a transitive verb which cannot take NP-ni, it becomes clear that Mary-ni does not belong to the matrix clause. Thus, in order to get enough information to complete the relative clause, which is the "lowest" and thus "first" clause to be completed, the parser must wait until the end of the entire sentence. To keep everything (three arguments, one verb and another accusative NP as the head NP) in the buffer can cause memory overload.

Another problem the delay model faces is "global ambiguity." In sentence (27b), for instance, the fact that the sentence involves a subordinate construction becomes clear at the complementizer to. However, due to the null argument, the sentence fragment in (27) is globally
ambiguous between (27b) and (27c). Even at the matrix verb, it is not possible to disambiguate the structure. Therefore, not only "how long" the delay parser waits, but also how it decides the output in globally ambiguous sentences must be made clear.

In conclusion, the strict serial, parallel, and delay models all present problems in processing Japanese and Korean. They all predict that the processing of Japanese and Korean is more difficult than that of English. It is questionable whether parsing a particular human language is more difficult than others. Assuming that the processing of any given human language is not any more costly than that of another, the problem, then, must lie in the proposed models, which fail to capture the processing of Japanese and Korean.

3.6. Modified Models

In order to account for the processing of Japanese, some modified models have been proposed (e.g., A. Inoue, 1991; Inoue & Fodor, in press; Mazuka & Lust, 1990). In this section, I will briefly summarize them and point out their potential problems.

3.6.1. Bottom-up Model

Mazuka & Lust (1990) propose a parametrized processing model which is based upon the syntactic characteristics of a language. They pointed out that a "top-down" processing
model would predict extreme difficulty in processing Japanese. By top-down processing, they mean that a syntactic structure is built starting with the initial symbol of the grammar, i.e., the topmost in all trees, and then built downward.\footnote{Here, the 'top-down' does not refer to processing among various processing levels such as the semantic level and the lexical level. Top-down here is strictly limited to syntactic processing; it refers to the computation of a higher node prior to the completion of lower nodes.} This roughly amounts to the assumption that the matrix clause S node is built as soon as the first word appears. Mazuka & Lust claim that due to the head-finality, left-branching characteristics of Japanese, along with null arguments and scrambling, Japanese would have to undergo frequent and massive backtracking if it is indeed processed in the top-down manner.

Alternatively, they propose the "bottom-up model," which is motivated by the parametric characteristics of Japanese, as summarized below.

\begin{equation}
\text{(29) Definition of bottom-up parsing organization:}
\end{equation}

In parsing organized according to "bottom-up" principles, hypotheses about constituent structure of lower constituents are sequenced before hypotheses about the relation of such constituents to higher constituents.

Specifically the parse tree is built from the lower node up. In particular, clauses are built from the lowest one and a new clause is placed above the previous clause. (Mazuka & Lust, 1990:179)

With this model, a sentence which begins with a deeply embedded clause as shown below does not require massive
backtracking. Since the first NP Taroo-ga is not assumed to be the subject of a matrix clause, the fact that the sentence starts out with the most deeply embedded clause does not cause backtracking when later the sentence turns out to be a complex sentence.

(30) \[
\text{[EC}_i \text{ [EC}_j \text{ [Taroo-ga katte EC}_k \text{ iru] inu}_k\text{-ni]}}
\]
\[
\text{Taro-nom keeps dog-by}
\]
\[
oikakerareta \text{ kodomo}_j\text{-o dakiageta] otoko}_i\text{-nom}}
\]
\[
\text{was chased child-acc lifted up man -nom}
\]
\[
\text{'The man who lifted up the child who was chased by the dog Taro keeps...'}
\]
\text{(Mazuka & Lust, 1990:168)}

It is important to note that Mazuka & Lust (1990) distinguish local (within-clause) from non-local (above-clause) processing. They claim that locally, the parser puts the arguments in the same clause until the verb appears, "unless other information is present such as a pause or particles that cannot co-occur in a same clause." Non-locally, above the clause level, they propose bottom-up processing. Thus in sentence (30), the "lowest" (relative) clause, Taroo-ga katte iru, is the first clause to be finished. The complex NP, whose modifier is Taroo-ga katte iru, is completed next. This model appears to be an effective model for Japanese; because there is no way to know the depth of embedding in Japanese, bottom-up parsing is more efficient than top-down parsing in Japanese.

However, the fact that Mazuka & Lust (1990) assume that first NPs belong to the same clause means that their model is not strictly bottom-up. If all the arguments are
first regarded as co-arguments of a verb, there is no reason to motivate delay parsing within a clause; keeping these arguments in the buffer is less efficient than attaching them immediately without waiting for the verb. Consequently, there are initial misanalyses within a clause. Mazuka & Lust (1990) indeed predict that the following sentences are misanalysed initially.

(31) a. [Hirosi-ga [[EC Masao-o mita] otoko]-o...]
   Hiroshi-nom Masao-acc saw man -acc
   'Hiroshi (does/did something) to the man who saw Masao.'

b. Hirosi-ga [EC [EC Masao-o mita] otoko]-o mituketa]
   Hiroshi-nom Masao-acc saw man-acc found tantei] -ni...
   detective-dat
   'Hiroshi (does/did something) to the detective who found the man who saw Masao.' (Mazuka & Lust, 1990)

In (31), both sentences have two canonically Case marked NPs prior to the first verb. There is nothing to motivate the clause boundary between the two NPs. Presumably, their model predicts that initial NPs are misanalysed as co-arguments.

The model proposed by Mazuka & Lust (1990), which is a bottom-up model beyond the clause level, has an advantage in avoiding the massive backtracking predicted by the total serial model. It also eliminates the problem of memory overload in Japanese that is predicted by the purely bottom-up model, by proposing that within a clause the
decision regarding the structure is made without waiting for confirming information. It is not clear, however, how the initial misanalysis within a clause affects the non-local level processing. For instance, what happens to the NP Hirosi-ga once the head NP appears and it is decided that Hirosi-ga does not belong to the relative clause? Is the attachment decision delayed; i.e., is the NP kept in a buffer until confirming information becomes available? Or, is it immediately attached to the higher clause? In that case, the distinction between non-local bottom-up processing and serial, full-attachment local processing becomes less defined.

3.6.2. Information-paced Parser

In his theoretical work, A. Inoue (1991) proposes an "information-paced" parsing. The model is a left-to-right, on-line, serial model with a "look-back." It is a serial model, but it "looks back" (checks) the analysis at the verb and also at the head NP of a relative clause construction and examines what has been processed. Any necessary revision takes place at this point.

A. Inoue claims that principles such as minimal attachment are also operative in processing Japanese. The difference between the model by A. Inoue and the original serial model proposed based on English is that revision in Japanese is cost-free. He claims that because the amount of information the parser receives in Japanese at each point of decision-making is smaller than that received in
English, a Japanese parser is "less confident" about the decision. With the phenomenon of scrambling and the existence of phonologically null arguments, a sequence of arguments does not always form a single clause. Due to scrambling and null arguments, the parser in Japanese is always at risk of making misanalyses. Due to this lower confidence in decision making, the parser commits less confidently to the structure in Japanese than in English. This results in a revision that is cost-free.

Let us examine the model by A. Inoue (1991) closely. The claim by A. Inoue that Japanese is processed serially is based on the sentences below.

Bob-nom Mary-to apple-acc gave  
'Bob gave Mary the apple.'

b. Bob-ga Mary-ni ringo-o tabeta inu-o ageta.  
Bob-nom Mary-to apple-acc ate dog-acc gave  
'Bob gave Mary the dog which ate the apple.'

The sequence shown in (32a) is "NP-ga NP-ni NP-o." This is a typical word-order which appears in a sentence with a ditransitive verb. In (32b), however, the three NPs, which are marked as if they were to be followed by a ditransitive verb, do not belong to a single clause; ringo-o, 'an apple,' is the complement of the relative verb tabeta, 'ate,' while the first two NPs, Bob-ga and Mary-ni are arguments classified by the matrix verb. A. Inoue claims that there is a sense of "surprise" when the subordinate verb appears; it is almost as if some ditransitive verb
which involves the giving of the apple from Bob to Mary was expected first. According to A. Inoue (1991), the sense of surprise would not occur if the phrase was processed in parallel or in delay. Also notice that the preferred structure in (32b) is congruent with the minimal attachment hypothesis; simplex clause analysis, which involves fewer clauses, is preferred over the relative clause analysis.

It is important to note that the sense of surprise in (32) can be accounted for with the delay model as well. It is possible for the parser to "expect" a verb and yet delay structure-building until enough information becomes available. In fact, both the deceived expectation and the cost of computing a complex structure such as a relative clause construction may contribute to some conscious processing cost at the verb. It is also possible to account for the sense of surprise with a ranked-parallel model (Gorrell, 1987). If structures are ranked, only the simplest structure (the minimal attachment structure in this case) may be consciously active in memory. The surprise effect could be associated with the selection of the low-ranked structure over the highly ranked structure. Only experimental evidence which examines whether or not just one structure is computed in an ambiguous sentence can determine whether or not Japanese is computed in a serial manner. The two experiments in the current study serve just this purpose.

A. Inoue's claim that revisions of analyses are virtually cost-free in Japanese is supported by an example
below. There appears to be no garden-path effect at *kodomo* in analyzing the following phrases.

(33) *Bob-ga Mary-ni ringo-o...*
    *Bob-nom Mary-to apple-acc*
    *Bob-ga [[Mary-ni ringo-o ageta] kodomo]-o...*
    *Bob-nom Mary-to apple-acc gave child-acc*

According to A. Inoue, in reading (33), the first-pass analysis, i.e., the analysis when the sentence first appeared, is that all three NPs are in the same clause. However, at the appearance of the head NP of the relative clause, it becomes clear that the simplex clause analysis is incorrect. A. Inoue claims that the reanalysis which expels the first NP outside the relative clause and which creates a complex NP does not appear to cause a garden-path effect. He claims that since the cost of reanalysis in Japanese is not high, frequent reanalysis does not result in processing difficulty. Thus there is no garden-path effect in (33).

The proposal of cost-free reanalysis in Japanese questions whether reanalysis occurs at all. Here a problem arises with regard to the measurement of the difficulty of processing and the definition of garden-path structures. In English, there are indeed garden-path structures which literally “shock” the readers, such as (34). These have been called “severe” garden-path structures (Inoue & Fodor, in press; Mazuka & Itoh, in press; Pritchett, 1988)
(34) (severe garden-path sentences)

a. The horse raced past the barn fell.

b. The cotton clothing is made from grows in Mississippi.

c. The daughter of the king’s son admires himself.

d. They told the boy that the girl met the story.

However, some English structures are not shockingly difficult to process and yet result in some measured increased processing cost. One of the representative examples is shown below.

(35) (mild garden-path sentence)

Mary knew the girl was from New York.

Presumably, the preferred structure is attaching the girl as an object of knew, instead of as a subject of the subordinate clause. Although the sentence is not uninterpretable, an increased processing cost has been reported frequently in the literature (e.g., Frazier, 1978).

Judgments of the processing difficulty of a given sentence are usually based on the native speakers’ intuition in the theoretical work. Utilizing intuition is a valid measure of processing cost, since native intuition is an important form of human language performance. However, there are some advantages in testing the sentences in an actual experiment. In experimentation, researchers may be able to detect smaller processing difficulties for two reasons. First, more than one sentence per sentence type is used in experimentation so that more data may be
obtained (in order to increase the statistical power). In this way, there is less chance of generalizing an effect which could be unique to the mere selection of a word or pragmatics associated with the particular word. The other advantage is that on the average, thirty to fifty subjects participate in one experiment. Therefore the outcome of the experiments reflect the processing of a larger pool of people. In this way, the risk of interpreting and generalizing native speakers' particular strategy on a limited number of sentences can be reduced by conducting experiments.

Intuitively, some difference is felt in the processing difficulty between (34) and (35). However, that difference alone is not enough to deny the possibility that there is an increased processing cost in (35). By the same token, the possibility of an increased processing cost in Japanese in (33) cannot be ruled out. Whether there is actual processing cost involved at the head noun or not in sentence (33), as well as at the verb in the relative clause in (32b), must be experimentally examined.

\[\text{\textsuperscript{22}}\] In the current research, for instance, there are four to five sentences presented per condition in a single experiment.

\[\text{\textsuperscript{23}}\] Indeed, the study of eye-movements on the construction analogous to (33) by M. Inoue (1990a, b) demonstrates that at the head NP, the reading times at the head NP are significantly longer than at the control, and the regression from the head NP to the previous region is significantly more frequent than the control.
3.6.3. Information-Paced, Ranked Flagged Serial Model

The model proposed by A. Inoue (1991) has been developed into a “ranked flagged serial” model (Inoue & Fodor, in press). This model attempts to account for phenomena in languages with various syntactic characteristics. The two most significant new features of this model is that (1) each incoming word is attached to the whole current partial phrase marker (a “full-attachment”), and (2) at each point, the processor records what alternative parses there are and how highly each alternative is valued (“flagging”). Thus, when the parser is lead down a garden-path and needs to reanalyze the structure, it simply goes back to the flags and selects the most highly weighted flag, and starts the reanalysis procedure.

The ranked flagged model is still an information-paced model, in the sense that “the parser makes the decisions (regarding the selection of the structure, and the need to reanalyze) with a confidence proportional to the quality of information it had available to base them on” (Inoue & Fodor, in press). Inoue & Fodor claim that the grammatical characteristics of Japanese influence the quality of information they provide to the processing; compared to English, the parser receives less information in Japanese.²⁵

²⁴ Their examples are from English and Japanese only; however the applicability of the model is not limited to just those two languages. Theoretically, their model should be applicable to any language.
²⁵ See section 3.2. for the summary of the grammatical characteristics of Japanese.
Thus, the confidence of the parser of Japanese is low each time it makes a decision. This presumably leads to the parser's willingness to reanalyze in Japanese.

The notion of full-attachment is a strong claim, since each time a new item appears in the sentence, it must find its place in a final tree. Recall that the motivation of the bottom-up model by Mazuka & Lust (1990) was to account for the fact that there is no way for the parser in Japanese to know where in the tree the first element of a sentence (and other NPs as well) should be located. The full-attachment hypothesis assumes that the first NP in a sentence belongs to the matrix $S$. If the parser judges that there is a need to change the status of the clause to which the NP belongs, it simply switches the $S[+\text{ROOT}]$ feature to $S[-\text{ROOT}]$ feature. Since this change involves switching only one feature, Inoue & Fodor claim that it does not involve a heavy processing cost.

The model by Inoue & Fodor (in press) is efficient in the sense that the parser hypothesizes one structure at a time. The proposed reanalysis system with flags seems to provide the parser with a good source of information to go back to. There is a concern of processing cost in raising flags, however. First of all, raising flags requires attention to what the alternative structure could be at each point. Although the parser does not actually build the structures, as in the (ranked) parallel parser, the process requires the parser to keep track of at least prominent alternative structures. This could predict that
the serial model proposed here is less efficient than the original serial model summarized in Chapter 2 in the first-pass. Especially, raising flags in a left-branching language seems to be more inefficient than in a right-branching language. Since Inoue & Fodor (in press) assumes that structural principles guide parsers and information such as thematic information plays a role in the second-pass (reanalysis), the flags raised at the first pass are structurally motivated. Presumably, in English, a flag is raised at *raced* in *The horse raced past the barn fell*. When the garden-path occurs at *fell*, the parser looks back to the flag at *raced* and choose the reduced relative alternative. Since this alternative indicated by the flag is valued much lower than the first choice, the garden-path is severe.

The same mechanism may not work in Japanese without adding an extra processing cost. Imagine raising and keeping flags in canonically Case-marked arguments in Japanese as in (33), repeated here as (36).

(36)  

<table>
<thead>
<tr>
<th>(36)</th>
<th>Bob-ga Mary-ni ringo-o...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bob-nom Mary-to apple-acc</td>
</tr>
<tr>
<td>a.</td>
<td>Bob-ga [[Mary-ni ringo-o ageta] kodomo]-o...</td>
</tr>
<tr>
<td></td>
<td>Bob-nom Mary-to apple-acc gave child-acc</td>
</tr>
<tr>
<td>b.</td>
<td>Bob-ga Mary-ni [[ringo-o ageta] kodomo]-o...</td>
</tr>
<tr>
<td></td>
<td>Bob-nom Mary-to apple-acc gave child-acc</td>
</tr>
</tbody>
</table>

Prior to the verb, the three arguments are canonically Case-marked. The first preference is a minimal attachment, in which all three arguments are co-arguments. According
to Inoue & Fodor (in press), when the minimal attachment is not correct, such as in (36a) or (36b), the parser goes back to the most highly ranked flag. In flagging for the reanalysis, thematic or pragmatic factors are not relevant. In left-branching language like Japanese, then, if words are in canonical order (thus there is no structural clue) the flags must be raised at almost each argument. At Mary-ni and ringo-o, the parser must raise flags, since there is nothing to distinguish the structural preference, including verb information. If thematic information is used when the verb appears, (36a) may be preferred over (36b), since the latter includes the postulation of a null argument. However, thematic information is not used in the initial process in this model. Therefore the flags remain equally weighted. In such a case, the postulation of flags is simply redundant or could potentially add a greater processing cost. Parsing a left-branching language like Japanese is more efficient if the parser simply goes back to evaluate which argument(s) stay in the same clause with the thematic information, instead of raising flags and expecting alternatives with no help from thematic information.26

26 Currently, a new model, “diagnosis and cure” model, is proposed by Fodor & Inoue (in press). This model still assumes serial computation, but it diverges from the ranked flagged serial under discussion here in the treatment of the process of reanalysis and the measurement of difficulty of garden-path. The reanalysis in the diagnosis and cure model is a “repair” of the portion of the initial hypothesis, and the difficulty of garden-path is determined by how easily the parser can detect the revision. For details, see Fodor & Inoue (in press).
3.6.4. Head-driven Model

The sequence of theoretical work by Pritchett (1988, 1991) proposes a head-driven model that is based on the "projection principle" (e.g. Chomsky 1981) and licensing by the head. According to this model, a phrasal node is not built until the head is reached by the parser. This model distinguishes between the types of reanalysis in terms of the cost associated with them. The type of reanalysis that is costly is that which violates the "Relicensing constraint."

(37) Relicensing constraint:

Under relicensing, a constituent must remain governed by its current licensor.\(^2\)

(Pritchett, 1991:254)

Relicensing, i.e., changing of the theta-role that is first assumed, is costly when the assigner (governor) of the role changes from the original one. In addition to (37), Pritchett (1988) claims that if the reanalysis is triggered by a non-governor, the reanalysis is not costly. The difference in the garden-path effect in the English sentences below seems to support his model.

(38) a. Mary knew her mother hated her.

b. Mary warned her mother hated her.

The syntactic structures of the two sentences appear to be

\(^2\) The Projection principle is such that each head (V, P, and N, for instance) projects up to the maximal projection (VP, PP, and NP, respectively), and the properties of the head are projected to all levels of the syntactic representation (Chomsky, 1981).

\(^2\) Pritchett (1991) employs the notion of "government" motivated in Chomsky (1986). Typically, a verb governs its complement(s), and a preposition (postposition) governs its complement.
identical. There seems to be no garden-path effect in (38a), while the sentence (38b) seems to cause a garden-path effect. Pritchett accounts for the lack of a garden-path effect by the type of reanalysis that (38a) takes; while the reanalysis in (38b) involves the change of its governor, that in (38a) does not. In (38a), the phrase her mother is governed by the matrix verb, knew. At the verb hated, it becomes clear that the complement of knew is not her mother but the entire subordinate clause. However, her mother remains governed by the same verb. Thus, the reanalysis does not violate the relicensing constraint. However, in (38b), the NP her mother must be split into her and mother. Then her remains governed by the verb warn, but mother is governed by the verb hate. This violates relicensing constraint, and reanalysis is costly.

The proposed model by Pritchett (1988, 1991) predicts less frequent misanalysis in processing languages such as Japanese and Korean than a serial models does, simply because the attachment decision is delayed until the verb. The model also accounts for the lack of a sense of “costly” reanalysis in a Japanese relative clause, which is noted by A. Inoue (1991). The sentence (33), repeated here as (39), is accounted for by cost-free reanalysis in Inoue’s model (1991).

(39) John-ga Mary-ni ringo-o ageta kodomo-o (sikatta).
   John-nom Mary-to apple-acc gave child-acc scolded
   ‘John (scolded) the child who ate an apple.’

The model by Pritchett (1988, 1991) accounts for the lack
of a sense of costly reanalysis as follows. First, the NP John-ga is interpreted mistakenly as governed by ageta, 'gave.' According to Pritchett's model, if the reanalysis is triggered by a non-governor, the reanalysis is not costly. When the change of the governor takes place at the head noun, the next (and correct) governor for John-ga, which is sikatta, is not available yet. Therefore, the reanalysis is not triggered by the governor. The governor for John is not available until the matrix verb sikatta 'scolded.' Thus the reanalysis of interpreting John-ga as outside of the relative clause is not costly. This explains why the sentence is not difficult to reanalyze.

The model by Pritchett also accounts for the mild sense of surprise in reanalysis in the example by A. Inoue (1991). Recall that A. Inoue claimed to have a sense of "surprise" at the verb in (32b), repeated here as (40).

(40) Bob-ga Mary-ni ringo-o tabeta inu-o ageta.
    Bob-nom Mary-to apple-acc ate dog-acc gave
    'Bob gave Mary the dog which ate the apple.'

In Pritchett's model, each of the NPs Bob-ga, Mary-ni, and

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However, as Mazuka & Itoh (in press) argue, the relicensing constraint alone does not account for the severe garden-path effect. Mazuka and Itoh (in press) point out that a sentence which does not violate the relicensing constraint can cause garden-path. See below.

(i) Yoko-ga kodomo-o koosaten-de mikaketa takusii-ni noseta.
    Yoko-nom child-acc intersection-at saw taxi-into put on
    "Yoko put the child on the taxi she saw at the intersection."

In (i), the head NP (non-governor) takusii-ni triggers a reanalysis. Despite the fact that the relicensing constraint in Pritchett (1991) predicts that this type of reanalysis is not costly, the sentence is difficult. It appears, then, that inserting a null argument in a subject position makes the sentence difficult, and the relicensing constraint must accommodate such cases.
ringo-o is built up to the NP, since no VP is created until the verb. Notice that the verb tabeta reveals that the three NPs do not belong to the same clause, since the verb does not subcategorize the Dative NP. However, the model by Pritchett (1988, 1991) predicts that there is no reanalysis or even a sense of surprise at the verb, since it is at the verb tabeta that the VP is built up. If there is a sense of surprise at the verb in (40), the model by Pritchett cannot account for it.

It is important to investigate the cost of processing (40), because it is difficult to decide which model better captures the processing of Japanese without examining the actual processing load in (40).

I have summarized the models by Mazuka & Lust (1990), A. Inoue (1991), Inoue & Fodor (in press), and Pritchett (1988, 1991). All of them take into consideration the grammatical characteristics of Japanese, and attempt to capture how the language is processed. In comparing the models, which model best captures the processing of Japanese cannot be concluded yet; the actual processing cost associated with each proposed model must be assessed. In the following chapters, a series of experiments attempt to reveal the appropriate processing model for Japanese and Korean.
4.0. Introduction

In Chapter 3, the characteristic features of serial, parallel and delay models were discussed, and the discussion pointed out that the direct application of any of these models would result in extraordinary processing difficulty in Japanese and Korean. In this chapter, four experiments (two each for Japanese and Korean) will be presented in order to investigate the processing of both languages. The experiments were designed to see whether multiple structures are computed at an ambiguous point. Evidence of the computation of only one structure will constitute support for the serial model. Evidence of the computation of multiple structures will provide support for some type of parallel model. Evidence of no computed syntactic structures at the ambiguous point will support a delay model.
4.1. Tasks Used in the Experiments

Before the discussion of each experiment, let us summarize the tasks used in the experiment, the lexical decision and grammatical decision tasks, and discuss some of the issues related to each of them such as to which information each task is sensitive, and which stage of processing each task taps.

4.1.1. Lexical Decision Task for the Investigation of Syntactic Computation

In the lexical decision task, a subject makes a decision whether or not a string of letters or characters is a real word in the subject’s native language. In the studies presented here, the test stimuli are all real words, and the fillers include some real words and some non-words. Non-words refer to some strings of letters for which meaning is not accessible to any native speaker of the language. Among non-words, there are two types: “pseudo-words,” which have some morphological resemblance to real words, and “absolute non-words,” which are strings of completely random characters.

The lexical decision task is employed in the current investigation because several experiments report that it is sensitive to syntactic information (e.g., Boland, 1993; Goodman et al., 1981; Lukatela, 1983; West and Stanovich, 1986; Wright and Garrett, 1984). That is, a word which fits the syntactic structure computed up to that point is
recognized faster than a word which does not. For instance, Wright and Garrett (1984) found that a verb following a modal and a noun following a preposition were recognized faster than the opposite pairings (i.e., a noun following a modal, and a verb following a preposition). Their sentences were as follows.

(1) a. If your bicycle is stolen, you must FORMULATE
   b.*If your bicycle is stolen, you must BATTERIES

(2) a. For now, the happy family lives with BATTERIES
   b.*For now, the happy family lives with FORMULATE

All target words were presented in capitalized letters, and the subjects were asked to make a lexical decision at those targets. In (1) and (2), the target words in the (b) sentences are ungrammatical continuations of the sentence fragment. While the error rates of the lexical decision task did not reach significance, the reaction times for the ungrammatical continuations were significantly longer than their grammatical continuation counterparts. Since the pragmatic factor was carefully controlled in Wright & Garrett (1984), they concluded that the results reflected a syntactic influence on lexical decision.

Gorrell (1987) utilized the lexical decision task for the purpose of an investigation of syntactic processing in English. By comparing the response times of lexical decision for words which continue the sentence grammatically and those which continue it ungrammatically, Gorrell found evidence that parallel structures are being
computed in an ambiguous structure.\textsuperscript{1,2}

As for the stage of processing tapped by a task, the lexical decision task appears to tap the stage of processing which is earlier than the one tapped by the grammatical decision task. This will be discussed in detail in 4.1.4.

4.1.2. Orthographical Issues in the Lexical Decision Task

In the lexical decision task, special attention must be paid to the selection of both target words and the non-words. For instance, it is well-known that low-frequency words are judged to be words more slowly than high-frequency words, independent of the syntactic effects on lexical decision. Using only non-words that are easy to detect (such as phonologically illegal and non-pronounceable words) not only affects the response times of non-words, but may also affect the response times of real words.\textsuperscript{3}

The issue of choosing target and non-words requires further attention in Japanese and Korean, since in both

\textsuperscript{1} See Chapter 2 for a summary of the study by Gorrell (1987).

\textsuperscript{2} The lexical decision task in experiments in Gorrell (1987) and in the current study is assumed to measure the effect of "post-lexical access" processing (e.g., Seidenburg et al., 1984), which should be distinguished from the "pre-lexical access" processing effect. The pre-lexical processing is an activation of (a) certain word(s) prior to the recognition, and it takes place in the lexical module. In contrast, the post-lexical processing is how recognized words are integrated into the syntactic context. For a detailed discussion of the syntactic effect on post-lexical processing operation, see Gorrell (1987).

\textsuperscript{3} See Seidenburg (1992) for a discussion of the effects shown by the stimuli mixed with various types of real words and non-words.
languages, materials were presented in non-alphabetic orthographies. In the Japanese experiments, Hiragana, Katakana, and Kanji characters were used. In the Korean experiments, Hangul was used. Let us discuss some of the orthographic issues that are unique to the lexical decision task in Japanese and Korean.

4.1.2.1. Spelling Real Words in Hiragana, Katakana and Kanji

One of the concerns here is the choice of characters in writing real words in Japanese. As mentioned in Chapter 2, a Japanese word can be spelled out using Hiragana, Katakana, or a Kanji and Hiragana combination. There is a customary way, however, for a word to be written most of the time. In this study, an effort has been made to use the most natural Kanji/Kana characters (or combination of Kanji/Kana characters) in the test sentences. This is to avoid the irrelevant effects of employing unusual orthography to write a word (for instance, using Katakana characters for writing Sino-Japanese) on the lexical decision task.

* See Chapter 2 for a detailed description of Japanese and Korean orthographic systems.

* Darnell, Boland and Nakayama (1994) found effects of Kanji/Kana dominance on the reading times of a word in Japanese, when the words were introduced in a constraining context. However, when the words were embedded in a non-constraining context, such orthography effects did not affect the reading time.
4.1.2.2. Physical Length and Phonological Length

The other problem in choosing stimuli is how to unify the length of words. Generally, in psycholinguistic experiments in English, word length and frequency are matched. Matching the length of words in Japanese is not straightforward; there are problems concerning the difference between the phonological length and the physical length of a word. Hiragana and Katakana are phonograms, in which one character corresponds to one mora in Japanese. Kanji, on the other hand, often represents more than one mora when pronounced. For instance, the word mainichi, 'every day,' has four morae (thus four Hiragana characters are used), but it is spelled out by two Kanji characters. Thus, in this case, spelling out a word in Kanji is physically shorter than spelling in Hiragana. This is quite common; very often the words spelled out in Kanji are shorter physically than those spelled out in Hiragana. Thus the choice of orthography results in a difference of phonological and physical length. Furthermore, many Japanese content words are partially written out in Kanji. The problem of length again surfaces, since one Kanji character does not always represent one mora; words matching the physical length may not necessarily match the number of morae. For instance, iku 'to go,' is written in two characters (one Kanji and one Hiragana), and there are two morae. In contrast, tagayasu 'to plough,' which is also written in two characters (one Kanji and one Hiragana), has four morae.
Due to all these factors, it is necessary to decide by which measure - physical or phonological - the length would be defined if Japanese word length were to be unified. In the current study, physical length was matched. This decision was based on findings by Nakayama (1990), which reports that the number of characters, not morae, had a significant effect on the lexical decision response times when the isolated words were presented on the screen. Following Nakayama (1990), the number of characters were matched in the test stimuli.

4.1.2.3. Use of Characters in Non-words

When creating non-words for the lexical decision task, the choice of characters again plays an important part. Since both Hiragana and Katakana characters are all legal phonological combinations (either V or CV), any non-word composed of those characters will be pronounceable. Thus, it is unlikely that Japanese readers will rule out some strings simply based on phonological information. However, mixing Katakana and Hiragana in the same word may enable subjects to develop a strategy which rules out the non-word based solely on the orthographic information, because

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1 There are clues that may be helpful in detecting non-words, using phonological information. For instance, the extensive use of "Yoo-on" (vowels with a glide in the middle) such as "kya, kyu, kyo," "mya, myu, myo," or "pya, pyu, pyo" may make the non-words easier to reject, simply because of the frequency of the use of those morae in Japanese lexicon. By the same token, words starting with "n" are nonexistent. Therefore, it is possible to utilize those cues in deciding words or non-words. Keep in mind, however, that the words containing "Yoo-on" in Japanese are not frequent. Thus, subjects cannot rely just on the phonological information.
constituents are usually written totally in either Katakana or in Hiragana. Since the use of Katakana is strictly limited to foreign words and onomatopoeias, there are no non-words created using Katakana or a Katakana/Hiragana combination. All the non-words were either all Hiragana or a Kanji/Hiragana combination.

Kanji were also used to create non-words, but special attention was required. Kanji characters are not phonograms but ideograms, which means that each has meaning as well as sound. If a non-word is created using two or more semantically related Kanji characters, subjects may take longer to reject it as a non-word than a non-word created using characters that are unrelated. Thus the combination of *asi*, 'foot,' and *ke*, 'hair,' may take longer to reject than the combination of *asi* 'foot' and *den* 'electricity.' Therefore, whether non-words with related characters should be totally excluded or mixed with unrelated combinations must be decided by the researcher according to the research objectives and the conditions which he/she manipulates.

Also, it is possible to create a non-word by spelling out a word using totally different Kanji. For example, the word *asi*, 'foot,' may be spelled out using a totally irrelevant Kanji character with sound /a/ and the one with /si/. Even though such word is pronounceable as /asi/, it does not mean 'foot.' A study by Wydell et al. (1993) using the categorization task found that the lexical access of Japanese words written in Kanji can be mediated by
phonological information. Thus there is a possibility that non-words created by homophonous Kanji characters do not serve as clear non-word stimuli. In order to avoid such phonological effects on the lexical decision task, this type of non-words were not used in the current experiment.

One of the ways to make non-words difficult to detect is to manipulate where in a constituent Kanji character(s) appear. Since Kanji characters are often used as the stem of a verb, and any inflectional part is spelled out in Hiragana, many Japanese predicates have Kanji first and Hiragana at the end. Case markers and postpositions, which are also written in Hiragana, follow the noun. Thus, when a non-word starts with Kanji and ends with Hiragana, it looks more similar to a real word than a non-word in the reverse order. One of the non-words were created, about 2/3 followed the pattern in which Kanji characters appeared at the beginning of the word and Hiragana followed them. One-third of the non-words followed the opposite pattern. None of the non-words contained Katakana.

4.1.2.4. Pseudo-words

Pseudo-words are generally harder to detect, since they have some physical resemblance to real words due to the use of real morphemes such as suffixes. In the current

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7 One of the few exceptions are cases in which there is a "beautification marker" 0, whose function is to make a certain word more polite than the bare form. It is usually spelled out in Hiragana. In this case, a Hiragana character precedes a Kanji word.

8 No real-word targets which are predominantly written in Katakana were used in Experiment 1.
study, about half of the non-words were pseudo-words and half were absolute non-words. The pseudo-words were created by attaching the morphological markers such as -i (an adjectival ending) or -ta (a perfective tensed verbal ending) to randomly selected clusters of Kanji or Hiragana characters.

4.1.2.5. Targets Using Hangul: Illegal Combination and the Complexity of a Character

Now I turn to issues concerning the Korean alphabet, Hangul. There are two main concerns in using the lexical decision task in Hangul: the illegal combination of phonemes and the complexity of a character.

As mentioned in Chapter 2, Hangul is a phonemic alphabet which combines up to four phonemes in one character (syllable block). The simplest syllable block is CV (a consonant and a vowel). There are combinations of CVC and CVCC as well. Since the physical size of each syllable block remains the same, the portion of the block devoted to each phoneme becomes smaller as the number of letters increases in one syllable. Thus, the verb stem word ilk-(ta), 'to read,' appears more complicated than i-(ta), 'to be,' since the former has four letters in one

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9 The vowels have a morphological marking which represents a 'zero' consonant. Thus, even vowels have the CV combination in orthography.

10 See Appendix D, in which the test sentences are written in actual Hangul characters.
block.\footnote{When a syllable starts with a vowel, a character which represents a zero consonant is added. Thus, the number of characters for ‘to read’ is four, and the one for ‘to be’ is two.}

Unfortunately, there is no study available for the effects of complexity on word recognition in Korean. In the current study, the complexity of the target words was not controlled. Alternatively, familiarity was controlled; a native speaker ensured that the chosen target words were all familiar words which would be used in everyday conversation.\footnote{The target words were chosen by the author, and were then checked for familiarity with a native speaker.}

Prior to the main experiments in both Japanese and Korean, the lexical decision task of those target words in isolation (without syntactic context) was conducted; this was to ensure that there was no difference in recognition times among the groups of target words.\footnote{This will be discussed in detail in 4.2.1.}

4.1.3. Contextual (Semantic/Pragmatic) Effects on the Lexical Decision Task

There are several experiments which report that the lexical decision task is sensitive to pragmatic context effects (Boland, 1993; Fischler and Bloom, 1985; Kleiman, 1980; Schwanenflugel and Shoben, 1985). For instance, Schwanenflugel and Shoben (1985) found that the expected completion words were recognized faster in “high constraint sentences” (sentences which bias the comprehension of the sentence in a particular way), while low constraint
contexts had only a weak effect.

(3) a. John kept his gym clothes in a **locker**
   b. John kept his gym clothes in a **closet**
   c. XXXX XXXX XXX XXX XXXXXXX XX X **locker**
   d. XXXX XXXX XXX XXX XXXXXXX XX X **closet**

The boldfaced words in (3) are the lexical decision targets. The sentence in (3a) is constraining, and the target word is easy to predict; the sentence is about a sports scene, and the target word, "locker," is commonly used as a place to keep one's gym clothes. The word is recognized faster when it is presented after the sentential context than when it is presented after the sequence of X's as in (3d). On the other hand, when the context is highly constraining but the target is unexpected, inhibition effects are observed. The reaction time to the unexpected target in (3b) is slower than when there is no context as in (3d).

The results from Schwanenflugel and Shoben (1985) suggest that the lexical decision task is also sensitive to semantic/pragmatic factors. Since what is of interest in the current study is the syntactic effect on lexical decision, semantically and/or pragmatically highly constraining context must be avoided. The neutrality of the context in the stimuli was ensured by conducting a preliminary off-line completion test, which will be discussed in 4.2.2.

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14 In a cross-modal experiment, however, Boland (1993) found thematic effects on lexical decision in a non-constraining context.
4.1.4. Grammatical Judgment Task

The grammatical decision task is one in which subjects are asked to decide whether a sentence or sentence fragment is grammatical or not. In this study, the response time and the type of response given were measured.

This task is employed because the response times and the accuracy of grammatical decision can also be used to reveal which structure(s) is/are computed. In order for subjects to judge the grammaticality of a given sentence fragment, the computed syntactic structure must be interpreted by the semantic module. Thus, this operation appears to tap a slightly later stage than the ones tapped by lexical decision.

The task of grammatical judgment appears to be sensitive to syntactic effects. Gorrell (1987) found in English that the grammatical decision response times were faster and accuracy was higher in the syntactically preferred structure than in the less-preferred structure. His experiment used an unambiguous simple structure, an ambiguous structure and an unambiguous complex structure as shown below.

(4) a. (unambiguous simple)
   The company was loaned money at low

b. (ambiguous)
   The company loaned money at low

c. (unambiguous complex)
   The company they loaned money at low

The ambiguous structure shown in (4b) can be interpreted as
a fragment of simple structure such as The company loaned money at low rates. Or, it can be a fragment of complex structure such as The company (which was) loaned money at low rates made a big profit this year. The response times and accuracy of the answer in the ambiguous structure patterned with those of unambiguous simple structure. The response times for those two conditions were faster than those for the unambiguous complex structure, and the correct percentage were higher. Gorrell (1987) concluded that in grammatical decision, the subjects' responses were based on the first syntactic structure computed, i.e., the simplest (minimal attachment) structure.

There are some reports suggesting that the grammatical decision task is also sensitive to semantic/pragmatic information. The word-by-word, incremental grammatical decision study by Boland et al. (1990), among others, demonstrated that plausibility affects the grammatical judgment. In Boland et al. (1990), the sentence pairs such as those below were compared.

(5) a. Which horse did the cowboy signal to surrender to the authorities?
   b. Which outlaw did the cowboy signal to surrender to the authorities?

While both sentences in (5) are grammatical, (5a) is implausible pragmatically since signaling to a horse to surrender is unusual in the real world. The judgment of "no (not make sense)" starts to diverge between (5a) and (5b) around to surrender, and continues to diverge until
the end of sentences. While almost 70% of time, condition (5a) was judged as not to make sense, the response in (5b) stayed positive (the sentence does "make sense") (about 80%). This suggests that grammatical decision is sensitive not only to syntactic information but also to semantic/pragmatic information. As in the case of lexical decision, then, it is important to keep pragmatic information as neutral as possible in the experiment using the grammatical decision task.

In this subsection, it was observed that the lexical judgment task is sensitive to both syntactic and semantic/pragmatic processing. The grammatical decision task is shown to be sensitive to semantic/pragmatic effects, as well as to syntactic processing. In the current study, the context was carefully controlled in order to minimize any possible semantic/pragmatic effects. The actual procedure for controlling such effects will be discussed in 4.2.2.

4.1.5. Motivation of Using Two Tasks

In this subsection, the motivation for using two different tasks will be discussed. Both the Japanese and Korean experiments used two tasks: the lexical decision task and the grammatical decision task. This was done in order to capture the processing mechanism more accurately and convincingly than the use of a single task would.

As discussed earlier, grammatical decision taps a slightly later stage of processing, including semantic
processing. Two tasks tapping only the later stages of
processing are not desirable, but two tasks tapping
different stages of processing are particularly useful. If
a language is processed in a serial manner, the response
times and the accuracy for the initial single hypothesized
structure should be faster than complex structures; thus,
the computation of just one structure would be shown. The
results from the grammatical decision should further
confirm the computation of a single structure. Other
grammatical complex structures could be computed by
reanalysis, but a minimal attachment structure should be
judged as grammatical significantly more often and faster
than the complex structures. Thus, the same pattern is
predicted by the serial model in both tasks.

If a language is processed in a parallel manner, two
tasks are necessary to investigate the "ranking" among
alternative structures. Gorrell (1987) found that, in
English, the lexical decision task supported the parallel
model, while the grammatical decision task supported the
serial model. He interpreted these results as two
different stages of processing being tapped by two tasks;
the lexical decision task taps the stage at which multiple
structures are computed, and the grammatical decision task
taps the level at which one structure reached the semantic
analysis by the semantic module. These results support for
the "Ranked Parallel model," in which there is a ranking
among the multiple possible structures. Since tasks
identical to those of Gorrell are used in the current
study, the ranking in the parallel computation can also be detected.

Two tasks tapping two different stages of processing are preferable in case the delay model is correct as well. If there is no syntactic structure computed when there is an ambiguity, the lexical decision task, which taps an earlier stage than grammatical decision, should reflect no difference across conditions, regardless of the preferred/non-preferred nature or the grammaticality of a structure. However, if the subjects are asked to perform the grammatical decision task after the disambiguating point, it should be possible to observe that all the structures are computed, since the parser has received enough information to construct them. Thus the "grammatical" answer should be the same across all the grammatical conditions. Since grammatical decision is sensitive to the complexity of syntactic structures, however, presumably the simplest minimal attachment structure would be computed faster than other possible structures. Thus there should be differences in the response times among the grammatical structures.

4.2. Experiments in Japanese

Now let us discuss the experiments for the current study. Overall, two main experiments and three preliminary tests were conducted in both Japanese and Korean. With a few exceptions, the procedures for each experiment and the
order of experiments are the same in both languages. In this subsection, the entire course of experiments in Japanese is described.

4.2.1. Preliminary Test 1 in Japanese

Prior to Experiment 1, a preliminary test (lexical decision task without syntactic context) was carried out. The task of Experiment 1 is a lexical decision task.

Since the effect on reaction times and accuracy (correct percentage) sought after is syntactic, the difference of response times in recognizing each word at the lexical level or effects of the pragmatic/semantic context information should not be eliminated. In order to confirm that the chosen target words per se do not vary in lexical recognition, a preliminary test examining the lexical decision response times with words in isolation (i.e., without syntactic information) was conducted prior to the main experiment.

The test material for preliminary test 1 had 300 words altogether, half of which were non-words, and half real words. All the target words (all real words) to be used for Experiment 1 were in the preliminary test. This preliminary test included 24 ditransitives (for condition A in Experiment 1), 24 transitives (for condition B), 24 conjunctions (for condition C), and 24 nominative NPs (for condition D). In addition to these, four extra words which satisfied each condition, a total of 16, were included in order to replace some of the target words in case some were
recognized unusually slowly. There were 38 real words as distracters, or fillers. These fillers included adjectives, accusative NPs, dative NPs, and verbs that were not in the main test, in equal ratio. Half of the non-words were absolute non-words. The other half were pseudo-words which had a morphological resemblance to real words such as Case markers or suffixes.

For the preliminary test, eleven subjects from Columbus, Ohio were tested. They were native speakers of Japanese who came to the United States after graduation from high school in Japan. All of them had normal or corrected normal vision (via contact lenses or eye glasses).

The words were presented by HyperCard on a Macintosh SE. The words, which were in Japanese characters, were presented in an individually randomized order. As soon as the subject pressed the tab key, the computer beeped, and the question number appeared. 1666 msec. after the beep, a string of Japanese writing (real or non-word) was presented in a rectangular box in the middle of the screen. The subjects were told that they would see a string of Japanese writing each time they heard a beep. They were instructed to judge whether the writing presented after the beep was a Japanese word or non-word, and to press the “yes” button.

\[ It was not crucial to fix the duration to 1666 msec; it seemed that 1.5 seconds were enough for the subjects to comfortably get ready for the appearance of the next word. The duration of 1666 msec. was chosen because the clock in the Macintosh SE turns once in 16.66 msec. It is simply fixed as such so that the presentation was made within a duration of 100 turns of the clock. \]
for real words, and "no" for non-words, as soon as possible. As soon as the subject pressed the "yes" or "no" button, the next question was automatically triggered, repeating the identical procedure. All subjects saw the words in the same order.

For the analysis of reaction times in the lexical decision, only the correct answers were used. The results of the preliminary test are summarized below.

TABLE 1

Results for preliminary test in Japanese (lexical decision in isolation)

Mean response times and correct percentage

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>time (msec.)</th>
<th>(N)</th>
<th>%correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>584 (305)</td>
<td></td>
<td>99.0</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>601 (296)</td>
<td></td>
<td>98.3</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>615 (304)</td>
<td></td>
<td>98.7</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>597 (292)</td>
<td></td>
<td>97.7</td>
</tr>
</tbody>
</table>

Although words in condition C were judged as real words slightly more slowly than the others, a statistical tool called the Analysis of Variance (hereafter ANOVA) revealed that there was no significant difference in recognition
times across the conditions ($F_1(3,30)=0.25, p<.86$). There was no any significant difference in the % correct either ($F_1(3,30)=0.58, p<.62$). Therefore, all the test words except two (tagayasita, 'to plough,' and baitenin-ga, 'the store clerk'), which had response times over 1000 msec, were used in Experiment 1. The two words responded slow were replaced in Experiment 1 with words nokosita 'left' and tomodati-ga 'friends', whose reactions times were 540 and 531 msec., respectively.

4.2.2. Preliminary test 2 in Japanese: Avoiding Context Effects

As discussed in 4.1.3., the lexical decision task is sensitive to pragmatic as well as syntactic contexts. In the current study, it is the syntactic effects that is expected. Thus, the effects which reflect non-syntactic context information, such as pragmatic information, must be eliminated as much as possible.

The test sentences in Experiments 1 and 2 used ambiguous sentence fragments in Japanese such as the following.

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16 Among the test target words, the response times for two words, tagayasita, 'to plough,' and baitenin-ga, 'the store clerk,' were over 1000 msec. There were some reasons which appeared to cause such late reaction times. For instance, the first word 'to plough' contained one Kanji character representing three morae. Also, the frequency of the word must be low, since the use of that Chinese character is strictly for agricultural terms. The second word involved three Chinese characters, and it is a compound word. These two reasons could have contributed to the long recognition times for each of these words. These two words were not included in the statistical analysis shown in Table 1.
The sequence of the ambiguous string of words was "locative adjunct--nominative NP with an adjective--dative NP--accusative NP with an adjective." After this sentence fragment, subjects performed lexical or grammatical decisions. Since there were three NPs, one locative adjunct, and two modifiers, a considerable amount of semantic/pragmatic information could be incorporated in this stimuli alone. Thus, it was necessary to set this stimuli as neutral as possible.

In order to avoid the context effects, a sentence completion norm was established. In the test, the first three NPs (NP-ga NP-ni NP-o) from the 24 target sentences were embedded in 72 grammatical but incomplete sentence fragments. Ten native speakers of Japanese from Columbus, Ohio were asked to complete (in writing) all the test sentence fragments naturally, using Japanese orthography. They had not participated in any of the other experiments related to the current study.

If a majority of subjects completed a given test sentence fragment using the same word, it was interpreted that the context represented in the sentence was constraining, which made subjects expect certain words over others. Such sentence fragments needed to be changed in order to minimize the context effect on lexical decision.
Target sentences which were completed with the same verb by more than 50 percent of subjects were changed. In four sentences out of 24, more than half of the subjects used the same verb for completion. Those four sentences were changed to more neutral context, and were tested again by another 16 subjects as a follow-up to confirm that the context was not constraining. In the second completion test, only one test sentence (test sentence number 18: appendix A) was judged to be still constraining. Thus, a precaution was necessary in the statistical analysis of lexical decision and the grammatical decision tests in Japanese. The average percentage of subjects completing the actual test sentence fragments in Experiment 1 using the same verb was 29.2%.

4.2.3. Main Experiment 1 (Japanese Lexical Decision)

Experiment 1 uses the lexical decision task in Japanese. As noted earlier, a given target is recognized as a real word faster when the target word fits in the syntactic structure computed by that point. Thus, the lexical decision task appears to be a suitable task for determining which syntactic structure(s) is/are computed at an ambiguous point. It will indicate whether at the

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17 The author's intuition was used in making the sentence fragments more neutral, based on world-knowledge and common sense.
18 The analyses by an ANOVA on Experiment 1 and 2 showed that test sentence 18 did not make any difference in the overall results.
19 The completion was typically by the ditransitive verb, which is the type used in condition A in both experiments in Japanese.
20 This is, of course, assuming that the pragmatic information is carefully controlled in the test stimuli.
initial stage of syntactic computation multiple structures are computed, or only one structure is computed, or no structure is computed until further information becomes available.

In the experiment, the response times of the lexical judgment in the preferred structure (the simplex sentence) were compared to those in the non-preferred structure (the structures with a relative clause or subordinate clause). The following are examples of target sentences in four conditions (A-D) used for the lexical decision experiment.²¹

(7) a. (condition A)
Gakkoo-de kawaii seito-ga sensee-ni oisii school-at cute student-nom teacher-to good kootya-o dasita/.
tea-acc served 'At school, a cute student served good tea to the teacher.'

b. (condition B)
Gakkoo-de kawaii seito-ga sensee-ni [[oisii school-at cute student-nom teacher-to good kootya-o nonda/] (hito]-o syookai-sita).]
tea-acc drank person-acc introduced 'At school, a cute student (introduced) the teacher (the person) who drank the good tea.'

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²¹ The same target sentences were also used as test sentences in Experiment 2 (the grammatical decision task), except that the subjects saw the disambiguating boldfaced words in (7) as part of a sentence fragment.
c. (condition C)

*Gakkoo-de kawaii seito-ga sensee-ni oisii kootya-o school-at cute student-nom teacher-to good tea-acc dakara/
therefore

*'At school, a cute student therefore good tea to the teacher.'

d. (condition D)

Gakkoo-de kawaii seito-ga sensee-ni oisii kootya-o school-at cute student-nom teacher-to good tea-acc onnanohito-ga/ (nonda-to itta).
woman-nom drank comp said

'At school, a cute student (said) to the teacher (that) a woman (drank good tea).'

Across the conditions, the sentence fragment up to the target word is identical; the target word (in boldface) disambiguates the structure.\(^{22}\) Condition A is a case of minimal attachment (Frazier and Fodor, 1978), in which the sequence of three NPs (NP-ga NP-ni NP-o) all belong to the same simplex sentence.\(^{23}\) The structure in condition B is against minimal attachment. While the first two NPs are part of a simplex sentence, the third NP belongs to the relative clause. Condition C was a case of ungrammatical continuation; the three NPs are followed by a conjunction. There is no way to grammatically connect the three NPs with

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\(^{22}\) The portions in the parentheses in conditions B and D are included in order to give examples of what the possible structure could be.

\(^{23}\) Following Gorrell (1987), I assume that the structure which observes minimal attachment is the preferred structure.
the conjunction.

Condition D is another case of nonminimal attachment, just like B. The sentence has a subordinate clause with a scrambled object NP. This condition is added to the conditions because the transitive verb in condition B may be decided as a verb as quickly as ditransitive verbs in condition A because the verb's major syntactic categorical information fits the syntactic "slot," although the argument structure and subcategorization do not. If lexical decision is blind to subcategorization of a target verb, the parser may attach any verb according to minimal attachment. In this case, the verbs in condition B are recognized as fast as the ones in condition A in the lexical decision test, not as a result of parallel structures being computed, but by virtue of simply having [+V] feature. In contrast to condition B, condition D continues the sentence in a less-preferred way like B, but the target is [+N]. Therefore D is exempt from the potential problem that is found in B. The targets in condition D should be judged as a word faster than C only when the less-preferred structure is being computed.

The syntactic category of the word for the lexical decision stays the same in each condition. In the condition A, the words for lexical decision are all ditransitive verbs in the past tense, which take a subject, [^24^]

[^24^]: To be exact, the structure in condition D is more complex than condition B. This is because condition D involves a scrambling of an accusative NP in the subordinate clause, while there is no scrambling and just a relative clause construction in B.
an object, and an indirect object as complements. In condition B, the words for the task are strictly transitive verbs in the past tense. The transitive verbs in condition B may never take NP-ni of any kind as their complements. In condition C, the target words for the lexical decision are conjunctions. In condition D, the words are nominative marked NP (NP-ga), which can be the subjects in subordinate clauses.

Predictions

If the sentences are processed in a serial fashion, only the preferred structure in condition A is computed. The lexical decision response time in condition A should be faster than the rest.

If Japanese is processed in a serial manner, and the lexical integration is blind to the subcategorization, condition B should pattern with A; targets in both A and B should be responded to faster and more accurately than those in conditions C and D.

If the sentences are processed in a parallel manner, the less-preferred structure(s) as well as the preferred structure are computed. Thus, all the lexical decision targets which make grammatical continuation possible (conditions A, B, and D) should be faster than condition C. Whether or not there is a ranking among structures in A, B and D will be examined independently in Experiment 2.
In the delay model, there is no syntactic structure built based only on the information of three NPs. Before the lexical decision target, all four conditions have exactly the same words: a locative adjunct and three NPs. Since no verb has yet appeared to indicate how the three NPs will be mapped in (a) clause(s) at the point of lexical decision, there should be no structure created according to the delay model. Thus, if the sentences are processed in delay fashion, there should be no difference in response times in all four conditions.

Method

Materials. Four forms each of 24 sentences were constructed, as illustrated above (see Appendix A and B for the list of all materials). These sentences were included in a list of 96 sentences. Among those 96, 48 sentences had real word targets and 48 had non-word targets. Of the 48 sentences which had real word targets, 24 were test sentences and 24 were fillers. Among the 24 fillers, 12 sentences had a target which grammatically continued the sentence fragments prior to the presentation of the target. Four of them had a target which started a new clause, and four had a target which completed the clause. The remaining four had a target which did not complete the sentence. Among the 48 sentences which had non-word targets, 16 had pseudo-word targets which had legal morphological markings, 16 had phonetically possible
combinations of Hiragana and Kanji, and 16 had unusual combinations of Hiragana and Kanji. Each group of 16 sentences which had non-words for targets had 6 sentences which were completed right before the target presentation, and ten sentences which were not completed before the presentation of the target.

The number of characters in the target words was unified across all conditions. Among 24 sets of test sentences, 14 had three characters and 10 had four characters. In the lexical decision experiment, about 2/3 of the non-words were either pseudo-words or complete non-words which started off with Kanji and ended with Hiragana. One-third were wholly non-words which had Kanji and Hiragana mixed randomly. There were no non-words created by using Katakana.

For the experiment, 24 sets of test sentences such as those shown in (7), were created. Four lists were made, and each list contained only one of the condition per sentence fragment. Thus, List 1 contained (7a) but not others, and List 2 contained (7b) and not others, etc. Each list contained 24 target sentences, with six sentence fragments per condition. This was to prevent the subjects from seeing the same kind of sentence fragments with different conditions four times.

Katakana was not used in the non-words, despite the fact that it is possible to mix Katakana along with Hiragana and/or Kanji to create non-words. This is because Katakana characters usually spell out one entire word (such as a foreign name or an onomatopoetic expression) and mixing Katakana with Hiragana or Kanji may assist subjects in developing a strategy to rule out the non-word simply by orthography.
Twenty-six sentences (1/4 target sentences which were randomly selected and 1/4 fillers randomly selected) were followed by a wh-question, which asked subjects the content of the previous sentence. The questions were all such that subjects could respond with one word (such as "autumn" or "the park").

Subjects. Forty-six native speakers of Japanese from Columbus, Ohio were paid to participate in the experiment. The ages of the subjects were between 18 and 54. All of the subjects had completed education up to (at least) high school in Japan. They all had normal or corrected vision and they were all naive to the purpose of the experiment. None of them had participated in the preliminary test or the written norm. They had not been told the purpose of the experiment prior to the experiment.

Procedure. The presentation for these conditions is actually up to the boldfaced words and does not continue till the end.

Lists 1, 2, and 4 were each tested by 11 subjects, and list 3 was tested by 13 subjects. The test was presented on a Macintosh SE30, with the Button Box, which sends the response to the clock in the Macintosh in

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26 Of forty-six, two subjects were rejected due to the poor performance in the wh-questions. They missed more than 10 wh-questions out of 26. Other policies regarding the data processing for the statistical analyses are described in detail in the section of the statistical analyses below.
milliseconds. Each time the subject pressed the "go" button, which is located on the right hand corner of the keyboard, the new test sentence started. Each word of the sentence appeared in the center of the screen. Following Gorrell (1987), each word was presented for the duration of 300 msec., and was immediately replaced by the next word. As soon as the last word of the syntactic context disappeared, the lexical decision target word appeared in the upper right corner of the screen. The target word was placed in this location in order to keep the subjects from relating the sentence with the target word. The subjects were given no instructions as to the relationship between the syntactic context and the target word. They were instructed to answer as quickly as possible after the target word appeared.

If the target word was a real word, subjects pressed the button labeled "yes," the rightmost of the five buttons. If the target was not a real word, subjects pressed the leftmost of five buttons, which was labeled "no." For the left-handed subjects the "yes" button was the leftmost of the five buttons, and "no" was the rightmost button.

For answering the wh-questions, which followed 26 sentences, subjects used the keyboard to type by themselves. They were allowed to type the answer either in

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27 The Button Box was custom-made specifically for Macintosh, in order to measure the response time with 1 millisecond accuracy.

28 All the subjects participating Experiments 1 and 2 were right-handed.
Romanized Japanese or in English. These questions were included in order to ensure that subjects paid attention to the content of sentential context, as well as to distract the subjects from the recurring syntactic pattern of target sentences.

Before the test session, a practice session was carried out. The practice session contained 16 sentences, including all the sentence types for the test conditions. If the subject seemed to be having difficulty in the task after the first 16 practice sentences, the identical practice session was repeated. Two people requested to repeat the practice session twice, and were permitted to do so. None of the subjects wished to repeat the practice session more than once. All subjects reported that they were confident after one or two practice session(s).

Results

Prior to the statistical analysis, the following procedure was conducted. Data from subjects who gave more than 10 wrong answers out of 26 wh-questions were eliminated from the statistical analysis because it was not clear whether these subjects were reading the syntactic context accurately. Since the purpose of the current experiment was to observe the syntactic effects on lexical decision, it was important to confirm that subjects were indeed reading the sentence. Eliminating these subjects left 11 subjects for each list. The results from the total
of 44 subjects were analyzed.

For the response times, the times when the subjects answered incorrectly (answered "no" for a real word target) were excluded. The numbers in parentheses indicate the actual N (the number of data points) for response times. The response times which were slower than [the individual subject's mean+2.5 STD] or faster than [the individual subject's mean-2.5 STD] were replaced with those numbers. The significance level throughout the experiments in the current study was .05.

Table 2 presents the mean reaction times and correct percentages for Experiment 1.

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>time(msec.)</th>
<th>% correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>743 (263)</td>
<td>99.6</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>805 (258)</td>
<td>97.7</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>839 (242)</td>
<td>91.7</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>802 (255)</td>
<td>96.6</td>
</tr>
</tbody>
</table>

The four conditions were analyzed by an ANOVA. The analysis revealed that there was a significant difference.
in the response times (\(F_1(3,129)=5.87, p<.001,\)
\(F_2(3,69)=5.00, p<.01\)) across the conditions. The post-hoc Tukey analysis on the response times revealed that conditions B, C, and D were significantly different from A at the .05 level.\(^2\) There was no difference between B, D, and C.

The number of answers across the four conditions were significantly different in by analysis using ANOVA by subjects (\(F_1(3,43)=9.13, p<.001\)) and by items (\(F_2(3,23)=9.80, p<.001\)). The post-hoc Tukey analysis on the correct percentages revealed that condition C was correctly answered significantly less often than conditions A, B, and D. There was no significant difference among conditions A, B and D at 0.05 level.

The main concern in this experiment was how types B and D (the grammatical and yet less-preferred structures) behaved in the experiment. It was expected that conditions B and D would behave like C (the ungrammatical continuation) if only one syntactic structure was computed by the parser. Conditions B and D are grammatical, but if they were not computed, the parser should treat them the same as an ungrammatical condition. The results from the response times show that this is indeed the case. Conditions B and D patterned with C. It is true that the mean response times for conditions B and D fell in between

\(^2\) This post-hoc analysis showed a robust effect in the subject analysis. The post-hoc analysis by item did not show effects as robust as those of the subject analysis. The post-hoc analysis by item revealed that condition A was significantly different from condition C. Nothing else was significant at the p<.05 level.
those for A and C. Therefore there does appear to be a trend that all grammatical conditions were faster than the ungrammatical condition, supporting a parallel model. However, this trend was not statistically supported. As mentioned above, the response times for conditions B and D were significantly slower than A.

The correct percentage of each lexical decision, in contrast, does appear to support a parallel model. Conditions B and D behaved like A, the simplex analysis. This is what is predicted if multiple structures were computed, and it does not seem to be compatible with the results of the response times. Despite their statistical significance, however, the results of the correct responses must be interpreted with caution. Note that the percentages of correct responses in all conditions were high; they were all above 90%. Thus, the correct percentage for condition C was not so poor. The standard deviation for each condition was very small (A=.06, B=.14, C=.28, D=.18), which means that a difference of just several wrong answers out of all answers (N=264) was statistically significant.

Thus far, the response time data support the serial model of processing in Japanese. However, the correct percentage data support the parallel model, although the results must be interpreted cautiously due to the high percentage correct for each condition. The results so far support the view that in Japanese, only the minimal attachment structure is computed initially when the parser
encounters an ambiguous sentence fragment. Now, let us vary the task and further investigate the nature of the processing of Japanese.

4.2.4. Main Experiment 2 (Japanese Grammatical Decision)

In Experiment 2, the grammatical decision task was employed. In this task, subjects were asked to decide whether a sentence or sentence fragment was grammatical or not at a given point. In the current experiment, the subjects were asked about grammaticality immediately after the presentation of the target words. Presumably, if any target word continued the fragment in a way which subjects were not expecting, the subjects would feel that the sentence was ungrammatical.

The test sentences for Experiment 2 are identical to those for Experiment 1. This time, however, the lexical decision target words were incorporated as part of the test sentences. The subjects read the sentence presented in (8) up to the **** symbols. As soon as the **** symbols appeared, they made a grammatical judgment.

(8) a. (condition A)
   Gakkoo-de kawaii seito-ga sensee-ni oisii
   school-at cute student-nom teacher-to good
   kootya-o dasita ****
   tea-acc served

b. (condition B)
   Gakkoo-de kawaii seito-ga sensee-ni oisii
   school-at cute student-nom teacher-to good
kootya-o nonda ****
tea-acc drank
c. (condition C)
*Gakkoo-de kawaii seito-ga sensee-ni oisii kootya-o
school-at cute student-nom teacher-to good tea-acc
dakara ****
therefore
d. (condition D)
Gakkoo-de kawaii seito-ga sensee-ni oisii kootya-o
school-at cute student-nom teacher-to good tea-acc
onnanohito-ga ****
woman-nom

Predictions

If Japanese is processed in a serial fashion, condition A should be judged as "grammatical" more often than condition B and condition D. The same trend should be observed in response times as well. Condition B and condition D should pattern with the ungrammatical structure of condition C in accuracy and response times because subjects should judge condition B and condition D ungrammatical. However, since grammatical judgment taps a slightly later stage than lexical decision, there is a possibility that some early recovery after the reanalysis in complex structure may be tapped. In this case, the complex structure B, which is less complex than condition D, should be judged as grammatical more often than D.
If Japanese is processed in a parallel or delay manner, the results from the lexical decision in Experiment 1 should reflect their predictions. On the contrary, the results from the lexical decision reflected a pattern that was not predicted by either model.

A strict parallel model computes all the grammatical structures with equal weight for an ambiguous fragment, and chooses one structure when disambiguating information becomes available. In the test sentences for grammatical judgment, the last word of the sentence fragment is the disambiguating information. Thus if the strict parallel model is correct, by the time the disambiguating word appears, all the grammatical structures are already computed, and any disambiguating word should be able to be a part of the structure. However, interpretation of a computed structure at the semantic processor requires verb information. Without verb information, as in condition D, the semantic processor must prematurely force interpretation. Thus, even with the strict parallel model, there is a difference among the grammatical conditions. Conditions A and B should pattern in the same way with regard to response times and the percentage of "grammatical" answers. They should be faster and judged grammatical more than condition D. Conditions A, B and D should be judged as grammatical more often and more quickly than the ungrammatical condition C, since interpreting the meaning of an unsuccessfully computed syntactic structure should take longer than any grammatical complex structure.
If there is a ranking among the alternatives, the minimal attachment structure in condition A should be more accurately judged as grammatical than complex structures B and D. This is because condition A, the minimal attachment structure, should be ranked higher than complex structures B and D. Further, between B and D, there may be a difference in response times and "grammatical" answer rate due to the difference in their complexity.\footnote{The prediction by the ranked parallel model here is analogous to the serial model. Thus it is not possible to completely select one model over the other by grammatical decision alone. However, with the results from lexical decision, the selection between the two will be made possible. If there is a ranking among the alternatives, the alternative structures should have been demonstrated by lexical decision. As discussed in 4.2.3., there was no strong indication of parallel computation in Experiment 1.}

In the delay model, the "grammatical" answer rate should be higher than ungrammatical condition, as long as the structure is grammatical. The parser starts computing a structure as soon as enough information is given. As long as the fragments do not violate grammaticality, they all should be recognized as grammatical eventually, although the time needed to compute each type in condition may differ depending on its complexity. Thus, conditions A, B and D should be judged as grammatical more frequently than C. The response times, in contrast, should reflect the time to compute each grammatical structure. Condition A, the minimal attachment structure, should be computed fastest, and thus responded to fastest of all of the grammatical conditions. Among complex structures, condition B is less complex than D. Condition B has a
verb, with subcategorization information. In contrast, condition D ends with another nominative marked argument. Thus, condition B should be computed faster than D. The ungrammatical condition should take longest, if they are computed at all.

Method

**Materials.** There were four forms each of 24 sentences, exactly the same as in Experiment 1. These sentences were included in a list of 83 sentences. The total number of sentences, including both target sentences and fillers, was reduced from 96 (as in Experiment 1) to 83. Since the target-to-filler ratio was still roughly 1/3-1/4, 83 sentences with distracting yes/no content questions were considered to be sufficient to distract subjects so that they would not become aware of the test sentences and develop any strategies. Indeed, an informal discussion with the subjects after the session revealed that they did not notice either the particular patterns occurring repeatedly or the purpose of the experiment.

Among the 83 sentences in one list, 24 sentences were test sentences and 59 were fillers. Of the 24 target sentences, the sentences for condition C (N=6) were

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The number of total sentences was reduced from 96 to 83 in order to shorten the experimental session. The number of test sentences was held constant, but the number of fillers was reduced by 13. It is important to note that no one from Experiment 1 complained of fatigue after his/her session. However, it was judged that a lesser number of sentences was advantageous to subjects, assuming the results obtained would be the same as with more sentences.
ungrammatical. There were 10 ungrammatical sentences in the fillers. These included negative polarity failures, argument structure violations (both in number and type of arguments), and totally incomprehensible strings. Among the grammatical fillers, 9 sentences were incomplete. No punctuation marker was presented in the test material. Most of the filler sentences were taken from Experiment 1, with minor changes for the grammatical decision task. Twenty-eight sentences (including target sentences and fillers) were followed by a yes/no question, asking subjects the content of the previous sentence or simply asking "was there a word X in the previous sentence?" The wh-questions which were employed in Experiment 1 were changed to yes/no questions in order to shorten the time each experiment session took. Since many Japanese subjects had little experience in typing Romanized Japanese or English, the yes/no question seemed to take less time to answer than the wh-questions. The purpose of the yes/no questions was to distract the subjects from detecting any recurrent pattern of test sentences among the fillers, as

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32 Some sentences had to be converted to ungrammatical sentences, and non-word targets were replaced with real word targets.

33 This type of question is not a content question. However, this type of question constituted about one-fourth of the entire questions and it was judged that they were not enough to lead subjects to develop any strategies. Furthermore, memorizing random words is harder than an organized group of words, such as a sentence (Miller, 1956). Thus, even if subjects did attempt to develop a strategy to answer to this particular type of question, they were likely to process the words as a sentence and not as a group of words.

34 On the average, Experiment 1 took 25 minutes, including the instruction and practice session. Experiment 2 took approximately 20 minutes per session.
well as to ensure that subjects did read and pay attention to the content of the syntactic context which preceded the target words.

For the experiment, four lists were created and each subject saw only one list.

Subjects. Forty native speakers of Japanese from Columbus, Ohio, were paid to participate in the experiment. None of them had participated in Experiment 1, nor did they know anything about Experiments 1 and 2. The qualification requirements for the subjects were the same as those in Experiment 1.

Procedure. Each list was tested by 10 subjects. The test materials were presented on a Macintosh SE30 screen. Subjects pressed the "go" button, which was located at the lower right of the keyboard, to start each sentence. The sentences were all presented automatically, word-by-word. Following Frazier (1978) and Gorrell (1987), the words of the test sentences appeared in the center of the screen for 300 msec. Each word replaced the one before it. As soon as the last word of the sentence or sentence fragment disappeared, four asterisks were presented in the center of the screen. The asterisks were to signal the subjects to perform the grammatical decision task for the portion they had just read.

The subjects were instructed to judge whether what they read was grammatical in Japanese, as quickly as
possible. The location of the “yes” and “no” buttons on the Button Box was the same as in Experiment 1. In responding to 28 yes/no questions about the syntactic context, the subjects were asked to type “h” for hai (yes) or “i” for iie (no).

Before the test session, a practice session was carried out. The practice session contained 12 sentences, including all the sentence types for the test conditions. The subjects were offered a chance to repeat the practice session if they were still not comfortable with the task after 12 sentences, but all of the subjects appeared comfortable by the end of the practice session. No one requested to repeat the practice session.

Results

Since all subjects missed less than ten yes/no questions, the scores from all subjects were used in the statistical analysis. Prior to the statistical analysis, the response times which were greater than [the individual mean + 2.5 STD] or less than [the individual mean - 2.5 STD] were replaced with those numbers.

Table 3 presents the mean reaction times and the correct percentage for Experiment 2.
### TABLE 3

Results for Experiment 2 in Japanese (grammatical decision)

Mean response times and correct percentage

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>time(msec.), (N)</th>
<th>%&quot;grammatical&quot; answer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>792 (210)</td>
<td>87.5</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1056 (45)</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1168 (16)</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>1801 (10)</td>
<td>4.2</td>
</tr>
</tbody>
</table>

The analysis by an ANOVA revealed that there was a robust main effect by the conditions ($F_1(3, 117)=290.56$, $p<.0001$, and $F_2(3, 69)=219.87$, $p<.0001$) for the percentage of correct grammatical responses. The post-hoc Tukey analysis revealed that the ratio of "grammatical" answers for condition A is greater than the conditions B, C, and D. Condition B was judged grammatical significantly more often than conditions C and D. There was no significant difference in the ratio of "grammatical" answers between C and D.

For response times, only the reaction times when the subjects answered "grammatical" were considered for analysis, which resulted in an unbalanced sample. The analysis by ANOVA revealed that the difference in the reaction times was statistically significant by item.
analysis and there was a tendency by subject analysis
(F1(3,117)=2.67, p<.06, F2(3,69)=3.11, p<.05). The post-
hoc Tukey analysis by item analysis revealed that the
grammatical decision times of condition D were
significantly slower than those of conditions A, B, and C.
However, the fact that the sample number for condition D
was N=10, while A was 210 must be taken into consideration.
This is highly unbalanced. Highly unbalanced sample sizes
violate the assumptions of both "normality" and
"homogeneity" of variance (cf. Keppel, 1991:283). This
increases the Type I error, i.e., making the rejection of
null hypothesis (H0) easier than usual. Thus, it is easier
to obtain statistically significant results when the cells
are highly unbalanced. There are "no useful rules of thumb
that specify the point at which unequal sizes and variance
heterogeneity become a serious problem" (Keppel, 1991:283).
But the size of condition A is 21 times greater than
condition D, and it appears that the cells are unbalanced
with little doubt. It is important that the statistical
results obtained from such highly unbalanced cells as those
be interpreted most conservatively.

Overall, there was a robust tendency to regard the
less-preferred structures as ungrammatical in Experiment 2.
The results immediately tease out some models. According
to the delay model, A, B, and D should be recognized
"grammatical" higher than ungrammatical condition C. The
response times should have reflected the complexity of
structures. Neither prediction was realized; there was a
big difference between conditions A and B in "grammatical" response rate. Although the cells were unbalanced in statistical analysis, response times showed that condition D was answered even more slowly than ungrammatical condition C. Likewise, the strict parallel model, which predicts no difference in both response times and "grammatical" answers at least between conditions A and B, was not supported by these results. The results are not totally congruent with the ranked parallel either. Against predictions by the ranked parallel model, grammatical condition D patterned with ungrammatical condition C in "grammatical" answer rate, and the tendency of response times was that ungrammatical condition C was faster than condition D.

The results of Experiment 2 in Japanese seem to be the most congruent with predictions by the serial model. Overall, condition A was judged as grammatical predominantly more frequently than other three conditions, by almost 90%. The conditions B-D ranged from 4.2-18.8%. The difference in response times between conditions A and B-D were not supported statistically, but the trend was congruent with the prediction: condition A was responded the fastest. The fact that condition B was judged "grammatical" less than A but more than C and D can be accounted for if it reflects the early reanalyses on some cases. In serial computation, only condition A is computed and other conditions, B-D, are considered to be ungrammatical. However, grammatical decision taps later
stage than lexical decision. Thus the stage tapped is not the earliest stage. Inevitably, there is a possibility that some structures easy to reanalyze can also be reflected in the results in grammatical decision.

The results from grammatical decision appear to be most congruent with serial model. The implications of the combined results in Experiment 2 will be discussed in the next section.

4.3. Conclusions from Main Experiment 1 and 2 in Japanese

In Experiment 1, the lexical decision response times revealed that the complex structures, conditions B and D, patterned with the ungrammatical condition, C. A similar pattern was observed in the grammatical decision task in Experiment 2. Condition A was predominantly judged as grammatical more frequently than conditions B, C, and D. At the same time, however, condition B was judged as grammatical more frequently than were C and D.

The results from Experiment 1 support the contention that only one structure, the minimal attachment structure, was computed at an earlier stage of processing than the one which grammatical decision taps. Furthermore, the results from Experiment 2 showed that minimal structures were computed faster than all the other conditions. Also, it was observed that non-minimal structures (condition B) were computed. The results of the computation of structure in condition B in Experiment 2 are most naturally interpreted
as the effects of early reanalyzed structures.

Even though the results as a whole are congruent with the serial model, it is important to note that some aspects of the datum suggest the parallel model. In the lexical decision error rate, conditions B and D patterned with the simplex structure A. Also, there appeared to be a trend in the lexical decision response times which suggests the parallel computation. That is, response times for conditions B and D fell in between conditions A and D, although the difference was not statistically supported. These results could mean that complex structures B and D were computed along with A, which constitutes evidence for parallel processing in Japanese. Even though the trend in grammatical decision was not totally congruent with strict parallel model, the ranked parallel is a possibility. The strong tendency for the minimal attachment structure, shown in condition A in grammatical decision, is analogous to the findings by Gorrell (1987), which support ranked parallel processing. Needless to say, further investigation is necessary to confirm either the serial or the ranked parallel model.

No strong results were observed in support of the delay model in either of the experiments. The ungrammatical condition C was responded to significantly slower than simplex condition A in the response times in Experiment 1. In the same task, the two complex structures, conditions B and D, patterned with condition C. This clearly shows that a parser does not wait to compute
syntactic structures until the verb appears. On the contrary, the parser starts to compute the simplest structure as soon as three NPs appear, if not earlier.

The fact that condition B patterned with ungrammatical condition C in lexical decision constitutes evidence that verb information, such as subcategorization, is used when the word is integrated into the current syntactic structure.

It is striking that Japanese, the overall syntactic structure of which is so unpredictable at the beginning of a sentence, is parsed serially. As mentioned in Chapter 3, the serial model that is discussed in this study predicts numerous initial misanalyses and consequent reanalyses in Japanese. The possible reason that these numerous reanalyses do not cause processing difficulties or frequent processing breakdowns, as well as modifications to the model, will be discussed in detail in Chapter 5.

4.4. Experiments in Korean

Now let us turn to the discussion of Korean experiments. The experiments in Korean followed almost exactly the same procedure as those in Japanese. Therefore, only the factors which were unique to the Korean experiments will be mentioned.
4.4.1. Preliminary Test 1 in Korean

In order to ensure that the difference of recognition
times in Experiment 1 (the lexical decision test) in Korean
is not due to context effects, a preliminary test was
conducted which examined the target words in isolation.

The procedure for material preparation was identical
to that of Japanese preliminary test 1. The test material
for preliminary test 1 in Korean had 232 words, including
the target words in Experiment 1 and the filler words.
Among the target words, there were 20 ditransitives (for
condition A), 20 transitives (for B), 20 conjunctions (for
C) and 20 nominative Case marked NPs (for D). The reason
that 20 target words per condition were used in the Korean
test, in contrast to 24 in Japanese, is that Korean does
not use the postposition hantey "to" to represent the goal
of the thematic structure of a verb such as 'to buy' or 'to
obtain.' Thus, verbs such as sa-ta, 'to buy,' or ilk-ta,
'to read,' were not used as ditransitive verbs in the
Korean experiments. In contrast, Japanese does allow ni,
'to' or 'for,' to represent a goal or benefactive phrases.
This difference in the nature of their verbs resulted in a
difference in the number of target words in each language.

As for the real word fillers and non-words, the same
ratio as that of the Japanese experiments was used.

The experimental procedures were exactly the same as
those used in preliminary test 1 in Japanese. Eleven
native speakers of Korean from Columbus, Ohio were tested
in the preliminary lexical decision test. The subjects had
had completed high school in Korea. Only one list was used, and all subjects saw the same list.

The table below summarizes the results.

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>time (msec.)</th>
<th>(N)</th>
<th>% correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>777</td>
<td>264</td>
<td></td>
<td>96.6</td>
</tr>
<tr>
<td>B</td>
<td>792</td>
<td>242</td>
<td></td>
<td>98.8</td>
</tr>
<tr>
<td>C</td>
<td>772</td>
<td>253</td>
<td></td>
<td>96.8</td>
</tr>
<tr>
<td>D</td>
<td>739</td>
<td>254</td>
<td></td>
<td>98.5</td>
</tr>
</tbody>
</table>

For the analysis of lexical decision reaction times, only the correct answers were used. The correct percentage was high across conditions, ranging from 96.6% to 98.8%. The results of the ANOVA revealed no significant difference in recognition times across the conditions ($F(3,30)=0.47$, $p<.71$). There was no significant difference in lexical decision answers ($F(3,30)=1.38$, $p<.25$). None of the group of target words used in Experiment 1 was significantly different from the rest when subjects conducted the lexical decision task on them in isolation.
4.4.2. Preliminary Test 2 in Korean

Following the same procedure that was used in the Japanese experiments, a sentence completion norm was established in Korean in order to avoid constraining pragmatic context effects on the lexical decision task. In the test, the first three NPs (NP-i/ka NP-hantey NP-ul/ulu) from the 20 target sentences were embedded in 42 grammatical but incomplete sentence fragments. The sentence fragments were all written in Hangul. Twelve native speakers of Korean from Columbus, Ohio were asked to complete (in writing) all test sentence fragments naturally, using Hangul. All of the subjects were naive to the purpose of the study.

As in Japanese preliminary test 2, if more than 50 percent of the subjects completed a sentence fragment using the same verb, that fragment was interpreted to be too constraining. Those sentence fragments were changed in order to minimize the high constraining context effect. More than half of the subjects used the same verb to complete four particular test sentences. Those four sentence fragments were changed, according to the world-knowledge and common sense of two native speakers of Korean. As a follow-up, the four changed sentence fragments were tested again by ten subjects who were naive to the test to confirm that the new fragments were not constraining. In the second completion test, none of the four fragments were judged to be constraining. The average percentage of subjects completing the test actual sentence
fragments in Experiment 1 using the same verb was 36.0%.

4.4.3. Main Experiment 1 (Korean lexical decision)

Experiment 1 in Korean employed the lexical decision task. The following are target sentences used in the lexical decision experiment in Korean.  

(9) a. (condition A)

Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey school-at cute student-nom teacher-to masii-ssen cha-lul chuwo-ss-tta/. good tea-acc served 'At school, a cute student served good tea to the teacher.'

b. (condition B)

Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey school-at cute student-nom teacher-to [[masii-ssen cha-lul masi-n/] (yoca]-lul good tea-acc drank woman-acc sokay-hae-ss-tta). introduced 'At school, a girl (introduced) to the teacher (the woman) who drank good tea.'

c. (condition C)

*Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey school-at cute student-nom teacher-to

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35 The same target sentences were also used as test sentences in Experiment 2 in Korean (the grammatical decision experiment).
masii-ssen cha-lul kurayse/
good tea-acc therefore
'*At school, a cute girl therefore good tea to the
teacher.'

d.(condition D)
Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey
school-at cute student-nom teacher-to
[masii-ssen cha-lul yoca-ka/
good tea-acc woman-nom
(masi-tta ko] malhae-ss-tta).
drank comp said
'At school, a cute girl (said) to the teacher (that)
a woman (drank) good tea.'

The words in bold face indicate the point at which a
lexical decision was requested. The test sentences were
created with identical criteria to those for the Japanese
test sentences. Thus, (9a) (condition A) is the simplex
sentence, (9b) (condition B) is the relative clause
continuation, (9c) (condition C) is the ungrammatical
continuation, and (9d) (condition D) is the sentential
complement continuation. 36

Predictions

The predictions for Experiment 1 in Korean are
identical to those of Experiment 1 in Japanese.

36 In conditions B and D, the presentation was up to the boldfaced
words. The portions in parentheses were added here in order to give
examples of what a possible structure would be.
Method

Materials. Four forms each of 20 sentences were constructed (see Appendices C and D for a list of all materials). These sentences were included in a list of 83 sentences. The ratio of test sentences to fillers was 1 to 3. Half of the lexical decision targets were real words, and the half were non-word targets. One-third of non-words used in the current experiment were pseudo-words which had real morphemes with nonsensical stems. They followed the legal phonological combinations of Korean. The second one-third of non-words were not pseudo-words, but they followed the legal phonological combinations of Korean. The rest of the non-words were all nonsensical and had illegal phonological combinations. Types of non-words were diversified in such a way as to avoid leading subjects to perform the lexical decision task simply on phonological grounds.

The number of characters (syllable blocks) in the target words was almost unified across all conditions. Among 20 sets of test sentences, 13 had three characters and 3 had four characters. Four sets had four characters for conditions A, B, and D, but the characters in condition C in those sets were only two or three characters. This is because the majority of stems in Korean verbs are two syllables, and the number of characters in the morpheme which follows the stem differs in conditions A and B.
Condition A is a direct, matrix ending verb in the past tense. The morpheme which attaches to the matrix verb in the past tense constitutes at least one full syllable block (tta) to the stem. On the other hand, condition B, which is the relative verb, required the stem to be attached by a consonant -n. Since the morpheme -n does not add another syllable to the verb stem, the verbs in condition B tend to be shorter than the ones in condition A. This is shown below.

(10) *il-ha-ta* "to work"

condition A: *il-hae-sstta*.

'(I/He/She/We/They) worked.'

condition B: *il-han*  'the person who) worked'

Each of the clusters of characters separated by the hyphen shown above corresponds to one syllable block in Hangul. The verb *il-ha-ta*, 'to work,' has three character blocks in condition A, but only two blocks in condition B. In order to unify the length of target words across conditions, then, it was necessary to select verbs which have "long" stems for condition B and verbs with "short" stems for condition A. While the length was matched as closely as possible without resorting to less frequent verbs for condition B, some sets were impossible to unify. Since the effect of less frequent verbs could seriously affect response times, shorter (by one syllable) but more common verbs were used in those four sets.17 The mean lengths

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17 For instance, the verb *pwuswu-ta* 'to break,' which has only two syllables for the stem, was used instead of a verb with a three-mora stem.
measured by the number of syllables were as follows: 3.25 in condition A, 3.05 in condition B, and 3.30 for both conditions C and D.

Twenty-five sentences (including target sentences and fillers) were followed by a yes/no question, asking subjects the content of the previous sentence or simply asking whether there was a word X in the previous sentence. This was to distract subjects so that they would not come up with strategies, as well as to ensure that they read the stimuli.

For the experiment, four lists were created and each subject saw only one list. Each list contained 20 target sentences, five sentences per condition.

Subjects. Forty native speakers of Korean from Columbus, Ohio were paid to participate in the experiment. All of the subjects had completed education up to (at least) high school in Korea. They all had normal or corrected vision and they were all naive to the purpose of the experiment. None of them had participated in the preliminary test or the written norm. They had not been told the purpose of the experiment prior to the experiment.

Procedure. Each list was tested by ten subjects. The test procedure was the same as in Experiment 1 in Japanese, except that the subjects used the Button Box for answering
the yes/no questions.\footnote{Subjects used the Button Box response keys when answering the Yes/No questions in order to speed up the experimental procedure. The reaction times for answering those questions were not measured.} Also, the size of Hangul characters was reduced from 24-point size to 18-point size in this experiment. This was to avoid the effects of “cosmetic” curve in the letter $d$ in the 24-point size. Although the 24-point size was large enough for the subjects to recognize words comfortably, it had one shortcoming; the letter $d$ had a cosmetic curve, which sometimes appeared to be part of the adjacent vowel. The curve changed the appearance of the adjacent vowel from $ey$ to $yey$. Thus, some subjects of preliminary experiment 1, whose character size was 24-point, pointed out that the combination of $d$ and $ey$ in Hangul sometimes appeared to be $dyey$.\footnote{This effect did not appear to affect the analysis of the results of preliminary experiment 1, since only 2 words out of 80 target words had such a problem. In fact, the statistical analysis was the same, even when those two words were excluded.} In the lexical decision test, it was extremely important to rule out such possibility of unintended ambiguity. Since the next smaller size, 18, did not have such a problem, the size in Experiment 1 was changed to 18-point. Prior to Experiment 1, it was confirmed by a native speaker of Korean that the 18-point size was legible in the fast-paced presentation of the current study.

Before the test session, a practice session was carried out. The practice session contained 16 sentences, including all the sentence types for the test conditions. If the subject seemed to be having difficulty in the task
after the first 16 practice sentences, the identical practice session was repeated. Two people requested to repeat the practice session twice. None of the subjects wished or appeared to need to repeat the practice session more than once; they all appeared confident after one or two practice session(s).

Results

Prior to the statistical analysis, the following procedure was conducted. The data from the subjects who gave more than ten wrong answers among 25 yes/no questions was eliminated from the final statistical analysis. Furthermore, the data from the subjects who missed more than 15% in the lexical decision task was not included for the statistical analysis. In total, the scores from seven subjects were excluded from the statistical analysis. Two subjects from each of lists 1 and 3, and one subject each from lists 2 and 4, made more than ten mistakes on the yes/no questions. Among them, two subjects’ scores were poor because they performed a “well-formedness” judgment on the yes/no questions, answering “yes” to all the yes/no questions. Another four subjects missed more than ten yes/no questions for no apparent reasons. Finally, score from one subject was eliminated since he scored 62% in the

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Both of their performances were not different from those of the rest of the subjects in the test trial. Both missed less than ten yes/no questions (3 and 4), and both results were used in the final statistical analysis.
lexical decision test. The scores from these seven subjects were not included in the statistical analysis, since it was not possible to confirm whether they were reading the sentence fragment preceding the target words.\textsuperscript{41}

Consequently, the data from thirty-three subjects was available for statistical analysis by ANOVA: eight subjects each for lists 1-3, and nine for list 4. In order to balance the number of subjects across the lists, one subject (randomly selected) from list 4 was also eliminated. Thus, there were thirty-two subjects in the statistical analysis.

Furthermore, condition B of one test sentence (#27 in the test) had an error.\textsuperscript{42} Thus, test sentence #27 was eliminated across the conditions. Also, the response times when the subjects' answers were wrong were not taken into statistical consideration.

\textsuperscript{41} The high percentage of wrong answers to the yes/no questions seems to be due to the lack of clear instruction on the yes/no questions, rather than the nature of the subjects' processing performance. Prior to the actual test session, subjects read the instruction sheet prior to the practice session. Supplementary oral instruction was also provided at that time. The seven subjects all reported that they understood the instruction. However, some subjects still took the yes/no question to be the grammatical decision in the test session.

After the first twenty subjects were tested, an example of a yes/no question was added to the instruction sheet. From that point on, everyone missed less than 4 questions.

\textsuperscript{42} The target word for test sentence #27, condition B was the relative verb in the past tense of mantul-ta 'to eat.' Ordinarily, the relative past verb has -n after the stem. However, mandul-da is a so-called "r" irregular verb. The final consonant of the stem "l" must be deleted when the past relative verb morpheme -n is attached. The test target word used in the test, following the morphological rule, was mandulun. The correct form should be mandun.
Table 5 presents the mean response times and correct percentages for Experiment 1 in Korean.

<table>
<thead>
<tr>
<th>Condition</th>
<th>time (msec.), (N)</th>
<th>%correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1444 (148)</td>
<td>97.4</td>
</tr>
<tr>
<td>B</td>
<td>1387 (141)</td>
<td>92.8</td>
</tr>
<tr>
<td>C</td>
<td>1260 (147)</td>
<td>96.7</td>
</tr>
<tr>
<td>D</td>
<td>1391 (147)</td>
<td>96.7</td>
</tr>
</tbody>
</table>

The statistical analysis by an ANOVA showed that there were no main effects of sentence type; there was no significant difference observed across conditions A-D in the response times ($F(3,93) = 1.14, p < .33$). No significant difference was observed in the error rate either ($F(3,93) = 1.71, p < .16$).

The delay model predicted that no difference would be observed across the conditions. As shown in (6), the sentence fragments up to the target word were identical across conditions A-D. If Korean subjects wait to hear the verb or further information before computing the syntactic structure, there should have been no difference across
grammatical/ungrammatical or minimal-attachment/non-minimal attachment conditions. Since the lexical decision task presumably taps the initial stage of syntactic computation, it is possible that the results reflect a stage of processing in which no syntactic structure is computed.

Even if the results are congruent with the delay model, however, there are some concerns with the results and they must be interpreted with extreme caution. They are null-results (results which reflect no difference caused by the treatment); therefore there could be possible independent reasons due to which the treatment (sentence types A-D) effects did not show up. It is therefore necessary to consider other possible reasons which could attribute to these results.

One of the possible reasons why the results did not approach significance could be because the statistical power was not enough. There were thirty-two subjects, each giving nineteen test points; thus, there were only 608 data points for all conditions, 152 for each condition. This sample size is smaller than the 264 data points per condition in Experiment 1 in Japanese. Therefore, there is a possibility that the main effects of each sentence type would approach a reliable difference if the number of data points were increased.

However, the "trend" of means appears to be problematic if this account is accepted. If the results did not reach statistical significance because of insufficient statistical power, the trend of means should
have followed one of the predictions of the hypothesis. According to the means of correct response times shown in Table 5, the fastest responses were observed in condition C, followed by condition B. The slowest response times were those for condition A, the minimal attachment condition; the condition of minimal attachment was the slowest of the four, and the ungrammatical condition was the fastest. This trend of means was not predicted by any of three discussed in the current study.

There may be a totally independent reason for the mean trend; the trend shown in the results of Experiment 1 may simply reflect the original difference in recognition times of the target words. However, the preliminary test has already eliminated this possibility. As shown in section 4.4.1., no significant differences were found among the conditions when the lexical decision task was conducted on the target words in isolation. Moreover, the trend of means across the conditions of the preliminary test, shown in Table 4, does not match that of Experiment 1. Therefore, it is unlikely that the results of Experiment 1 reflect the difficulty of recognizing the target words themselves.

There are two possible ways to interpret this trend when there is no significant difference across conditions. One is to take the trend seriously and to consider it as a

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43 In the preliminary test, condition D was the fastest, whereas condition D in Experiment 1 was the second slowest. Condition A, which was the slowest in Experiment 1, was not the slowest in the preliminary experiment; it was the second slowest, and it was almost the same as the third, condition C.
true phenomenon. If the trend had reflected the true phenomenon of manipulated conditions, it should have been close to the trend predicted by one of the hypotheses. This did not happen. Alternatively, it could be argued that the mean trend happened just by "chance," and that there was actually no difference across the conditions. In this case, it does not make sense to interpret the trend seriously. It is true that the Korean response times, approximately 1400 msec on the average, were much longer than the response times in Japanese, which ranged from 750 to 850 msec. Thus, a difference between conditions may appear large, but it does not result in a significant difference. Along with greater response times, the standard deviation in this experiment was substantial, which made the difference among means difficult to detect.

Aside from the trend of means, the fact that the mean response times in Experiment 1 were nearly twice as long as the response times of preliminary test 1 in Korean appears to be problematic. In Japanese, the mean of preliminary test responses was approximately 600 msec., while the lexical decision response times in Experiment 1 were 750-800 msec. Compared with the case in Japanese, the results in Korean seem unusual.

"Of course, means from one experiment cannot be simply compared with those from a totally independent experiment. However, the response times of lexical decision response times in Japanese did not differ from those of English, both ranging around 700 msec. Compared to English or Japanese, the results obtained here in Korean are slower."
A possible reason for such slow response times in Experiment 1 in Korean could be that the size of the Hangul characters was smaller in Experiment 1 than in the preliminary test. In preliminary test 1 in Korean, 24-point size characters were used. The Hangul characters in the 24-point are about 1/2 inch in height and width on a Macintosh SE screen. The 18-point characters used in Experiment 1 in Korean were about 2/5 inch in height. After the test, none of the subjects who participated in Experiment 1 said that the characters were illegible; overall the subjects performed adequately in the yes/no questions, averaging a 24% error rate. It appeared that the subjects comprehended the sentences. However, on a couple of occasions, two subjects leaned momentarily toward the screen to see the target words during the practice session. Although they both answered "yes" when asked whether the characters were legible, the characters could have been too small for measuring on-line processing effect.

In order to confirm that the results did not reflect effects of character size, the experiment was replicated using a larger character size.

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46 In fast-paced presentations as in the current experiment, performed in conjunction with another task (lexical decision), such an average for yes/no question should be satisfactory.

45 Both had normal or corrected vision. One had eye glasses, and the other had normal vision.
4.4.4. Follow-up of Main Experiment 1 (Korean Lexical Decision)

In this follow-up test, the 24-point character size was used. There were no potentially misleading cosmetic curves on any of the consonants this time. The test sentences and targets were identical to those of the original Experiment 1 in Korean, except that five practice sentences were added to the practice session.

Predictions

Predictions for this experiment are identical to those for Experiment 1 in Korean.

Method

Materials. The materials were identical to those for Experiment 1 in Korean, except this time the character size was changed to 24-point, and the number of sentences in the practice session was increased to 16. The practice session was made longer in order to ensure that subjects were truly comfortable with the task before they started the test.

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The manipulation of characters made it possible to eliminate the cosmetic curve which was observed in preliminary test 1. Other devices, such as equipments, were the same as those used in preliminary test 1 and Experiment 1.

The number of practice sentences was increased in order to ensure that subjects were totally comfortable with the lexical decision task by the time they started the test session.
Subjects. Sixteen native speakers of Korean from Columbus, Ohio were paid to participate in the experiment. All of the subjects had completed education up to (at least) high school in Korea. They all had normal or corrected vision and they were all naive to the purpose of the experiment. None of them had participated in the preliminary test 1, Experiment 1 in Korean, or the written norm in preliminary test 2. They were not told the purpose of the experiment prior to the experiment session.

Procedure. The procedure of the experiment is identical to those of Experiment 1 in Korean, except that the test materials were presented in a larger character size than in Experiment 1. This time, 24-point size was used.

Results

Prior to the statistical analysis, the data was treated following the same procedures as in main Experiment 1. The results of the follow-up test are shown in Table 6.
TABLE 6

Results for Experiment 1 in Korean
(lexical decision with syntactic context:
character 24-point size)

Mean response times and correct percentage

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>time(msec.) (N)</th>
<th>%correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1363 (75)</td>
<td>98.7</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1523 (72)</td>
<td>94.7</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>1381 (75)</td>
<td>98.7</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1339 (75)</td>
<td>98.7</td>
<td></td>
</tr>
</tbody>
</table>

The results by an ANOVA showed that there were no main effects of sentence type in the response times (F1(3,45)= 0.76, p<.51). No significant difference was observed in the error rate either (F1(3,45)= 1.32, p<.27). The trend of means this time showed that condition B was the slowest, and condition D was the fastest. Conditions A and C were in between. The mean trend of the follow-up test was, again, not predicted by any of the hypotheses.

Most importantly, the response times in the follow-up test were not shortened despite the fact that the character size was larger than that used for Experiment 1. The results of the t-test for all of the correct response times in Experiment 1 and in the follow-up test confirmed that,
indeed, there was no difference between reaction times in Experiment 1 and the follow-up (t=2.05, p>.05).

The results of the t-test indicate that both tests, using different character sizes, resulted in the same response times. It was clearly demonstrated that character size was not the reason for the null effect in Experiment 1. On the contrary, character size does not seem to have mattered in subjects' performance of the task.

Since there was no significant difference between Experiment 1 and the follow-up test, the data from both experiments was combined in order to lend more power to the statistical analysis. Any effects which were not observed simply due to lack of power in Experiment 1 are more likely to show up in the combined analysis.

Table 7 below shows the means and correct percentages of the data from Experiment 1 and the follow-up test combined.
TABLE 7

Combined Results for lexical decision in Korean (using 18 and 24 point character sizes)

Mean response times and correct percentages

<table>
<thead>
<tr>
<th>Condition</th>
<th>time (msec.) (N)</th>
<th>%correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1408 (211)</td>
<td>97.8</td>
</tr>
<tr>
<td>B</td>
<td>1431 (213)</td>
<td>93.3</td>
</tr>
<tr>
<td>C</td>
<td>1301 (222)</td>
<td>97.4</td>
</tr>
<tr>
<td>D</td>
<td>1374 (222)</td>
<td>97.4</td>
</tr>
</tbody>
</table>

The combined data (48 subjects, N=228 per condition) was analyzed by an ANOVA. Despite the larger data size this time, no significant main effect of response times was observed (F(3,141)=1.31, p<.25, F(3,171)=0.41, p<.74). The correct percentage was not significant either (F(3,141)=2.45, p<.06, F(3,171)=0.47, p<.70).

The results seem to show that there is no difference across the sentence types. Having discussed extra-linguistic reasons for the results, it is tentatively concluded that the results in lexical decision in Korean reflect a true phenomenon of processing Korean. The fact that grammatical conditions, A, B, and D, patterned with ungrammatical condition C is congruent with the prediction which delay model makes.
Needless to say, further experiments will be necessary before one may make an absolute claim the delay model in Korean. Let us now move on to discuss experiments using grammatical decision. Using the second task on the identical material will better aid us to interpret the results of Experiment 1.

4.4.5. Main Experiment 2 (Korean Grammatical Decision)

The task of Experiment 2 in Korean is the grammatical decision task. The test sentences for Experiment 2 are identical to those for Experiment 1, except that the lexical decision target words are part of the sentence. The representative test sentences are shown below.

(11) a. (condition A)

Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey
school-at cute student-nom teacher -to
masii-ssen cha-lul chuwo-ss-tta ****
good tea-acc served
'At school, a cute student served good tea to the teacher.'

b. (condition B)

Hakkyo-eyse yeppun hakseng-i sensayngnim-eykey
school-at cute student-nom teacher -to
masii-ssen cha-lul masi-n ****
good tea-acc drank
c. (condition C)

*Hakkyo-eye yeppun hakseng-i sensayngnim-eykey
school-at cute student-nom teacher -to
masii-ssen cha-lul kurayse ****
good tea-acc therefore

'*At school, a cute girl therefore good tea to the
teacher.'

d. (condition D)

Hakkyo-eye yeppun hakseng-i sensayngnim-eykey
school-at cute student-nom teacher -to
masii-ssen cha-lul yoca-ka ****
good tea-acc woman-nom

Predictions

Predictions are the same as those for Experiment 2 in
Japanese.

Method

Materials. There were four forms with 20 sentences
each. These sentences were included in a list of 83
sentences. The target-to-filler ratio was roughly 1 to 3.
Among the 83 sentences, 20 sentences were test sentences
and 63 were fillers. Of the 20 target sentences, the
sentences for condition C (N=6) were ungrammatical. There
were 13 ungrammatical sentences in the fillers. These
included negative polarity failures, argument structure
violations (both in number and type of arguments), and totally incomprehensible strings. Among the grammatical fillers, 6 sentences were incomplete. Twenty-four sentences (including target sentences and fillers) were followed by a yes/no question. For the experiment, four lists were created and each subject saw only one list.

Subjects. Sixteen native speakers of Korean from Columbus, Ohio were paid to participate in the experiment. They were all naive to the purpose of the experiment. The qualification requirements for the subjects were the same as in Experiment 1. None of the subjects had participated in any of the experiments described previously.

Procedure. Each list was tested by 4 subjects. The procedure followed in this experiment was the same as in Experiment 2 in Japanese, except the subjects used the buttons on the Button Box to answer the yes/no questions, as well as to perform the grammatical decision task.

The practice session prior to the test session contained 11 sentences, including all the sentence types for the test conditions. The subjects were offered a chance to repeat the practice session if they were still not comfortable with the task after 11 sentences, but no one requested to repeat the practice session. All of the subjects appeared comfortable by the end of the practice session.
Results

The table below summarizes the response times the subjects took when they answered correctly, the percentages of correct answers, and the percentages of "yes (grammatical)" answers.

<table>
<thead>
<tr>
<th>Target</th>
<th>Condition</th>
<th>Mean response time (msec.)</th>
<th>Correct percentage</th>
<th>&quot;grammatical&quot; answer percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1161</td>
<td>(72)</td>
<td>90.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>2341</td>
<td>(34)</td>
<td>42.5</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2623</td>
<td>(11)</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2478</td>
<td>(5)</td>
<td>6.3</td>
<td></td>
</tr>
</tbody>
</table>

The rightmost column represents the percentage of "grammatical" responses, in which the subjects judged a sentence fragment grammatical. The response times show how long subjects took to answer "grammatical" to each fragment.

Prior to the final analysis by an ANOVA, the same procedure as in the previous experiments was conducted. ANOVA revealed that there was a robust main effect of the conditions observed in the percentage of correct
grammatical decision responses ($F_1(3,45)=62.18$, $p<.0001$, and $F_2(3,57)=77.83$, $p<.0001$). The post-hoc Tukey analysis revealed that the ratio of "grammatical" answers for condition A was the highest; it was significantly higher than for conditions B, C, and D. The "grammatical" answers for condition B were significantly less than those for condition A, and greater than for conditions C and D. There was no significant difference anywhere else.

For the analysis of response times, only the reaction times when the subjects answered "grammatical" were considered. Due to the high ratio of "ungrammatical" responses for conditions B, C, and D, the sample size for the response times was greatly unbalanced. However, an ANOVA revealed that the difference in response times was statistically significant ($F_1(3,45)=4.63$, $p<.05$, $F_2(3,57)=8.71$, $p<.0001$). The post-hoc Tukey analysis revealed that grammatical decision times for condition C were significantly slower than those for condition A.50

The minimal structure, condition A, was judged "grammatical" more accurately than B at 90% of the time. It is interesting that condition B was judged as "grammatical" nearly half of the time. Condition B was judged grammatical more frequently than condition C or D. Also notice that the trend of mean response times showed that condition A was a more than a full second faster than

50 As mentioned in 4.2.4., the interpretation of statistical analysis with unbalanced cells must be extremely conservative, due to the violations of the assumptions of "normality" and "homogeneity" of variance.
the rest of the conditions, although the differences between condition A and conditions B, D were not statistically supported.

The delay model predicted that all grammatical conditions should be judged grammatical most of the time. The fact that there are differences among the "grammatical" answer rates eliminates the possibility of the delay processing.

Both strict and ranked parallel models are rejected for the same reasons as in Japanese grammatical decision; most of the time the grammatical condition D was not judged grammatical. It was judged grammatical even less frequently than the ungrammatical condition C.

These results are most congruent with the hypothesis by the serial model. Condition A, the minimal attachment structure, was recognized as grammatical most of the time (90%). In contrast, the "grammatical" answer rates for complex structures were in general less than half of the time. In addition, there was a difference between the two complex structures. Condition B was recognized as grammatical more frequently than condition D. This trend can be accounted for if only minimal attachment structure was computed initially for condition B, but some early reanalyses took place, and these were reflected in the "grammatical" answer rate. Notice, when subjects answered "grammatical" to condition B, they took more than twice as long to do so. This can be accounted for if the response times for condition B reflect reanalysis of the initial
incorrect structure.

4.5. Conclusions from Main Experiments in Korean

The results of Experiment 2 in Korean were almost the same as those of Experiment 2 in Japanese. Condition A was judged grammatical more often than other non-minimal attachment structures, and then there was a further difference among the complex structures.

Apparently, the results of Experiment 1 and 2 are in conflict. The results from Experiment 1 were most congruent with the delay model, while those from Experiment 2 were most congruent with the serial model.

If the delay model is correct, there should be no evidence of a computation of structures at the stage which is tapped by lexical decision. The results from Experiment 1 are in accord with this. However, the delay model predicts that in grammatical decision task, in which the disambiguating information is provided at the end of each test sentence, all the grammatical structures should be judged grammatical, although complex structures may take longer to compute. This was not so; there was a significant difference between A and B, as well as between B and C, D.

It is possible to limit the delay until the verb to start computation. Conditions A and B have the verb, and condition D does not. Thus, if the delay lasts until the verb, at least conditions A and B should be judged
grammatical most of the time. However, the difference between conditions A and B rejects this interpretation as well.

If the serial model is correct, the evidence of computing a single structure should be reflected not only in grammatical decision but also in lexical decision. In fact, it is crucial to see the computation of a single structure in lexical decision, since the task taps the initial syntactic computation. As is shown, the results in lexical decision did not show computation of any structure.

The fact that the results of lexical decision in Experiment 1 were a null effect and that the response times were unusually long makes the delay model appear suspicious. In a null effect, there is always a possibility that the phenomenon did not show up due to some independent reasons. At this point, it is not possible to choose one model over the other; however, the support for serial processing appears to be stronger than for delay processing. At any event, the current study is the first to examine the processing model of Korean (and Japanese), and there are no other experimental studies available to which one may relate. The results are preliminary even in the case of Japanese, which seems to have more consistent results than those of Korean. Further study in both languages, including replication and experiments with different tasks and syntactic structures, is necessary.
5.0. Introduction

In this chapter, the implications of the experimental results for the processing of Japanese and Korean will be discussed. Due to the type of experimental sentences used in the current study in both languages, the discussion will center around processing on the local (clause-internal) level. Beyond the local level, the discussion will be based on native intuition. At the same time, possible experiments are proposed for examining the issues raised during the discussion.

In terms of generalizing the results, we must be cautious since the experiments in the current study hardly exhaust all of the issues concerned with the processing of Japanese and Korean. More experiments with varied tasks must be conducted, as well as tests on other types of syntactic structures using the same tasks, before any absolute conclusions can be drawn. What is discussed here, rather, is a descriptive interpretation of the limited data
and their implications.¹


One of the primary concerns in the current study is whether any structure(s) is/are computed at an ambiguous point, and if so, how many structures are computed in Japanese. The test sentences consisted of three NPs (NP-ga NP-ni NP-o), and one locative PP. This is shown below.

(1) gakkoo-de kawaii seito-ga sensee-ni oisii
  school-at cute student-nom teacher-to good
  kootya-o....
  tea-acc

Since Japanese is head-final and it has the phenomena of null arguments and scrambling, the resulting structure of (1) is totally unknown.

In the current study, the results from two experiments in Japanese showed that only one structure (the minimal attachment structure) was computed in an ambiguous string such as (1). This was shown by the fact that the response times of condition A were faster than those of B, C, and D.

¹ Although the overall results in Experiments 1 and 2 in Japanese in the current study were most congruent with a serial model, it is possible that Japanese is not processed in serial at any time. More specifically, it is possible that Japanese is processed in "mixed delay" manner, in which some part of a sentence is processed in serial and some part delay. Or, specific syntactic structures not tested in the current study may always be processed in delay. We cannot totally disregard this possibility. It is necessary to test serial computation using various syntactic structures before one may conclude that Japanese is processed in serial at any time.
in both Experiments 1 and 2. The results suggest that in reading the string of NP-ga NP-ni NP-o, the parser computes a syntactic structure in which all three arguments belong to the same clause.

The fact that conditions B and D did not pattern with A in Experiments 1 and 2 in Japanese is consistent with the serial model, and not with the delay (or head-driven) model. If a Japanese parser waits until the head ("V" in this case) appears, there should have been no difference across conditions A-D. This was clearly not so. The difference in lexical decision response times across the conditions suggests that a syntactic structure is built prior to the appearance of the verb. This is in accord with the serial, full-attachment model proposed by Inoue & Fodor (in press). Although there were some implications for parallel processing in the correct percentage in Experiment 1, the support was not strong.

When we consider the characteristics of the language, it is surprising that Japanese is processed serially. As noted in Inoue & Fodor (in press), a top-down, full-attachment approach is rather risky, since often the initial hypothesis is not correct. In Japanese, not all the arguments prior to the first verb belong to the same clause. There is always a chance that the sentence will turn out to be one which has a relative clause or subordinate clause construction, as in conditions B and D. Since Japanese syntactic characteristics tend to generate numerous ambiguous structures which make processing harder,
one can naturally expect that the parser would be very cautious in its approach.

On the other hand, the top-down, full-attachment approach is not so surprising when we consider the fact that the "reward" of waiting until the head appears may not be so great. Notice that there are numerous ways in which the sentence may unfold even if the parser waits for the verb, the head of a VP. For the sake of simplicity, let us take an example of two NPs with a transitive verb.

(2) a. John-ga ringo-o tabeta.
   John-nom apple-acc ate
   'John ate an apple.'

   b. [[John-ga ringo-o tabeta] ato], Mary-ga kita.
      John-nom apple-acc ate after Mary-nom came
      'After John ate an apple, Mary came.'

   c. John\textsubscript{i}-ga [[EC\textsubscript{i} ringo-o tabeta]hito\textsubscript{i}]-o mita.
      John-nom apple-acc ate person-acc saw
      'John saw the person who ate an apple.'

   d. John\textsubscript{i}-ga [[EC\textsubscript{i} ringo-o tabeta]to] itta.
      John-nom apple-acc ate comp said
      'John said that he ate an apple.'

Certainly, the verb narrows down the analysis a little; if the first verb is an intransitive verb, then the first NPs (NP-ga NP-o) are most likely not in the same clause as the verb. However, if the subcategorization of a verb is compatible with the first two NPs, then the parser still cannot be sure whether or not the NPs belong to the same clause. Furthermore, Japanese verbs do not have
morphological markings to indicate whether the verb is from an adjunct clause, a relative clause, or a matrix clause as in Korean. Thus, the complexity of the sentence -- whether or not the sentence contains subordinate or relative clauses -- is not known even when the verb appears. In other words, waiting for the verb in Japanese is not so rewarding in terms of receiving information for processing. It appears, then, that a Japanese parser makes the best judgment regarding the structure, utilizing information it receives prior to the appearance of the verb as much as possible. In the next subsection, the discussion will focus on types of information other than the verb which can be utilized by the parser in the initial hypothesis in Japanese.

5.1.1. Information from Case marking

One of the prime candidates of information used is the one given by Case markers. Recall that the test sentences had three arguments marked by ga, ni, and o. This is the canonical order, which fits the minimal attachment structure. The results of how condition D behaved in both experiments suggest that a parser must utilize the Case information on-line. Recall that in condition D, there were four arguments, each marked by ga, ni, o, and ga, respectively. An example of condition D is shown below.

(3) Gakkoo-de kawaii seito-ga sensee-ni
    school-at cute student-nom teacher-to
There is no verb in Japanese which takes two nominative NPs, an accusative NP, and a dative NP as arguments. The only way for the sentence to continue grammatically is to place the four arguments in more than one clause. The prime candidate is perhaps grouping the first two arguments together, since sensee-ni can be interpreted as the subcategorization of the verb that takes a clausal complement, as in (4a) below. The other possibility, although the preference is less prominent, is the case in which there is a clause boundary immediately after NP-ga, as in (4b).

(4) a. \(\text{IP Kawaii seito-ga } \text{sensee-ni} \)
   \(\text{cute student-nom teacher-to} \)
   \(\text{[CP oisii kootya-o zyosei-ga mottekita-to]itta}. \)
   \(\text{good tea-acc woman-acc brought-comp said} \)
   'A cute girl said to the teacher that the lady brought good tea.'

b. \(\text{IP Kawaii seito-ga [CP sensee-ni} \)
   \(\text{cute student-nom teacher-to} \)
   \(\text{oisii kootya-o zyosei-ga mottekita-to]itta}. \)
   \(\text{good tea-acc woman-acc brought-comp said} \)
   'A cute girl said that the lady brought good tea to the teacher.'

In this way, more information as to the placement of the initial three arguments (NP-ga NP-ni NP-o) will be given if the parser is cautious and waits until enough information
becomes available. If the parser waits until the appearance of the verb, there should be no increased processing cost at the fourth argument, NP-ga. This is because the parser is still waiting at this point. The results showed that this strategy was not employed; the fact that the second nominative NP, zyosei-ga, was recognized more slowly than condition A in the lexical decision test, and that condition D was judged ungrammatical 95.8% of the time in the grammatical decision test, strongly suggests that the first three arguments had been attached in one clause by the time the target word zyosei-ga appeared.

The claim that Case information is utilized in processing of Japanese is not new; A. Inoue (1991) proposed the use of Case information in his models (both the partial-delay and the information-paced model). The question now is how it is used. I propose here that Case information places each argument into an appropriate position in the structure on-line, and furthermore, that the parser is sensitive to canonical order. If the NPs appear in canonical order, the parser attaches them in a single clause of up to three arguments, top-down. Thus, NP-ga is attached as a subject, NP-ni as an indirect object, and NP-o as an object, regardless of the verb that follows them.

Canonical order is used not only clause-internally, but appears to extend its influence beyond a single clause. There seems to be a difference between the reading of (5a)
and its non-scrambled counterpart, (5b).

(5) a. Gakkoo-de kawaii seito-ga sensee-ni
school-at cute student-nom teacher-to
[[oisii kootya-o zyosei-ga nonda-to] itta].
good tea-acc woman-acc drank-comp said

b. Gakkoo-de kawaii seito-ga sensee-ni
school-at cute student-nom teacher-to
[[zyosei-ga oisii kootya-o nonda-to] itta].
woman-acc good tea-acc drank-comp said

‘At school, a cute student told the teacher that a
woman drank good tea.’

Both sentences refer to the same event. The only
difference is that the subordinate clause has a scrambled
object in (5a), while (5b) keeps the canonical order inside
the subordinate clause as well. While a considerably
increased processing cost appears to be associated with
zyosei-ga in (5a), the processing cost associated with
zyosei-ga in (5b) appears to be not as great. One of the
possible reasons for this is that the order in (5b) is
still a canonical order. NP-ga NP-ni NP-ga is a typical
order when there is a subordinate clause. On the other
hand, the order NP-ga NP-ni NP-o NP-ga is not the canonical
order of the subordinate clause. Rather, the first three
NPs are interpreted as a simplex clause, and a surprise
comes when the second NP-ga appears.

As a future project, the claim for dependency of the
canonical Case marking can be confirmed experimentally by
the lexical decision task (or a self-paced reading task).
Assuming that everything else is equal, such as the length and frequency of the target words, the response times of the lexical decision task (or reading times) at zyosei-ga in (5a) should be faster than at kootya-o in (5b). Or, one may obtain results of longer reading times and more frequent regressions by observing eye-movements in (5a), especially around zyosei-ga.

It is intriguing that canonical case marking plays such a major role in the on-line processing of Japanese, despite the fact that Japanese has a relatively free word-order. One would expect that the parser would be less sensitive to the order of the NPs, and that it could process non-canonical NPs fairly easily. Contrary to this speculation, the results suggest that canonical Case information plays an important role. Consequently, it is predicted that sentences with non-canonical order, especially those which leads to the wrong structure, are
harder to process than canonically marked sentences.\textsuperscript{2,3}

5.1.2. Null arguments

So far, we have discussed the processing of a sentence in Japanese in which arguments are all overtly present. As noted in Chapter 3, Japanese has null arguments as well as overt ones. The processing of a sentence with null argument(s) is more complicated than that of a sentence with all arguments present. This is partially because a sentence with null argument(s) often involves more than one interpretation, and it is sometimes globally ambiguous. Thus it is necessary to control the structure of a test sentence and its interpretation carefully. Moreover, null arguments are often null pronouns, which require referents in context. Without careful control of context, difficulty in processing may reflect the parser's trouble of finding the referent.

\textsuperscript{2} Scrambling is accompanied by an increased focus on the fronted NP. There is no doubt that context plays an important role in processing scrambled sentences. In experiments on scrambling, one must test the sentences both with the proper context and without any context to eliminate factors based on the context effect.

\textsuperscript{3} Although it is not identical to the use of Case information, the NP marked by \textit{wa} (a topic marker) must play an important role in Japanese. M. Inoue (1991) compared eye-movements in reading the relative clause with NP-\textit{wa} and NP-\textit{ga} as subjects. The results suggested that \textit{wa}-marked NPs were processed differently from \textit{ga}-marked NPs.

It is said that the mechanism of conveying information in these languages is heavily dependent on the discourse, and topic construction is, of course, deeply related to it (e.g. Huang, 1984). In the investigation of topic phrase in processing, however, one must carefully distinguish the syntactic effects from the post-syntactic (such as semantic) effects, since the topic construction is greatly related to semantic processing.
Despite these possible complications, whether or not null arguments aid the processing of Japanese is a question of interest. An experiment in Yamashita (1994) gives evidence in support of the hypothesis that null arguments, as well as overt ones, contribute to the processing of Japanese. In Yamashita (1994), three types of relative clauses were compared in a self-paced, word-by-word reading task. While one structure (the "Regular relative" construction) had one argument missing in the relative clause, the other two ("PP relative" and "Gapless relative" constructions) did not. The sentences are shown below.

(6) a. (Regular relative)

[(Yuumee-na haiyuu-ga nessinni
famous actor-nom ardently
kooen-de ECiotta] syasinj]-ga
park-at took photo-nom
saikin tyuumoku-sareta.
recently attention-was paid
'The photos that the famous actor took at the park attracted attention recently.'

b. (Gapless relative)

[(Yuumee-na haiyuu-ga nessinni
famous actor-nom ardently
syasin-o totta] sakuhinsyuul-ga
photo-acc took collection-nom

For a detailed description of these three complex NP constructions, see Chapter 3.
In a self-paced reading task with word-by-word presentation, subjects saw both a nominative NP (haiyuu-ga) and accusative NP (syasin-o) in the PP relative and Gapless relative constructions. In contrast, the Regular relative construction had only one argument: a nominative NP. In the experiment, the reading times of the head NP in the Regular relative construction were significantly slower than those in the PP relative and Gapless relative constructions. From this, Yamashita concluded that the parser was aware that one argument (an accusative NP) was missing when the verb in the relative clause appeared in an Regular relative structure, and it therefore committed "less" to the simplex clause analysis. This was not so with other relative constructions; since the parser saw both NPs, which were good candidates for the arguments of
the verb in the relative clause, it committed to a simplex analysis. Thus, the subjects were surprised when they saw the head NP appear in Adjunct and Pragmatic relative constructions.\footnote{This is not to say that there is no processing cost associated with the head NP in the Argument relative construction. Since it is a non-minimal structure, some extra processing cost compared to the simplex structure is associated with Argument relative constructions as well. The results of the experiment in Yamashita (1994) demonstrated that the cost of processing the head NP in Argument relative constructions must be less than in the other two.}

The results in Yamashita (1994) support the hypothesis that the Japanese parser is aware of null arguments as well as overt arguments. The information from null arguments is also used in the on-line processing. This does not mean that the parser postulates null arguments indiscriminately, wherever they are possible. Such a strategy would not be efficient. However, in an environment in which a null argument is very likely to be motivated (such as the one shown in the Argument relative construction), the parser postulates null arguments. It appears that the general preference in processing Japanese is not to posit null arguments, and positing null arguments occurs only as a last resort.
5.2. "Global" Top-down and "Local" Top-down Processing, and the Notion of a Matrix Clause

The term "top-down" in syntactic processing has various definitions. One refers to the global organization of an entire sentence, in which the first NP is attached to the matrix clause as a subject (Kimball, 1973). The other definition is local, and refers to processing within a clause. In particular, it refers to a computation in which the first NP is attached to the subject position of a clause (not necessarily a matrix clause), and the VP is created before all the elements in the projection appear. In the previous section, we suggested that the experimental results support the hypothesis that locally Japanese is processed top-down. Although the experimental results in the current study do not offer evidence whether or not global processing also occurs in top-down fashion, let us discuss two existing hypotheses.

Just how and when the matrix clause is recognized is an interesting issue in a left-branching language like Japanese. This is because unlike English, whose initial NP is most likely the subject of a matrix clause, the relationship between the initial NP and the structure as a whole is obscure at the beginning of a Japanese sentence. As discussed in Chapter 3, the first word in a sentence in Japanese could belong to the most deeply embedded clause.

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As in Chapter 3, "top-down" processing here strictly refers to syntactic processing, rather than to the various levels of processing modules.
Such an example is repeated below.

(7) \[ \text{[EC}_i \ [EC}_j \ [\text{Taroo-ga EC}_k \ \text{katte iru} \ \text{inu}_k\text{-ni}] \]

\text{Taro-nom \ keeps \ dog-by}

\text{oikakerareta \ kodomo}_j\text{-o dakiageta \ otoko}_i\text{-ga koronda.}

was chased \ \text{child-acc \ lifted up \ man \ -nom fell}

'The man who lifted up the child who was chased by the
dog Taro keeps fell.'

The first word Taroo-ga is not the subject of a matrix clause but instead belongs to the most deeply embedded relative clause. Thus, a model which hypothesizes the first clause as the matrix clause risks numerous initial misanalyses. In order to accommodate the left-branching characteristics of Japanese, Mazuka & Lust (1990) propose the bottom-up processing model in Japanese, as discussed in Chapter 3. They propose that globally, the computation of the lowest (the most deeply embedded) clause is completed before the higher clause in a left-branching language like Japanese. The syntactic tree is therefore built from the lower portion of the entire syntactic structure upward. This also entails that a Japanese parser delays the decision regarding which clause is the matrix clause.

In contrast, the approach taken by Inoue & Fodor (in press) is that the parser immediately decides that the first clause is the matrix clause (the clause which has a "[+ROOT]" feature). When the parser encounters the higher clause, the previous clause which was originally hypothesized to be the matrix clause changes its status to the subordinate clause. In this way, the global tree is
built from the top and pushed downward. Inoue & Fodor claim that this process of changing the status of a clause involves only one feature change (from [+ROOT] to [-ROOT]) each time, and is therefore not costly.

This is an empirical question which is difficult to test. The proposal by Inoue & Fodor is attractive in the sense that it is applicable to both English and Japanese; in both types of language, the parser starts out from the matrix clause, and changes that status only when necessary. However, it is necessary to demonstrate independently that the feature change is not very costly. The proposal by Mazuka & Lust must make explicit when the arguments expelled from the lower clause are built in the higher clause. In their proposal, arguments expelled from the lowest clause will not be attached into the higher clause immediately, since the next verb, which provides the information for the next higher clause, is not present at that point. Therefore those orphaned arguments must be kept in a buffer, which will induce some memory load. In order to prevent memory overload, it is necessary to limit the amount of information kept in the buffer and the duration of maintenance.


Although it is too early to conclude that Japanese is indeed processed serially based on the results of
experiments in the current study alone, let us take the discussion of serial processing in Japanese one step further. If Japanese is indeed processed serially, then numerous reanalyses are inevitable, as predicted in Chapter 3. This is because approximately half of Japanese sentences (in a written text) are non-simplex sentences, i.e., sentences including relative clause(s) or subordinate clause(s), most of which can be ambiguous. The original assumption in the classic serial model discussed in Chapter 2 is that reanalysis in a serial model is very costly. Thus, serial parsing predicts difficulty in a left-branching language.

Inoue & Fodor (in press) challenge this assumption of costly reanalysis and propose that Japanese reanalysis is cost-free. This certainly accords with the intuition that the processing of Japanese is no more difficult than that of English or any other language.

The results of Experiment 2 in Japanese demonstrate, however, that Japanese reanalysis is not quite cost-free. Recall that the grammatical decision task taps slightly off-line processing. Thus, if a reanalysis is cost-free and immediate, there is certainly more than a chance that condition B would have been judged grammatical. The fact is that over 80% of the time the sentence fragments in condition B were judged ungrammatical. Furthermore, when the subjects indeed responded "grammatical" for condition

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See Chapter 3 for the detailed discussion of the simplex/complex sentence ratio in Japanese written texts.
B, the response took almost 1.4 times longer than the responses in condition A. One of the possible accounts for these results is that at least 300 msec after the presentation of the verb (or even longer), the parsers had not recovered from the initial incorrect analysis. This is not in accord with the claim that reanalysis in Japanese is cost-free.

Let us take a closer look at the sentence in condition B. If we continue the sentence fragment after the grammatical decision, one of the possible preferred structures of an entire sentence will be as follows.

(8) Gakkoo-de kawaii seito-ga sensee-ni [[oisii school-at cute student-nom teacher-to good kootya-o nonda] hito]-o syookai-sita.

tea-acc drank person-acc introduced

'At school, a cute student introduced to the teacher the person who drank the good tea.'

Until it reaches the verb nonda in the relative clause, the parser places the three arguments, seito-ga, sensee-ni, and kootya-o, in the same clause. When the verb nonda appears, the parser decides that at least two arguments, the nominative NP seito-ga and dative NP sensee-ni, must belong to the higher clause. This is because the verb nonda is a strict transitive verb which does not take a dative NP. At the same time, the parser identifies the complex NP oisii kootya-o nonda hito as an accusative marked NP, which can be a co-argument with the two NPs which were expelled. When the verb syookai-sita appears and the parser sees that
the clause ends there, it confirms that all arguments belong to that verb.

It is true that the first reanalysis at nonda does not appear severe enough to cause a processing breakdown. Although the results of experiments confirmed that such a sentence as in (8) is not as easily processed as the simplex sentences, the interpretation is obtainable without an extreme difficulty.

This relatively effortless reanalysis represents a typical mystery of Japanese processing, and there seem to be two factors which account for it. One of them is that attachment in Japanese is not as committed as that of English. Recall that in Japanese, due to the head-finality and SOV word-order, there is no verb to give information regarding the subcategorization until all the possible arguments appear. Yet, we have observed in Experiment 1 that all three arguments are already attached prior to the appearance of the verb. The attachment of arguments in Japanese must, then, simply be a strategy which is not warranted by information from a verb. As soon as the sentence starts, the parser starts to attach arguments using the Case information. This is presumably because such an operation is more effective than keeping arguments in a buffer or computing all possible structures. Then, the computed structure receives certain confirmation when the verb appears. Attachment made prior to the verb is therefore somewhat tentative, and the commitment of the parser to the structure is not as serious. The
characteristics of Japanese processing can be summarized as follows.

(9) Japanese: Attachment --> Confirmation

Further, the confirmation the parser receives by the verb information in Japanese does not always eliminate other possible structures. As shown below, sometimes the reanalysis is triggered by a word which appears later than verb, such as a head NP of a relative clause.

(10) Bob-ga [[Mary-ni ringo-o ageta] kodomo]-o...

Bob-nom Mary-to apple-acc gave child -acc

Thus, waiting until only the next verb does not always guarantee the disambiguation of structure. Even though Japanese parser attaches arguments as they appear, it cannot be absolutely confident with the current analysis, and it must remain flexible to accommodate the later change. The flexibility or lesser commitment to the current structure in on-line processing leads to the relative ease of processing Japanese, despite numerous reanalyses.

In contrast, English has the verb prior to its complement(s). If English is processed serially, it is possible to hypothesize and project the entire VP as soon as the verb appears. Excepting the subject and a few other cases, attachment in English takes place after the projection is hypothesized. The characteristics of English processing can be summarized as below.

(11) English: Projection --> Attachment

Take, for instance, the classic garden-path sentence
The horse raced past the barn fell. At raced, the matrix VP is hypothesized and projected, and the following items are attached, almost as if they confirm the hypothesized projection. The shock native speakers receive from fell in this sentence demonstrates how much the parser had been committed to the previous structure.

The proposal that Japanese parser commits less to the current structure than the one in English is not new; the "information-paced" model proposed by A. Inoue (1991) and Inoue & Fodor (in press) takes this approach. It also resembles the "Tentative Attachment Strategy" proposed by Mazuka and Itoh (in press) in the sense that the decisions parser makes are tentative.

The proposed model here diverges from the one by Mazuka & Itoh (in press) in the sense that the current model claims that the tentative nature of attachment in Japanese does not last until the sentence ends. Rather, the parser must sometimes commit to the structure prior to the end of a sentence. Let us elaborate this point.

It seems that the duration of ambiguity is the second factor to account for the relatively effortless reanalysis

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There are other accounts for this phenomenon, although this account is not incompatible with all of them. See Frazier & Fodor (1978), Pritchett (1988), among others.

The "Tentative Attachment Strategy" is as follows.

In Japanese, a parsing decision is tentative until the sentence is finished. By tentative we mean that reanalysis of each decision will have a psychologically measurable cost (i.e., it is not cost-free), but any single reanalysis will not be costly enough to cause conscious processing difficulty. When reanalysis is combined with other complexities, e.g., lexical ambiguities, multiple reanalyses, pragmatic naturalness, etc., it becomes increasingly costly to the extent that it becomes conscious. (Mazuka & Itoh, in press)
of Japanese. Recall that in (8), shortly after the two arguments are expelled, the verb *syookai-sita*, which is a prime candidate to be the verb which will classify the two arguments, appears. This type of reanalysis is quite common in Japanese, due to the word-order and branching direction. Since the verb is at the end of a clause, and each clause is closed before the higher clause is closed, the reanalysis motivated by thematic structure of the verb usually occurs on a clause level. In this sense, Japanese reanalysis is "small" and "frequent." However, there seems to be a limit to how long the parser can stay flexible; compare the sentence below with (8); the sentence below is more difficult.

(12) John-ga Mary-ni ringo-o tabeta kodomo-o
    John-nom Mary-to apple-acc ate child-acc
    syookai-sita hito-o mikaketa.
    introduced person-saw
    ‘John saw the person who introduced to Mary the child who ate an apple.’

This is a so-called "center-embedded" sentence, in which the most deeply embedded relative clause is placed in the middle of the sentence. It has been demonstrated that this type of sentence in Japanese is harder to process than the left-branching structure (Abe, et al., 1988; Mazuka et al., 1989). The difficulty in (12) cannot be because of the degree of embedding. Sentence (7), repeated here as (13), is triply embedded, but it is not center-embedded. The sentence is not as difficult as (12).
(13) \[[EC_i \quad [EC_j \quad [[Taro-ga \quad EC_k \quad katte \quad iru \quad] \quad inu_k \quad -ni] \quad[Taro-nom \quad keeps \quad dog-by \quad oikakerareta] \quad kodomo_j \quad -o \quad dakiageta] \quad otoko_i \quad -ga \quad koronda. \quad was \quad chased \quad child-acc \quad lifted \quad up \quad man \quad -nom \quad fell \quad 'The \quad man \quad who \quad lifted \quad up \quad the \quad child \quad who \quad was \quad chased \quad by \quad the \quad dog \quad Taro \quad keeps \quad fell.'

Intuitively, a sense of increased processing load can be detected somewhere around the second head NP, hito-o in (12). It almost feels as if we do not know how to incorporate hito-o with the previously computed structure. This can be accounted for in the following way. Assuming the serial computation, the parser reanalyzes the simplex structure at tabeta by expelling the two arguments John-ga and Mary-ni. These two NPs need to be attached as soon as possible, due to memory constraint. Thus, when the higher verb syookai-sita appears, the parser judges that the two NPs are classified as arguments of the verb. After the parser has committed to the structure, the next word, hito-o, signals that the previous clause is a relative clause, and moreover, that one of the arguments must belong to a higher clause. This process appears to be difficult. The increased processing load may be measured by reading times in the vicinity of hito-o or by eye-movements.

It is interesting that the first reanalysis at kodomo-o is relatively easy but the second reanalysis at hito-o is clearly harder. It may be that, once expelled from the current clause, arguments may act similarly to a wh-phrase, finding the verb which subcategorizes them. The
parser takes an approach somewhat similar to the "Most Recent Filler" principle (Frazier, et al. 1983), in the sense that it attempts to put the expelled arguments into an immediately higher clause. Once successful in putting them into one higher clause, the parser may send the structure to a higher stage. The reanalysis at *hito-o* in (12) comes after the structure is sent to the higher stage, and is therefore harder to reanalyze this time.

The comparison of (8) and (12) suggests that Japanese has two types of reanalysis. One is on the local clause level, which is initiated mainly by the appearance of the verb or the head NP; the other is long-distance reanalysis, which takes place after the previous analysis has been sent to a higher level of processing, as in the case of (12). This idea of two levels of processing is not new; it is proposed as the two-staged model, "the sausage machine," by Frazier & Fodor (1978). According to this model, reanalysis becomes harder after the parser has sent the previous structure to the higher processor. The different processing cost in Japanese can be accounted for if local level reanalysis takes place prior to the point at which the parser sends the analysis to the second stage.

That Japanese parser experiences difficulty in such a long-distance reanalysis seems plausible, since sending a computed structure to the higher processor to semantic information is only natural in terms of memory limitation. Even if Japanese parser commits less to current structure and stays flexible to a degree, it must go ahead and send
it to the next processor within a reasonable length of words, for the sake of memory limitation.

In sum, the incorrect initial hypothesis must be reanalyzed in Japanese, and the operation of reanalysis is associated with an extra processing cost. When reanalysis occurs at the local level, its cost is small. When reanalysis involves a long-distant clause which has already been sent to the second stage, a heavy processing cost appears to be involved.

5.4. The Processing Model of Korean

Now let us discuss the processing model of Korean. As discussed in Chapter 4, the lexical decision task in Experiment 1 in Korean had a null effect. Furthermore, there is a concern of extraordinarily longer response times of lexical decision in Experiment 1 compared to preliminary experiment 1. Therefore, the results of Experiment 1 alone cannot constitute conclusive evidence in support of the delay model. The results of Experiment 2 in Korean were most congruent with the serial model.

The delay model does not seem unreasonable when we take into consideration the advantage in waiting until the verb. The verbs in Korean provide the parser with information as to the status (matrix or subordinate/relative clause) of the current phrase. This is shown below.
At school, a cute student gave good tea to the teacher.

At school, a cute student saw the lady who gave good tea to the teacher.

The verb chwuo-ss-ta in (14a) unambiguously marks the ending of a simplex construction. In contrast, the verb chwu-n in (14b) shows that there is a relative clause construction. The identical structures in Japanese have ambiguity between the simplex and relative clause construction until the word next to the verb appears. In other words, the amount of disambiguating information which becomes available by waiting until the verb is certainly more in Korean than in Japanese. In this sense, a limited delay model until the verb is not an unreasonable model for Korean.

It is important to note, however, that waiting for a verb does not always disambiguate a structure in Korean. When the verb in the relative clause is compatible with the dative marked NP, such as a ditransitive verb like chwu-ta 'to give,' it is possible to "give" good tea "to the
teacher." Compare the next two examples with (14b).

(15) a. [[Hakkyo-ese yeppun hakseng-i sensayngnim-eykey school-at cute student-nom teacher -to masii-ssen cha-lul chwu-n] hwue].... good tea-acc gave after

'After the cute student gave the teacher good tea at school...'


'At school, the cute student (saw) the lady who gave the teacher good tea.'

When the relative clause is a ditransitive, whether or not the dative NP sensayngnim-eykey belongs to the relative clause is unknown. In some cases, as shown in (15a), all three NPs belong to the same clause. On the other hand, the first NP yeppun hakseng-i, must be expelled in (15b). In this way, waiting for the verb in Korean does not always disambiguate the structure totally, just as in Japanese.

It is somewhat counter-intuitive if Korean and Japanese, which share many grammatical characteristics in common, are indeed processed differently. Both languages have rich Case information, and both have disambiguation by the verb at the end of a clause, which does not always disambiguate the structure completely. Recall that in

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10 The verb in the temporal adjunct, such as 'after,' is also morphologically marked in a manner identical to that of relative clause construction in Korean.
Japanese, Case information appears to play a major role in on-line, full-attachment of each NP. It appears unnatural that the Korean Case marking system is ignored initially, as the delay processing entails. When we compare results from both languages, we indeed find that the serial computation is in better accord with the Korean grammar. The results from grammatical decision in Korean can be accounted for by the serial model; condition A, the minimal attachment structure, was judged as grammatical 90% of the time. Condition B, on the other hand, was judged as grammatical about half of the time. The “grammatical” answer rate for condition B was not as high as that for condition A, but it was much higher than conditions C or D. Notice, however, that the judgment response times for condition B were twice as long as A. This can be interpreted that grammatical decision tapped the level where some sentences were reanalyzed in condition B.  

Also, although two different experiments cannot be directly compared, the fact that the “grammatical” answer rate for condition B was higher in Korean than in Japanese could 

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"A similar phenomenon may exist in Japanese. Mazuka & Itoh (in press) report that when the verb is attached by an aspectual morpheme, there seems to involve less processing cost than when the verb is in the past tense. Also, when the verb in gerundive, a similar effect is observed. Compare (i) with (ii) and (iii).

(i) John-ga Mary-ni ringo-o tabeta...
   John-nom Mary-to apple-acc ate

(ii) John-ga Mary-ni ringo-o tabe-nagara...
     John-nom Mary-to apple-acc eat-while

(iii) John-ga Mary-ni ringo-o tabete...
     John-nom Mary-to apple-acc eating

One of the possible accounts for such a difference between (i) and (ii), (iii) is that in the latter the morpheme, along with subcategorization of the verb, aids reanalysis."
indicate that the morphological markings on the relative verb promoted the reanalysis in Korean.

Since the current data alone cannot choose one model over the other for Korean, an experiment can be implemented to further investigate the issue. One way to confirm the serial computation is to measure eye-movements. For such an experiment, conditions identical to those present in Experiments 1 and 2 should be used. If Korean is indeed processed serially, there should be regressions at the verb in conditions B and D, while there should not be at the verb in condition A. If Korean is indeed processed in a delay manner, the regression should not occur in conditions A and B, since in both conditions the appearance of the verb is when the computation of the structure starts. Instead of regression, there should be a difference in reading times of the verbs in the two conditions.

5.5. Universality in Language Processing and Future Research

In this study, we have investigated how Japanese and Korean are processed. The results in Japanese were most congruent with the serial model. The results in Korean were rather inconclusive between the serial and delay models, but there was a stronger support for the serial model than for the delay model. In English, also, there have been reports of experiments suggesting that the language is processed serially (e.g. Frazier & Rayner,
1982; Frazier, 1978). If indeed English is processed serially, and so are Japanese and Korean, a question naturally emerges whether the serial model is universally the default as the human language processing mechanism. Prior to drawing any tentative conclusions on the issue, let us discuss the motivation behind serial processing in each language discussed here.

If English, Japanese, and Korean are indeed processed in serial, the motivation for serial processing in these languages appears to be the result of totally different grammatical characteristics. In Japanese, where the status of a current structure in on-line processing is not clear literally until the entire sentence is completed, the parser makes the best guess on-line about the organization of the local tree and utilizes anything that may help, such as Case information. If the initial hypothesis fails, it is usually fixable locally since the reanalysis is initiated by the appearance of a verb or a head NP. The same is true with Korean. Japanese and Korean are processed in serial because such a strategy is the best among all the alternatives; in other words, other ways such as parallel or delay models are even less efficient due to memory overload or too many alternative structures associated with them. If English is processed in serial, it must be because it is a head-initial language with no
null arguments, which leaves less room for ambiguity.\footnote{\ Of course, there is a possibility that English is processed in parallel with a ranking among alternatives, as proposed by Gorrell (1987). The ranked parallel is also a reasonable model for English, since the number of alternative structures is less than that of left-branching languages such as Japanese and Korean.}

It appears, then, that the mechanism of the processing of a particular language is governed by the quality of information which the parser receives in that language (cf. A. Inoue, 1991; Inoue & Fodor, in press). Although it is possible that all languages are processed serially, it is premature to make such a conclusion at this stage; the observations thus far suggest that other languages with totally different grammatical characteristics may be processed in a non-serial manner, as long as such a way utilizes the grammatical information of the language more effectively than serial processing.

Even if not all languages are processed serially, it is still possible to maintain the universality of a human language processing mechanism. Whether a language is processed serially or in other ways is a considerable difference in strategies, but it may be a somewhat peripheral factor to the human language processing mechanism as a whole. Since any human being has approximately the same memory limitation and processing capability restricted by the limitation regardless of his/her native language, there must be many aspects which the processing of all languages share.

For instance, the general preference for minimal attachment structures over non-minimal attachment
structures in Japanese and Korean was confirmed by the current study. There are numerous reports that this strategy is in operation in English (e.g., Frazier, 1978; Frazier & Rayner, 1982). Although it is not clear whether this is true with every language at this point, the preference for minimal attachment structures could be part of what is universal about human language processing. Besides the preference for minimal attachment, the cost-efficiency in processing within a given grammar must be true universally.

Extensive word is necessary before one may make absolute conclusions about any of the issues discussed in the current study. The confirmation of each model for English, Japanese and Korean, the detailed mechanism of both local level and non-local level in those languages, and the universality in human language processing mechanism, all await further research. As a future direction, it will be necessary to further investigate each language, as well as languages with characteristics other than those of English, Japanese and Korean.

It is important to promote studies of processing mechanism in languages other than English. At the same time, experiments in English should be promoted even more forcibly, since they will not only reveal the mechanism of sentence processing in English, but also contribute exploring the universality in processing. Research in English has advantages over any other languages. In English, there are many preceding reports for reference and
comparison. Furthermore, English has an advantage over non-alphabetical languages since it has less complicated orthography - certainly less elaborate than that of Japanese, Chinese or Korean. In interpreting the results obtained in English, one must be careful to distinguish whether results come from the specific grammatical characteristics of a language or from a universal mechanism of processing. Of course, the same is true for studies in any other languages, including Japanese and Korean. By distinguishing which phenomena are language specific and which are not, the universality of a human language processing mechanism will be gradually revealed.

Finally, the current discussion reemphasizes the importance of theoretical study as well as experimental study in the investigation of human language processing mechanism. Both theoretical and experimental studies play an indispensable role to each other. There is much to be done, and each piece of the puzzle must be solved step-by-step, through both theoretical and experimental investigations.
Appendix A

Japanese Test Sentences in Alphabet

All the sentences were presented in Hiragana, Katakana and Kanji characters in the actual test sessions.

1. Ofisu-de zimi-na syokuin-ga kakarityoo-ni
   office-at plain lady-nom section chief-to
   sibui otya-o
   strong tea-acc
   (A) dasita (B) nonda (C) dakara (D) zyosee-ga
       served drank therefore woman-nom

2. Tookyoo-de iyarasii hoomonkyaku-ga seezika-ni
   Tokyo-at shrude visitor-nom politician-to
   mezurasii kabin-o
   rare vase-acc
   (A) miseta (B) kazatta (C) sikasi (D) zyotyuu-ga
       showed displayed but maid-nom

3. Kyoositu-de yasasii sensee-ga daigakusee-ni
   classroom-at gentle teacher-nom college student-to
   hukuzatu-na koosiki-o
   complicated formula-acc
   (A) situmon-sita (B) hakken-sita (C) dakedomo
       questioned discovered however
   (D) yoomuin-ga
       janitor-nom
4. Kissaten-de namaiki-na huryoo ga yuujin ni
   cafe at conceited bad boy nom friend to
   nonki-na koohai-o
   easy going junior man acc
   (A) syookai-sita (B) kudoita (C) sonoato
       introduced pursued after that
   (D) motinusi-ga
       owner nom

5. Matikado-de kiza-na syoonen-ga zyosidaisee-ni
   street at stuck up boy nom female college student to
   omoi nimotu-o
   heavy luggage acc
   (A) watasita (B) suteta (C) masaka
       handed threw away by no means
   (D) ekiin-ga
       train station worker nom

6. Syokudoo-de takumasii untensyu-ga obasan ni
   restaurant at stout driver nom middle aged lady to
   yasui teesyoku-o
   cheap set meal acc
   (A) tyuumon-sita (B) aziwatta (C) keredomo
       ordered tasted however
   (D) wakamono tatiga
       young people nom

7. Inaka-de keti-na sakka-ga musiko ni
   countryside at stingy writer nom son to
   ii kamera o
   good camera acc
   (A) yuzutta (B) kowasita (C) sikaruni (D) syasinka-ga
       gave broke however photographer nom
8. KYOTO-DE GANKO-NA SYUZIN-GA DESI-NI
Kyoto-at stobburn master-nom clerk-to
atarasii kikai-o
new machinery-acc
(A)makaseta (B)ugokasita (C)naruho (D)yuumeezin-ga
left (to him) operated indeed celebrity-nom

9. ZITAKU-DE OMOSIROI ONIISAN-GA YUUZIN-NI
home-at interesting brother-nom friend-to
hen-na bideo-o
strange video-acc
(A)kasita (B)utusita (C)dakedo (D)nakama-ga
lent shot but friends-nom

10. SITAMATI-DE SIRAGA-NO OBAASAN-GA KOMEYA-NI
downtown-at gray-haired old lady-nom rice merchant-to
furui syakkin-o
old debt-acc
(A)haratta (B)wasureta (C)tadasi
paid forgot however
(D)sakaya-ga
liquor merchant-nom

11. SUTAZIO-DE UMAI KASYU-GA OTOOSAN-NI
studio-at good singer-nom father-to
mizikai uta-o
short song-acc
(A)sasageta (B)kiita (C)sorede
dedicated listened then
(D)okyaku-ga
customer-nom
12. Osaka-de heta-na zyooyu-ga kantoku-ni
    Osaka-at bad actress-nom director-to
    kuroi tebukuro-o
    black gloves-acc

    (A) nageta (B) nuida (C) datte
    threw took off but

    (D) kanyaku-ga
    audience-nom

13. Eki-de zyoohin-na huzin-ga tyoonan-ni
    station-at sophisticated lady-nom first son-to
    taisetu-na kaban-o
    important bag-acc

    (A) azuketa (B) kakaeta (C) tokorode
    deposited held by the way

    (D) tomodati-ga
    friend-nom

14. Kaigi-de wakai katyoo-ga syain-ni
    meeting-at young section chief-nom office workers-to
    zansin-na sinseehin-o
    smashing new product-acc

    (A) hiroo-sita (B) hihan-sita (C) tinami-ni
    demonstrated criticized incidentally

    (D) tyuugakusee-ga
    junior high school student-nom

15. Nooka-de henkutu-na roozin-ga hitorimusume-ni
    farmhouse-at ostinate old man-nom only daughter-to
    hiroi toti-o
    large land-acc

    (A) nokosita (B) tukatta (C) keredo
    left used however

    (D) himago-ga
    great grandchild-nom
16. Department store-at good clerk-nom girl-to
hade-na yoohuku-o
flasy clothes-acc
(A)susumeta (B)sityaku-sita (C)tokoroga
recommended tried on but
(D)kooosee-ga
high school student-nom

17. Charity-at active wife-nom everyone-to
oisii okasi-o
good cake-acc
(A)yaita (B)tabeta (C)desuga
baked ate but
(D)kodomoo-ga
child-nom

18. Hiroshima-at cheerful youngster-nom principal-to
takai piano-o
expensive piano-acc
(A)todoketa (B)naosita (C)tumari
delivered repaired in other words
(D)sityoo-ga
mayer-nom

19. Bar-at poor musician-nom dancer-to
utukusii hanataba-o
pretty flower-acc
(A)ageta (B)motta (C)nanoni (D)tizin-ga
gave held despite acquaintance-nom
20. Nagasaki-de akarui syoozyo-ga oneesan-ni
Magasaki-at bright girl-nom sister-to
mezurasii omiyage-o
rare souvenir-acc
(A) tanonda (B) yorokonda (C) saredo
asked was pleased at however
(D) kyuuuuu-ga
classmate-nom

21. Resutoran-de tanomosii dansee-ga koibito-ni
restaurant-at masculine man-nom girlfriend-to
gooka-na yubiwa-o
gorgeous ring-acc
(A) okutta (B) kantee-sita (C) sunawati
sent appraised in other words
(D) uriko-ga
sales clerk-nom

22. Kooen-de tiisai otokonoko-ga ryoosin-ni
park-at small boy-nom parents-to
ooki-na kyandee-o
big candy-acc
(A) nedatta (B) sisyoku-sita (C) sikaraba
asked tried then
(D) nakayosi-ga
good friend-nom

23. Kenkyuusitu-de yarite-no senpai-ga kyoozyu-ni
lab-at capable senior man-nom professor-to
akai tubo-o
red vase-acc
(A) tukutta (B) watta (C) naraba (D) koohai-ga
made broke in that case junior man-nom
24. Yokohama-de utukusii zyojuu-ga hahaoya-ni
Yokohama-at pretty actress-nom mother-to
kakkoii kuruma-o
good-looking car-acc
(A)katta (B)tometa (C)yueni (D)otona-ga
bought parked therefore adults
Appendix B

Japanese Test Sentences in Japanese Orthography

1. オフィスで地味な職員が係長に渋いお茶を
   (A) 出した (B) 飲んだ (C) だから (D) 女性が

2. 東京でいやらしい訪問客が政治家にめずらしい花びんを
   (A) 見せた (B) 飾った (C) しかし (D) 女中が

3. 教室でやさしい先生が大学生に複雑な公式を
   (A) 質問した (B) 発見した (C) だけでも (D) 用務員が

4. 喫茶店でなまいきな不良が友人にのんきな後輩を
   (A) 紹介した (B) くどいた (C) その他 (D) 持ち主が

5. 街角できさな少年が女子大生に重い荷物を
   (A) 渡した (B) 捨てた (C) まさか (D) 駅員が

6. 食堂でたくさんい運転手がおばさんに安い定食を
   (A) 注文した (B) 味わった (C) けれども (D) 若者達が

7. 田舎でけちな作家が息子にいいカメラを
   (A) ゆずった (B) こわした (C) しかるに (D) 写真家が

8. 京都でごっこな主人公が弟子に新しい機械を
   (A) まかせた (B) 動かした (C) なるほど (D) 有名人が

9. 自宅で面白いいお兄さんが友人に変なビデオを
   (A) 貸した (B) 映した (C) だけど (D) 仲間が

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10. 下町で白髪のおばあさんが米屋に古い借金を
   (A) 払った (B) 忘れた (C) ただし (D) 酒屋が

11. スタジオでうまい歌手がお父さんに短い歌を
   (A) 手綱 (B) 聴いた (C) それで (D) 客が

12. 大阪で下手な女優が監督に黒い手袋を
   (A) 投げた (B) 脱いだ (C) だって (D) 観客が

13. 駅で上品な婦人が長男に大切なかばんを
   (A) あずけた (B) かかえた (C) ところで (D) 友だちが

14. 会議で若い課長が社員にざら新製品を
   (A) 披露 (B) 批判した (C) ちなみ (D) 中学生が

15. 農家でへんくつな老人が一人娘に広い畑地を
   (A) 残した (B) 使った (C) けれど (D) ひ孫が

16. デパートでうまい店員が女の子に派手な洋服を
   (A) すすめた (B) 試着した (C) ところが (D) 高校生が

17. バザーで活発な奥さんがみんなにおいしいお菓子を
   (A) 焼いた (B) 食べた (C) ですが (D) 子供が

18. 広島で陽気な青年が校長に高いピアノを
   (A) 届けた (B) 直した (C) つまり (D) 市長が

19. バーで貧しい音楽家が踊子に美しい花束を
   (A) あげた (B) 持った (C) なのに (D) 知人が

20. 長崎で明るい少女がお姉さんに出しょおみやげを
   (A) 頼んだ (B) 喜んだ (C) けれど (D) 徒友が
21. レストランで頼もしい男性が恋人に豪華な指輪を
(A) おくれた (B) 鑑定した (C) すなわち (D) 売り子が

22. 公園で小さい男の子が両親に大きなキャンディを
(A) ねだった (B) 試食した (C) しからず (D) 仲良しが

23. 研究室でやり手の先輩が教授に赤い壺を
(A) 作った (B) 割った (C) ならば (D) 後輩が

24. 横浜で美しい女優が母親にかっこいい車を
(A) 買った (B) 止めた (C) ゆえに (D) 大人が
Appendix C

Korean Test Sentences in Alphabet

All the sentences were presented in Hangul in the actual test sessions.

1. Samusil-eyse cengswukhan yecikwen-i
   office-at sophisticated female worker-nom

   kyeycang-hantey kkaman ingku-lul
   section chief-to red ink-acc

   (A)tuleo-ss-ta (B)epcilun (C)kurayse (D)yeseng-i
   gave (polite) spilled therefore lady-nom

2. Seoul-eyse kyohwalhan cengchika-ka
   Seoul-at shrewd politician-nom

   sonnim-hantey kuehan kulim-ul
   guest-to rare painting-acc

   (A)cwue-ss-ta (B)chingchanhan (C)kurena
   gave praised but

   (D)hwaka-ka
   painter-nom

3. Kyosil-eyse sangnyanghan sonsayngnim-i
   classroom-at gentle teacher nom

   haksayng-hantey pwukcaphan kongsik-ul
   student-to complicated formula-acc

   (A)mwule-ss-ta (B)palkyonhan (C)kuriko
   asked discovered and

   (D)paksa-ka
   professor-nom
4. Taygu-eyse chaksilhan chinku-ka
Daegu-at serious friend-nom
bwullyangsonyon-hantey aluntaun si-lul
bad boy-to beautiful poem-acc
(A)sokae-hae-ss-ta (B)amkihan (C)kurihayo
introduced memorized and then
(D)akassi-ka
girl-nom

5. Kilmok-eyse cosukhan sonyon-i
street-at precautions boy-nom
tayhaksayng-hantey mukowun kabang-ul
college student-to heavy bag-acc
(A)konnee-ss-ta (B)ilopolin (C)kuremuro
handed lost even if
(D)uncensu-ka
driver-nom

6. Siktang-eyse nemremhan unconsu-ka
restaurant-at masculine driver-nom
acumoni-hantey ssan congsik-ul
old lady-to cheap set menu-acc
(A)cumun-hae-ss-ta (B)megechiwun (C)kuronikka
ordered ate (it) up so
(D)chongnyondul-i
youngsters-nom

7. Sikol-eyse insaekhan nongpu-ka
countryside-at stingy farmer-nom
atul-hantey kun cib-ul
son-to big house-acc
(A)poyo-ss-ta (B)pakoy-han (C)kuromyen
showed destroyed in that case
(D)cakka-ka
writer-nom
8. Pwusan-eyse owangohan cwuin-i  
Pusan-at stubborn master-nom  
cemwon-hantey tarun kake-lul  
clerk-to another store-acc  
(A) makkye-ss-ta (B) sicak-han (C) kurendye  
left started however  
(D) cikin-i  
craftsman-nom

9. Cip-eyse chakhan hyongnim-i  
house-at gentle brother-nom  
chinku-hantey isanghan pitio-lul  
friended-to strange video-acc  
(A) billye-ss-ta (B) kwamsang-han (C) kurayto  
rented watched but  
(D) sinsa-ka  
gentleman-nom

10. Sinay-eyse nulkun halapeci-ka  
downtown-at old grandfather-nom  
ssalcangsa-hantey manun ton-ul  
rice store-to lots of money-acc  
(A) cipul-hae-ss-ta (B) icepolin (C) kurehciman  
paid forgot however  
(D) swulcangswu-ka  
liquor shop owner-nom

11. Suthyutio-eyse yumyenghan kasu-ka  
studio-at famous singer-nom  
abeci-hantey ccalbun swupil-ul  
father-to short song-acc  
(A) bache-ss-ta (B) cwulphanhan (C) kedaka  
dedicated published despite  
(D) chongkak-i  
single man-nom
12. Kwukcang-eyse setwulun yobaywu-ka
theater-at bad actress-nom
kamtok-hantey yonpwunhong cekoli-lul
director-to purple Chogoli-acc

(A)tencye-ss-ta (B)mantuln (C)ttarase
threw made therefore

(D)kwankayk-i
audience-nom

13. Yok-eyse kosanghan swuknye-ka
station-at sophisticated lady-nom
pise-hantey cwungyohan selyu-lul
secretary-to important paper-acc

(A)ponae-ss-ta (B)kkyeanun (C)ttarase
sent held consequently

(D)chacang-i
conductor-nom

14. Hoyuy-eyse celmun kwacang-i
meeting-at young section chief-nom
sawon-hante kapyewun tacaki-lul
employee-to heavy typewriter-acc

(A)sencen-hae-ss-ta (B)pwuswun (C)tespwutyese
advertised broke by the way

(B)pwusacang-i
vice president-nom

15. Pwuye-eyse kocisikhan noin-i
Puyo-at stubborn old man-nom
ttal-hantey elin chepcsik-ul
daughter-to small adopted son-acc

(A)namgye-ss-ta (B)saranghan (C)kureca
left (to take care) loved and

(D)cungson-i
great grandchild-nom
16. Paykhwacem-eyse  tancenghan cemwon-i
department store-at good looking clerk-nom

kokyosayng-hantey  hwalyehan os-ul
high school student-to glamorous clothes-acc

(A)kuwen-hae-ss-ta (B)ipebon (C)haciman
    recommended tried on but

(D)hakseng-i
student-nom

17. Kwangcwu-eyse hwaltalhan emeni-ka
Kwangju-at active mother-nom

atul-hantey kin pyenci-lul
son-to long letter-acc

(A)sse-ss-ta (B)thaywun (C)kuntey
    wrote burnt but

(D)hyeng-i
brother-nom

18. Sinchon-eyse senggonghan chongnyen-i
Sinchon-at respectable young man-nom

kyocang-hantey pissan phiano-lul
principal-to expensive piano-acc

(A)pwucye-ss-ta (B)swurihan (C)kurayya
    sent repaired otherwise

(D)namca-ka
man-nom

19. Swulcip-eyse kananhan umsikka-ka
bar-at poor musician-nom

ayin-hantey alumptawun kkoch-ul
lover-to beautiful flowre-acc

(A)sensa-hae-ss-ta (B)cangsikhan (C)kurenteyto
    gave (as a gift) decorated even so

(D)siin-i
poet-nom
20. Taycen-eyse keiyewun sonye-ka
Dae-Chon-at cute  girl-nom

ennis-hantey pali-ei  hyangswu-lul
mother-to  Paris-gen souvenir-acc

(A)putak-hae-ss-ta  (B)kaytturin  (C)kurehtamyen
asked  broke  then

(D)kupwutul-i
classmates-nom
Appendix D

Korean Test Sentences in Hangul

1. 사무실에서 정숙한 여직원이 게당한데 까만 잉크를
(A) 듬셨다 (B) 잔뜩 들 (C) 그래서 (D) 아셨다

2. 서울에서 고찰한 정치가가 손님한테 귀한 그림을
주었다 칭찬한 그리나 회가

3. 고실에서 상냥한 신생님이 학생한테 복잡한 공식을
물었다 발견한 그리고 박사가

4. 대구에서 착실한 친구가 불량소년한테 아름다운 시를
소개했다 암기한 그리하여 아가씨가

5. 집목에서 조숙한 소년이 대학생한테 무거운 가방을
건네었다 잃어보긴 그러므로 은전수가

6. 식당에서 늘름한 은전수가 아주머니한테 산 정식을
주문했다 먹어치운 그러니가 청년들이

7. 시골에서 인색한 농부가 아들한테 큰 집을
보였다고 파격히 그러면 작가가

8. 부산에서 원고한 주인이 점원한테 다른 가계를
맡겼다 시작한 그런데 직인이

9. 집에서 작한 형님이 친구한테 이상한 비디오를
빌렸다 감상한 그리고 선사가
10. 시내에서 놓은 할아버지가 싼장사한테 많은 돈을 지불했다 잃어버린 그럴지만 숨잡아가

11. 스튜디오에서 유명한 가수가 아버지한테 잃은 수필을 바쳤다 충만한 가다가 총각이

12. 국장에게 서류를 여전히 감독한테 연봉총 저그리를 면직되며 따라서 관객이

13. 역에서 고상한 숙녀가 비서한테 중요한 서류를 보냈다 깨끗은 오렌지 차장이

14. 회의에서 젊은 과장이 사원한테 가벼운 타자기를 신청했다 부순 덧붙여서 부상장이

15. 부여에서 고지식한 노인이 말한데 어린 젊자식을 낳겼다 사랑한 그리고 충손이

16. 백화점에서 단정한 접원이 고교생한테 화려한 옷을 길했다 임아론하지만 학생이

17. 광주에서 활달한 어머니가 아들한테 긴 편지를 썼다 빈곤 근데 형이

18. 신춘에서 성공한 청년이 고장한테 비싼 피아노를 부쳤다 수리한 그래야 남자가

19. 술집에서 가난한 음악가가 여인한테 아름다운 꽃을 선사했다 창직한 그런데도 시인이

20. 대전에서 귀여운 소녀가 언니에게 꽃리의 항수를 투탁했다 깨친 그런다면 길우들도
LIST OF REFERENCES


Miller, G. A. (1956). The magical number seven plus or minus two, or some limits on our capacity for processing information. *Psychological Review*, 93.


