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The Effects of Phrase-Length Order and Scrambling in the Processing of Visually-presented Japanese Sentences

Katsuo TAMAOKA
(International Student Center, Hiroshima University, Japan)
Hiromu SAKAI
(Graduate School of Education, Hiroshima University, Japan)
Jun-ichiro KAWAHARA
(Graduate School of Education, Hiroshima University, Japan)
Yayoi MIYAOKA
(Hiroshima University of Economics, Japan)

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Correspondence: Katsuo Tamaoka, Ph.D.
International Student Center, Hiroshima University
1-1, 1-chome, Kagamiyama, Higashi-Hiroshima, 739-8523 JAPAN
Tel & Fax: 0824-24-6288
E-mail: ktamaoka@hiroshima-u.ac.jp

Abstract

The present study investigated the effects of phrase-length and scrambling in the processing of Japanese sentences. Reading times of short phrases, long phrases, verbs and whole sentences, measured by the method of self-paced reading, did not differ in terms of phrase-length order and scrambling. In addition, four different types of sentences constructed on the basis of phrase-length order and scrambling did not affect duration times of correctness decision making for sentences. However, error rates differed between canonical and scrambled sentences regardless of phrase-length order. This result implies that scrambled sentences were harder to judge as correct sentences than canonical sentences. Thus, scrambling affects the appropriate integration of information while phrase-length order is simply an indication of 'preference', and not of 'cognitive processing'. To explain the present result, the authors propose the 'configurational structure without movement', which predicts no difference in speed between the processing of canonical and scrambled sentences, apart from error rates.

Word order in Japanese sentences is generally flexible, apart from the rule that verbs must come at the end of a sentence (see general information in Nakayama, 1999; Nemoto, 1999). In the case that active sentences containing ditransitive verbs (or an active sentence with a verb of three arguments) such as *Mary-ga John-ni sono hon-o watasita* meaning 'Mary gave John that book', Japanese speakers allow six different word orderings by swapping the subject (NP-ga), the direct object (NP-ni) and the indirect object (NP-o) into any order such as *John-ni Mary-ga sono hon-o* (NP-ni, NP-ga, NP-o) or *sono hon-o Mary-ga John-ni* (NP-o, NP-ga, NP-ni). The existence of this free word order phenomena has triggered intense debate concerning the phrase structure of Japanese. The present study investigated which syntactic structure actually represents the cognitive processing of the Japanese sentences by testing the effects of canonical and scrambled sentences with two different phrase lengths.

Three Syntactic Structures for Explaining Word Order

There are three possible syntactic structures for explaining the free word order phenomena. The following sections introduce these structures.

(1) Non-configurational Syntactic Structure

The first structure is the 'non-configurational' syntactic structure. A group of linguists (e.g., Farmer, 1984; Hale, 1980, 1981) attribute the existence of free word order to the non-configurational structure. Since word order in Japanese does not alter the fundamental meaning, they claimed that the Japanese language is referred to a non-configurational or 'flat' structure. As shown in Figure 1, the two noun phrases and the verb are all connected at the same level. In the non-configurational structure, there is no considerable difference among syntactic positions of phrases: noun phrases can be generated freely in any position in the sentence. A canonical order (SOV; Subject, Object and Verb) of *Mary-ga John-o nagutta*, meaning 'Mary hit John', can be correctly expressed by altering the nominal noun phrase *Mary-ga* and the accusative noun phrase *John-o*. A changed order of the sentence *John-o Mary-ga nagutta* (OSV) does not make any effect on the essential meaning of the canonically-ordered sentence. Consequently, according to this structure, a difference in word order should not affect the sentence processing.

Insert Figure 1 about here.

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(2) Configurational Syntactic Structure with Movement

The second structure is called a ‘configurational’ syntactic structure. Several linguists (e.g., Miyagawa, 1989; Saito & Hoji, 1983; Saito, 1985; Hoji, 1985; Whitman, 1987) argue that Japanese has a ‘configurational’ structure. These authors claim that an instance of phrasal movement results in free word order phenomena. Ross (1967) originally referred to this as ‘scrambling’, which the movement of noun phrases from their original positions to their derived positions. For example, as shown in Figure 2, *Mary-ga John-o nagutta* reflects canonical order (SOV) of an active sentence containing a transitive verb. Once the accusative noun phrase *John-o* is moved to the frontal position of the sentence, this sentence exhibits a scrambled order (OSV) of *John-o Mary-ga nagutta*. Although the essential meaning of this sentence does not change, the scrambled order will require a syntactic operation of phrasal movement from a trace of the canonical position to the fronted position. Thus, scrambled sentences in the configurational structure with movement must require an extra cognitive load for syntactic operation.

Insert Figure 2 about here.

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(3) Configurational Syntactic Structure without Movement

The third structure is ‘configurational structure without movement’ which distinguishes it from ‘non-configurational structure’ and ‘configurational structure with movement’. Ueyama (1999) argues that certain instances of Japanese ‘scrambled’ phrases and sentences are ‘base-generated’ in their surface positions. Fukui (1989) makes a similar point that scrambling is a ‘substitution’ into a base-generated position. As depicted in Figure 3, the configurational syntactic structure without movement presupposes that both canonical (SOV) and scrambled (OSV) structures are initially available for cognitive syntactic operation. In other words, both sentences of *Mary-ga John-o nagutta* and *John-o Mary-ga nagutta* can be constructed based upon the initial stage of sentence processing. Thus, although this structure is configurational, syntactic operation is not required to understand or produce sentences. As a result, an extra cognitive load for sentence processing will not be required for the processing of scrambled sentences. However, when an accusative phrase is placed in the frontal position, the distance for matching an accusative phrase with a verb may cause some difficulty in accurately process the sentences. This cognitive process is further explained in the later of the introduction with Figure 4.

Insert Figure 3 about here.

Scrambling Effects on Sentence Processing and the 'Gap' Filling Parsing

Studies concerning the effects of scrambling show contrasting pictures. Chujo (1983) conducted a semantic correctness decision task for both canonical and scrambled orders of active sentences with transitive verbs. For example, 'Tadao deceived Yukiko' is written in two ways; a canonical SOV sentence such as *Tadao-ga Yukiko-o damasita* and a scrambled OSV sentence such as *Yukiko-o Tadao-ga damasita*. After showing these sentences randomly mixed with incorrect ones on a computer display, Chujo asked participants to judge whether a sentence semantically made sense by pressing a 'Yes' or 'No' button. Chujo found that scrambled sentences took longer to produce a decision than canonical sentences. This tendency was much more clearly observed when a sentence had an inanimate object (e.g,. *Osamu-ga nimotu-o oita* vs. *Nimotu-o osamu-ga oita*, meaning 'Osamu put down his luggage').

Chujo's findings are compatible with the approach of the configurational structure with movement shown in Figure 2. If the nominative NP-ga is placed in its canonical position before the accusative NP-o, speakers can comprehend the sentence without any extra effort. However, the case is different if the accusative NP-o is placed before the nominative NP-ga. Since the semantic decision task used by Chujo deals with the process of sentence comprehension (not sentence production), participants in his study had to perform mental syntactic operations which, in some sense, reconstruct the scrambled NP to its original position. As shown in Figure 4, in a canonical sentence, the accusative NP appears just before a verb. However, when the accusative NP is placed in the frontal position (i.e., scrambled order), speakers must know whether the frontal accusative NP is appropriate for the object with typically appear just before the verb. The speakers therefore perform mental operations in search for a 'gap' in the original position of the scrambled accusative NP.

Insert Figure 4 about here.

The 'active filler strategy' hypothesis first proposed for English (Frazier & Clifton, 1989) and Dutch (Frazier & Flores d'Arcais, 1989) also applied to some studies of Japanese *Wh*-scrambling constructions (Aoshima, Phillips & Weinberg, 2002; Sakamoto, 2002). According to this strategy, speakers must search for the gap required by a displaced NP in the scrambled sentence. For instance, in the scrambled sentence *John-o Mary-ga nagutta* in Figure 4 (ii), an accusative NP *John-o* is placed at the front. This frontal NP initiates a search for 'gap' which is originally placed just before the transitive verb *nagutta* in canonical order. For the reason of the 'gap' filling parsing, speakers need extra time to process scrambled sentences.

Findings of No scrambling effects and their Explanation

The findings of Chujo (1983), however, were not confirmed by other psycholinguistic studies. Nakayama (1995) and Yamashita (1997) conducted on-line sentence processing experiments using the self-paced reading method, which did not find any differences in reading times between canonical and scrambled sentences. To explain, both Nakayama and Yamashita adopted the non-configurational (or flat) structure. As depicted in Figure 1, both the nominative NP-ga and the accusative NP-o are located in parallel under the single flat level. Since there is no specific canonical order in this structure, any word order can be generated to construct a sentence. As a result, word order, or more precisely noun phrase order, has no effect on the receiving of information in written sentences. Sakamoto (2001), further elaborating upon the results of Yamashita (1997), stated that because particle markers are attached to all noun phrases which provide clear identification regarding functions of noun phrases in the particular sentence, inputted information given by a different order of various noun phrases (i.e., scrambled sentences) does not require an extra cognitive processing load.

The findings of Nakayama (1995) and Yamashita (1997) could be caused by two reasons, sensitivity of stimulus conditions and the measuring method of self-paced reading. First, both authors used complex sentences for stimuli. In self-paced reading, preceding information is likely to affect processing of the following sentence. When target sentences have a complex, embedded syntactic structure, processing must require a heavy cognitive load of the syntactic and semantic processing used not only for a scrambled phrase but also for an embedded phrase. Second, the self-paced reading method is often observed as a constant key-pressing reflex which may not reflect actual reading times for phrase-by-phrase (or word-by-word) on-line sentence processing. Thus, sentences with a simple syntactic structure were used for the present experiment while the self-paced reading was kept as used by Nakayama and Yamashita for the purpose of examining its methodological appropriateness.

Effects of Phrase-length Order and Scrambling

Although Japanese word order is so flexible that a short single sentence with a ditransitive verb of three arguments (NP-ga, NP-o, NP-ni and V) can be written in six different noun phrase orders, it is surprising that the frequency of any type of scrambled sentences in informal speech is reported to be less than 1 percent (originally calculated in Yamashita & Suzuki, 1995, as cited in Yamashita, 1997). Establishing the extremely low frequency of scrambled sentences produced by native Japanese speakers, Yamashita and Chang (2001) further indicated that Japanese speakers almost exclusively constructed a canonical sentence when a long subject phrase and a short object phrase were provided. However, when a long object phrase and a short subject phrase were provided, Japanese speakers produced about 20 percent of scrambled sentences in the order of a long object phrase before a short subject phrase. Taking this as evidence, Yamashita and Chang (2001) suggested that Japanese preferred to have long phrases before short phrases, and named it 'long-before-short' preference. This preference pattern of 'long-before-short', however, contradicts the preference of English speakers who produce short phrases before long phrases (Bock, 1982, 1986; Bock & Warren, 1985). Since both effects of phrase-length order and scrambling seem to tie together, the present study investigated the effects of phrase-length and scrambling together.

Predictions of Phrase-Length Order and Scrambling Effects According to Three Syntactic Structures

The following predictions are proposed in relation to the three syntactic structures. The non-configurational structure (see Figure 1) requires no specific priority in phrase (or word) order. Thus, not only scrambling but also phrase-length order could be considered to have no effect on the processing of either canonical or scrambled sentences. In contrast, the configurational structure with movement (see Figure 2) predicts that canonical sentences are more quickly and accurately processed than scrambled sentences due to the syntactic 'gap' filling operation (see Figure 4). If the Japanese preference of the long-before-short phrase-length order has any effect on sentence processing, it would be further expected that canonical sentences with the long-before-short phrase order are more quickly and accurately processed than canonical sentences with the short-before-long phrase order. When both factors of scrambling and phrase-length order are combined, it is expected to create an even greater effect in the configurational structure. In other words, scrambled sentences with the 'short-before-long' phrase order should require the longest processing time and result in the highest error rate. In statistical terms, a significant interaction should be obtained for the variables of scrambling and phrase-length. On the other hand, the configurational structure without movement (see Figure 3) only predicts a higher error rate for scrambled sentences than canonical sentences due to matching an accusative NP with a verb for appropriate semantic judgments. Since both canonical and scrambled sentences are base-generated in this structure, reading times should not be affected by either scrambling or phrase-length. With these predictions based upon the three syntactic structures, the present study investigated the effects of scrambling and phrase-length in the processing of Japanese sentences.

EXPERIMENT

Using a sentence-correctness decision task with self-paced reading, the present experiment investigated the effects of scrambling and phrase-length on the processing of visually-presented Japanese sentences.

Method

Participants

Twenty-four graduate and undergraduate students (19 females and 5 males) at Hiroshima University in Japan, all native speakers of Japanese, participated in this experiment. Ages ranged from 19 years and 0 months to 33 years and 10 months, with the average age being 22 years and 10 months on the day of testing. Participants were randomly assigned to each of four sentence lists (explained in the following section on materials).

Materials

As listed in the Appendix, 48 correct and 12 incorrect sentences (a total of 60 sentences) were created for the sentence correctness decision task. This task employed self-paced phrase-by-phrase reading. As shown in Table I, four different types of correct sentences were used for the task. The first and second types of stimulus sentences were short-before-long sentences (i.e., English-preferred sentences) while the third and forth types were long-before-short sentences (i.e., Japanese-preferred sentences). These two types of short-before-long and long-before-short sentences were further divided into SOV canonical or OSV scrambled sentences. Classifying in this way, the experiment examined the effects of phrase-length order and scrambling on Japanese sentence processing.

Insert Table Ⅰ about here.

The first type of sentences were canonical (i.e., SOV) sentences combining a long subject phrase, a short object phrase and a verb. For example, a sentence beginning with a short subject (or nominative) phrase *wakai dansei-ga* [a young man] followed by a long object (or accusative) phrase *kon'iro-no zubon-o haita tyuunen-no dansei-o* [a middle-aged man wearing blue pants] was concluded with a verb *korosita* [killed]. Based upon this sentence a second scrambled (i.e., OSV) sentence, was formed by altering the nominative case maker for the subject (i.e., *ga* in Japanese) and the accusative case maker for the object (i.e., *o* in Japanese). This second sentence therefore consisted of a short object phrase *wakai dansei-o*, a long subject phrase *kon'iro-no zubon-wo haita tyuunen-no dansei-ga* and the same verb *korosita*.

The third and fourth types of sentences were constructed using a phrase-length condition of long-before-short. Like the first type of sentences, the canonical SOV sentences were in the standard order of subject and object phrases, but they had a long subject. An example of this form is the sentence: *kon'iro-no zubon-o haita tyuunen-no dansei-ga wakai dansei-o korosita* [A middle-aged man wearing blue pants killed a young man]. As in the first and second types, the fourth type of sentences were created by switching the subject and the object, the above sentence becoming, *kon'iro-no zubon-o haita tyuunen-no dansei-o wakai dansei-ga korosita* [A young man killed a middle-aged man wearing blue pants].

It was expected that reading times would become faster when participants saw sentences containing the same words. Thus, in order to prevent this problem of repeatedly encountering the same words, a cross-counter design was used to assign participants to different sentences. Four lists of sentences were given to four groups of participants. Each list consisted of three sentences in each category. In other words, there was a total of 12 sentences for correct 'Yes' responses in each list.

Twelve syntactically or semantically incorrect sentences were used for correct 'No' responses to the task. Six sentences had inappropriate case markers while other six sentences semantically did not make sense. Unlike sentences with correct 'Yes' responses, the cross-counter design was not used for sentences with correct 'No' responses since data for the latter were not used for analysis in the present study. All participants received the same twelve incorrect sentences (listed in the Appendix).

Using the four types of sentences for correct 'Yes' responses and the single type of correct 'No' responses, the experiment investigated how the two variables of phrase-length order and scrambling influenced the cognitive processing of differing sentence structures.

Measurements

This experiment employed a sentence-correctness decision task combined with self-paced sentence reading. In this task there were three different measurements as shown in Figure 5. First, the self-paced reading time was recorded phrase by phrase (more precisely, a noun plus a particle such as *dansei-ga*, *koniro-no* and *zubon-no*). These measured times (in milliseconds) reflect the on-line sentence processing which is the process of inputting lexical information to understand sentential context. Second, soon after having read a sentence, participants were required to make a decision whether or not it was semantically and/or syntactically correct. The duration time for the sentence correctness decision was also recorded. This duration time was expected to show syntactic and semantic integration and verification of inputted information. Third, sentence-correctness decision was measured as an error rate on the basis of the number of incorrectly-judged items divided by the total number of stimulus items in each condition. The error rates reflect how correctly information was inputted through on-line sentence reading. These three measurements were used in the present experiment to investigate effects of word-length order and scrambling.

Insert Figure 5 about here.

Procedure

Sentences were presented to participants using a self-paced moving window reading presentation. The presentation was controlled by a PC/AT compatible computer programmed by Microsoft Visual Basic 6.0 + Microsoft DirectX8. An arrow '→' was projected on the left side of the computer display for 600 milliseconds to indicate to participants the beginning of word presentation. The first word appeared on the computer screen next to the arrow. Each word appeared in the position it would be in if the whole sentence were to be presented on the screen. When the participant pressed the space key on the keyboard, the second word appeared. The end of a sentence was indicated by a period '。', which refers to the completion of a sentence in a Japanese written text. Participants were instructed to read the sentences as quickly and accurately as possible. Reading times of phrases were automatically recorded by the computer. Soon after the period appeared, the participants were requested to make a sentence-correctness decision by pressing the right arrow key for 'Yes' or the left arrow key for 'No'. The participants were instructed to use both hands; the left hand to press the space key to read the words constructing a sentence, and the right hand to press the arrow keys. No difficulties were observed by any participant in performing the task. The duration time for the sentence-correctness decision was also automatically recorded. Eight practice trials were given to the participants prior to the commencement of the actual testing.

Analysis and Results

Extremes among reading times of words and sentence correctness decision times (less than 100 milliseconds and longer than 3000 milliseconds) were recorded as missing values. Three values out of all the participants fell into this category. Only correct responses for correct sentences (syntactically and semantically correct sentences) were used for analyzing reading time and sentence correctness duration in the present experiment. Since one participant missed all three items of a specific category, these data were excluded from analysis. Thus, the degree of freedom in participant analysis is one less.

Direct comparison of reading time in each lexical position across experimental conditions is impossible unless characteristics of phrases such as word frequency, number of symbols (or letters) and number of morae are controlled. In this sense, the positional analysis of Yamashita (1997) is inappropriate because words in the same positional order differ (e.g., comparing *tegami* 'letter' to *kanozyo* 'she'). Difference of words in terms of the numbers of symbols and morae can be often adjusted by linear regression (see Mazuka, Itoh & Kondo, 1997; Gunji & Sakamoto, 1999). However, since it is a widely-accepted notion that word frequency (i.e., the index of how often a word is printed) has a strong effect on word processing (e.g., Tamaoka & Hatsuzuka, 1995; Tamaoka & Takahashi, 1999; and see Taft, 1991 for general discussion), adjustment by linear regression should be included. Yet, ideally, words used in phrases should be exactly matched across all the conditions. Thus, the present study compared identical short phrases and long phrases, so that the only differences were nominative and accusative particles (case markers) added at the end of each phrase. The means of reading times of short phrases, long phrases, verbs and whole sentences, duration times of sentence correctness, and error rates for the task are presented in Table II. The following statistical tests analyze both participant (F_1) and item (F_2) variability.

Insert Table II about here.

Reading Times of Short Phrases

A 2 (short-before-long or long-before-short phrase order) X 2 (canonical or scrambled) analysis of variance (ANOVA) with the repeated measures was performed on reading times of a short phrase. The main effect of phrase-length order was not significant in participant analysis [F_1(1,91)=0.13, *n.s.*], but significant in item analysis [F_2(1,44)=9.78, p<.01]. This significant result in the item analysis might be caused by phrase collocation. Some phrases combined with a verb could be found next to each other more frequently than others, which might have affected the reading time. However, because this effect was only significant in the item analysis, only a few phrases resulted in extremely faster or slower reading times. The main effect of scrambling was not significant either in participant analysis [F_1(1,91)=2.83, *n.s.*], or in item analysis [F_2(1,44)=4.01, *n.s.*]. The interaction of scrambling and phrase-length order was not significant in participant analysis [F_1(1,91)=0.03, *n.s.*], or item analysis [F_2(1,44)=0.21, *n.s.*]. To conclude, the reading times of short phrases were not effected by phrase-length and scrambling.

Reading Times of Long Phrases

In the same manner as with the analysis of reading times of short phrases, reading times of long phrases were matched across the four types of sentences. The same 2 X 2 ANOVA with the repeated measures was performed on reading times of a long phrase. The main effect of phrase-length order was not significant in participant analysis [F_1(1,91)=0.16, *n.s.*], or in item analysis [F_2(1,44)=1.20, *n.s.*]. Likewise, the main effect of scrambling was not significant in either participant analysis [F_1(1,91)=0.01, *n.s.*], or item analysis [F_2(1,44)=0.16, *n.s.*]. In addition, the interaction of scrambling and phrase-length order was not significant in participant analysis [F_1(1,91)=0.03, *n.s.*], or item analysis [F_2(1,44)=0.21, *n.s.*]. Therefore, phrase-length order and scrambling had no effect on reading times for long phrases.

Reading Times of Verbs

Japanese sentences being head-final, all the verbs across the four types of sentences come at the end; it was therefore possible to directly compare all the conditions. A 2 X 2 ANOVA with the repeated measures was performed on the reading times of verbs. The main effect of phrase-length order was not significant in participant analysis [F_1(1,91)=0.46, *n.s.*], or in item analysis [$F_2(1,44)=1.15$, *n.s.*]. The main effect of scrambling was not significant in either participant analysis [$F_1(1,91)=0.09$, *n.s.*], or item analysis [$F_2(1,44)=0.02$, *n.s.*]. The interaction of scrambling and phrase-length order was not significant in participant analysis [$F_1(1,91)=0.28$, *n.s.*], or item analysis [$F_2(1,44)=0.44$, *n.s.*]. Again, there were no effects of phrase-length order and scrambling on the reading times of verbs.

Reading Times of Whole Sentences

In that there were neither significant main effects nor significant interactions in the reading times of short phrases, long phrases and verbs, it was naturally expected that there would be no significant effects in the reading times of whole sentences. To confirm this, the present study performed a 2 X 2 ANOVA with the repeated measures for the reading times of whole sentences. As expected, the main effect of phrase-length order was not significant in participant analysis [$F_1(1,91)=0.62$, *n.s.*], or in item analysis [$F_2(1,44)=3.52$, *n.s.*]. The main effect of scrambling was not significant in either participant analysis [$F_1(1,91)=0.11$, *n.s.*], or item analysis [$F_2(1,44)=0.67$, *n.s.*]. The interaction of scrambling and phrase-length order was not significant in participant analysis [$F_1(1,91)=0.00$, *n.s.*], or item analysis [$F_2(1,44)=0.02$, *n.s.*]. Again, there were no effects of phrase-length order and scrambling on the reading times of whole sentences.

Duration Times of Sentence Correctness Decisions

After reading a whole sentence, participants made a correctness decision based upon their syntactic and semantic understanding. The duration times of a correctness decision for a sentence were also analyzed using a 2 X 2 ANOVA with the repeated measures. The main effect of phrase-length order was not significant in participant analysis [$F_1(1,91)=0.19$, *n.s.*], or in item analysis [$F_2(1,44)=0.51$, *n.s.*]. The main effect of scrambling was not significant in either participant analysis [$F_1(1,91)=1.48$, *n.s.*], or item analysis [$F_2(1,44)=2.71$, *n.s.*]. The interaction of scrambling and phrase-length order was not significant in participant analysis [$F_1(1,91)=1.25$, *n.s.*], or item analysis [$F_2(1,44)=2.33$, *n.s.*]. Therefore, phrase-length order and scrambling did not effect duration times of sentence correctness decisions.

Error Rates of Sentence Correctness Decisions

Error rates of correctness decisions for correct ‘Yes’ responses (48 appropriate sentences) were analyzed using a 2 X 2 ANOVA with the repeated measures. The main effect of phrase-length order was not significant in participant analysis [$F_1(1,91)=2.48$, *n.s.*], or in item analysis [$F_2(1,44)=1.86$, *n.s.*]. The main effect of scrambling was significant in both participant analysis [$F_1(1,91)=5.58$, $p<.05$], and item analysis [$F_2(1,44)=5.19$, $p<.05$]. The interaction of scrambling and phrase-length order was not significant in participant analysis [$F_1(1,91)=0.16$, *n.s.*], or item analysis [$F_2(1,44)=0.12$, *n.s.*]. Therefore, scrambling influenced the error rates of correctness decisions. As shown in Table II, the overall average error rate of SOV canonical sentences was 5.2 percent while the average error rate of OSV scrambled sentences was 12.9 percent. It was concluded that the effects of scrambling created this 7.7 percent difference in the error rates.

DISCUSSION

Reading times of short phrases, long phrases, verbs and whole sentences, which were measured by the method of self-paced reading, did not differ in terms of phrase-length order and scrambling. In addition, four different types of sentences constructed on the basis of phrase-length order and scrambling did not affect duration times of correctness decision making for sentences. Despite all these findings of no effects, the present experiment found that error rates differed between canonical and scrambled sentences regardless of phrase-length order. This result implies that scrambled sentences were harder to judge as correct sentences than canonical sentences. Thus, scrambling affects the appropriate integration of inputted information while phrase-length order is simply an indication of ‘preference’, and not of ‘cognitive processing’.

Considering the above conditions, the question arises as to how these results can be explained in terms of syntactic structure. In that effects of scrambling and phrase-length order were not observed in reading time and sentence-correctness decision time, the present experiment did not support the use of the configurational structure with movement for syntactic as depicted in Figure 2. Nevertheless, task errors occurred in scrambled sentences at a higher rate than those in canonical sentences. Therefore, this result of higher errors did not wholly sustain the non-configurational structure as depicted in Figure 1. For the explanation of these results, we propose the third type of syntactic structure, ‘configurational structure without movement’, as shown in Figure 3. In this model, both the structures of canonical and scrambled sentences are ‘base-generated’ and, therefore, both structures are available for syntactic parsing from the initiating stage. However, as shown in Figure 6, the nominative NP-ga is placed at a higher level in the structure of canonical sentences whereas the accusative NP-o is also placed in the same higher level for scrambled sentences. Thus, apart from higher error rates, syntactic operations such as the ‘gap’ filling parsing shown in Figure 4 for scrambled sentences is not required.

Despite no difference in reading times, errors were more frequently produced in scrambled sentences than canonical sentences. When the nominative NP-ga (subject) comes first (i.e., a canonical sentence), the VP is constructed by the accusative NP-o (object) and verb. In this condition of SOV, as depicted in Figure 5, the object NP-o is checked to match with the following verb. This matching process is completed easily within a single VP level. On the other hand, when the accusative NP-o comes first (i.e., a scrambled sentence), the matching between the accusative NP-o and the verb is not so easily completed due to the change in the level of structure. Matching is required between the NP-o and the VP (consisted of the NP-ga and the verb). A greater number of errors were produced in scrambled sentences than in canonical ones, because the matching process between object and verb goes beyond a single structural level. As such, the present study proposed the configurational structure without movement for the processing of scrambled sentences.

Insert Figure 6 about here.

Three Fundamental Issues

Although the present study proposed the configurational structure without movement as the third type of syntactic structure, it would be premature to draw concrete conclusions from the results of this single experiment. Closely examining the three studies by Chujo (1983), Nakayama (1995), Yamashita (1997) and ourselves, we suggest further investigating the following three issues.

The first issue rests upon the complexity of stimulus sentences. Chujo (1983) used a simple sentence containing a verb of two arguments without adjectives and adverbs. In contrast, Nakayama (1995) and Yamashita (1997) constructed longer stimulus sentences accompanied by adjectives. Likewise, the present study also utilized longer sentences to examine the effects of phrase-length order. These longer, and to some degree more complex sentences may have weakened the effects of scrambling, which resulted in the null effects obtained by Nakayama (1995), Yamashita (1997) and our study. It could also explain how Chujo (1983) observed the pure effects of scrambling by avoiding sentence complexity.

The second issue is whether method of self-paced reading is a proper means to determine processing speed. While self-paced reading has been used in previous studies of sentence processing (e.g., Hirose & Inoue, 1998; Mazuka, Itoh & Kondo, 1997; Nakayama, 1995; Sakamoto, 1996), we observed that Japanese speakers were likely to read at a constant pace of speed while pressing a key to see the next phrase. Once a key-pressing pace was established, no difference in reading speed was observed regardless how sentences were structured. The null effects of scrambling found by Nakayama (1995), Yamashita (1997) and the present study can be partially attributed this constant key-pressing rhythm. On the other hand, Chujo (1983) displayed all words in a sentence at once. Again, it could be explained that due to this display method, Chujo (1983) successfully observed the effects of scrambling in reaction time on sentence correctness.

The third issue is concerning with the nature of tasks. Yamashita (1997) used a probe word after each sentence to check whether a Japanese speaker carefully read it. In this task, Japanese speakers had to concentrate on remembering words used in a sentence, rather than simply processing sentences. In this case, the self-paced reading set up by the speed of checking with each word again nulls the effects of scrambling. In Chujo's study (1983), a semantic decision task was used asking participants whether or not a sentence made sense. In this task, Chujo recorded half of the sentences incorrect in terms of semantic context. This straightforward method could be useful for examining scrambling effects. The present study used a similar task, but sentences for 'No' responses had two types. One half of the sentences were semantically incorrect while the other half were syntactically incorrect. However, it should be pointed out that Chujo included sentences with no case particles such as *Osamu nimotu oita*. In the experiments of Chujo, this type of sentence was considered as a correct response; however, the inclusion of sentences with no case particles could be judged as an incorrect response. We have no way to see how Japanese speakers responded to these sentences with no case particles because Chujo did not report error rates. This fundamental problem detracts from the strength of Chujo's argument.

As these issues remain an unanswered, the effects of scrambling in the cognitive processing of Japanese sentences should continue to be thoroughly investigated in future studies.

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Table I. Examples of Sentences in a Function of Phrase-Length Order and Scrambling in Experiment 1

Phrase Length	Scrambling	Sentence Examples		
Short before long (English preferred)	SOV – Canonical sentence	wakai dansei-ga Short subject NP-ga nominative a young man	kon'iro-no zubon-o haita tyuunen-no dansei-o Long object NP-o accusative a middle-aged man wearing blue pants	korosita. Verb killed
	OSV – Scrambled sentence	wakai dansei-o Short object NP-o accusative a young man	kon'iro-no zubon-o haita tyuunen-no dansei-ga Long subject NP-ga nominative a middle-aged man wearing blue pants	korosita. Verb killed
Long before short (Japanese preferred)	SOV – Canonical sentence	kon'iro-no zubon-o haita tyuunen-no dansei-ga Long subject NP-ga nominative a middle-aged man wearing blue pants	wakai dansei-o Short object NP-o accusative a young man	korosita. Verb killed
	OSV – Scrambled sentence	kon'iro-no zubon-o haita tyuunen-no dansei-o Long object NP-o accusative a middle-aged man wearing blue pants	wakai dansei-ga Short subject NP-ga nominative a young man	korosita. Verb killed

Table II. Error Rates (%), Sentence Reading (ms) and Sentence-Correctness Decision Time (ms) in a Function of Phrase Length and Scrambling in Experiment 1

Phrase Length	Scrambling	Short Phrase		Long Phrase		Verb		Total Time		Correctness Decision		Error Rate	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Short before long	SOV	950	276	2183	775	515	204	3648	232	641	176	6.9%	17.0%
	OSV	891	255	2168	750	526	261	3584	237	750	286	13.9%	25.9%
Long before short	SOV	844	302	2125	646	508	209	3478	232	686	220	3.5%	12.4%
	OSV	803	284	2111	609	471	196	3386	232	691	217	11.8%	21.2%

Note: 'M' refers to a mean while 'SD' refers to a standard deviation.

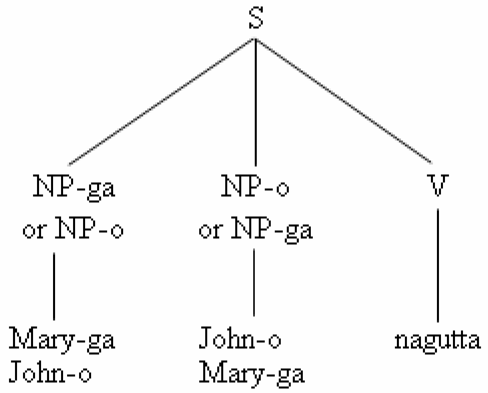
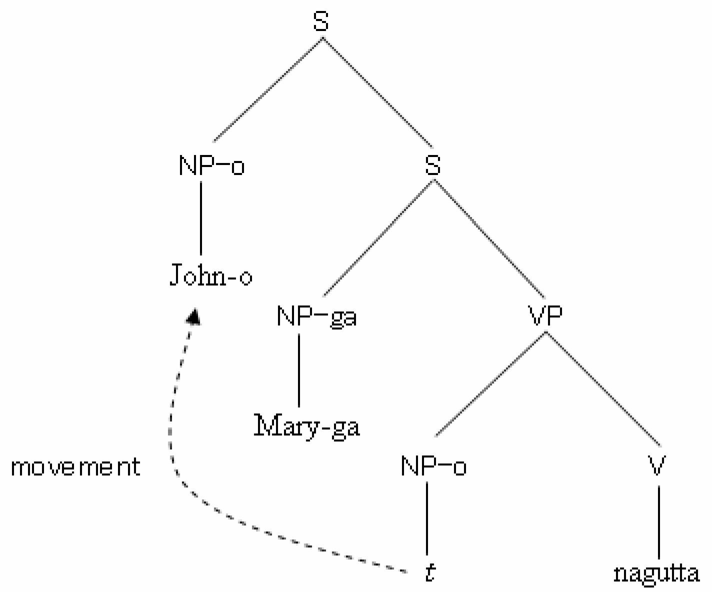


Fig. 1. Non-configurational structure

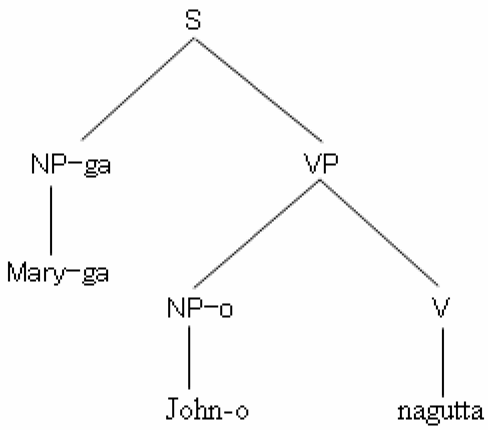
Note: NP-ga refers to a nominative case-marked noun phrase.
NP-o refers to an accusative case-marked noun phrase.



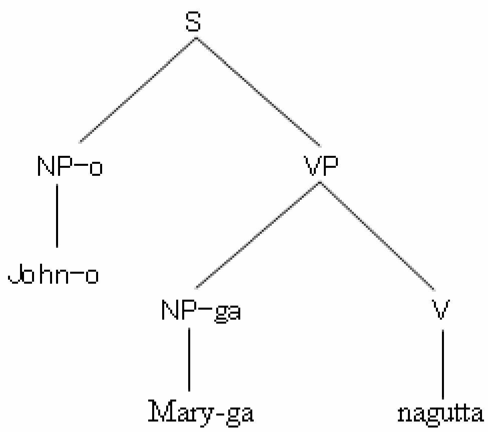
(ii) A scrambled order

Fig. 2. Configurational structure with movement

Note: NP-ga refers to a nominative case-marked noun phrase.
NP-o refers to an accusative case-marked noun phrase.
t refers to a trace.



(i) A canonical order



(ii) A scrambled order

Fig. 3. The configurational structure without movement

Note: NP-ga refers to a nominative case-marked noun phrase.
NP-o refers to an accusative case-marked noun phrase.

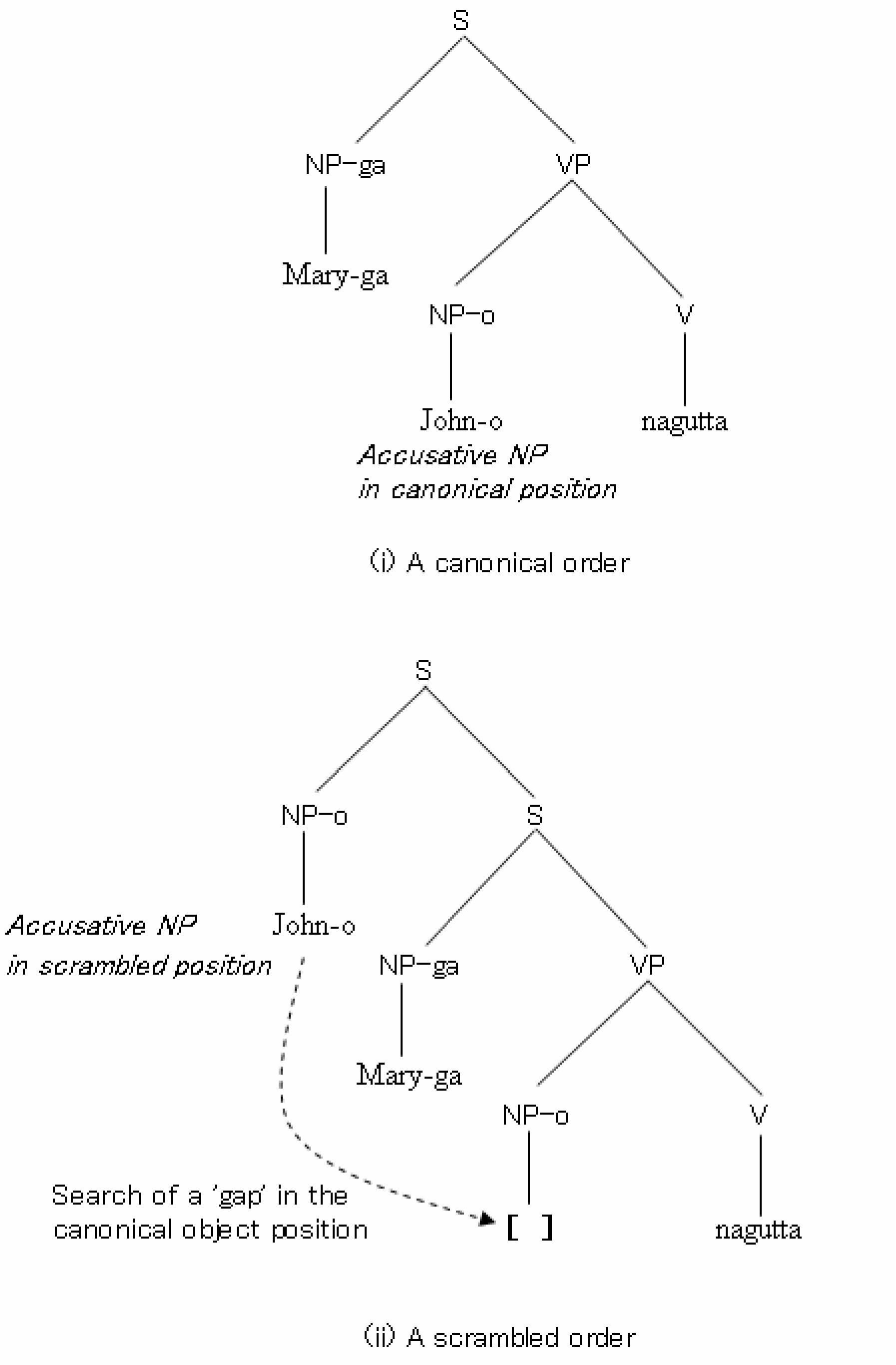


Fig. 4. The hypothesis of 'gap' filling parsing

Note: NP-ga refers to a nominative case-marked noun phrase.
NP-o refers to an accusative case-marked noun phrase.
[ ] refers to a 'gap'.

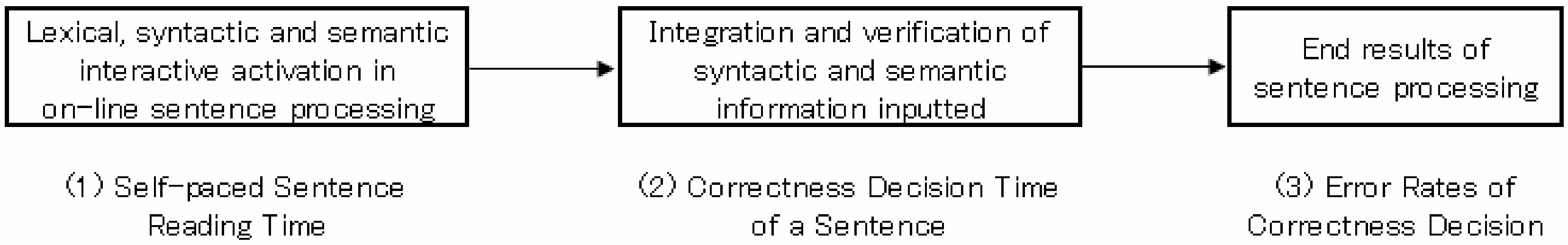
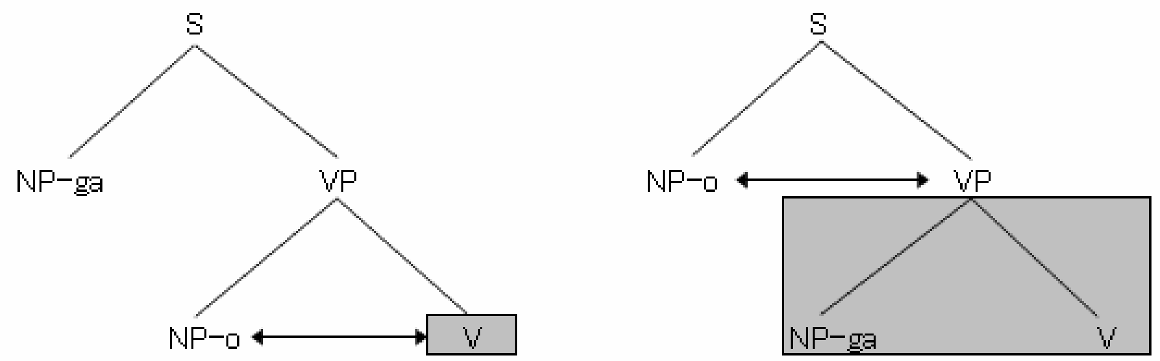


Fig. 5. Measurements of sentence processing in the present experiment



(i) A canonical order (ii) A scrambled order

Fig. 6. Matching of NP−o and verb in configurational structure without movement
Note: Arrows refer to semantic matching.

APPENDIX

Sentences used for the semantic decision task in Experiment

1 Correct sentences for semantic decision (correct 'Yes' responses)

1.1 SOV sentences with the order of short before long

1 黄組の女の子が赤いリボンをしている白組の女の子を突き飛ばした。
Kiigumi-no on'nanoko-ga akai ribon-o siteiru sirogumi-no on'nanoko-o tukitobasita.

2 若い男性が青いスカートをはいた若い女性を驚かした。
wakai dansei-ga aoi sukaato-o haita wakai zyosei-o odorokasita.

3 A高校の生徒が黒いトレーニングウエアを着たB高校の生徒を脅した。
A kookoo-no seito-ga kuroi toreeningu uea-o kita B kookoo-no seito-o odosita.

4 A子さんが帰りの電車の中で窓側にすわっていたB子さんを起こした。
A-ko san-ga kaeri-no densya-no naka-de madogiwa-ni suwatte ita B-ko san-o okosita.

5 1組の女の子がドアの前に立っていた2組の男の子をにらみつけた。
1-kumi-no on'nanoko-ga doa-no mae-ni tatteita 2-kumi-no otokonoko-o niramituketa.

6 A社の社員が5時で勤務時間が終わったB社の社員を連れ出した。
A-sya-no syain-ga 5-ji-de kinmu zikan-ga owatta B-sya-no syain-o turedasita.

7 A校の選手が青いユニフォームを着たB校の選手を追い抜いた。
A-koo-no sensyu-ga aoi yunihoomu-o kita B-koo-no sensyu-o oinuita.

8 A高校の生徒が黒い学生服を着たB高校の生徒を背負った。
A-kookoo-no seito-ga gakuseihuku-o kita B-kookoo-no seito-o seotta.

9 A社の社員が社員食堂で昼食をとっていたB社の社員を呼び出した。
A-sya-no syain-ga syain syokudoo-de tyuusyoku-o totteita B-sya-no syain-o yobidasita.

10 1組の男の子が白いTシャツを着た2組の男の子を蹴飛ばした。
1-kumi-no otokonoko-ga siroi T-syatu-o kita 2-kumi-no otokonoko-o ketobasita.

11 2組の男の子が黒い半ズボンをはいた3組の男の子を泣かした。
2-kumi-no otokonoko-ga kuroi hanzubon-o haita 3-kumi-no otokonoko-o nakasita.

12 若い男性が紺色のズボンをはいた中年の男性を殺した。
Wakai dansei-ga kon'iro-no zubon-o haita tyuunen-no dansei-o korosita.

1.2 OSV sentences with the order of short before long

1 黄組の女の子を赤いリボンをしている白組の女の子が突き飛ばした。
Kiigumi-no on'nanoko-o akai ribon-o siteiru sirogumi-no on'nanoko-ga tukitobasita.

2 若い男性を青いスカートをはいた若い女性が驚かした。
Wakai dansei-o aoi sukaato-o haita wakai zyosei-ga odorokasita.

3 A高校の生徒を黒いトレーニングウエアを着たB高校の生徒が脅した。
A-kookoo-no seito-o kuroi toreeningu uea-o kita B-kookoo-no seito-ga odokasita.

4 A子さんを帰りの電車の中で窓側にすわっていたB子さんが起こした。
A-ko san-o kaeri-no densya-no naka-de madogawa-ni suwattteita B-ko san-ga okosita.

5 1組の女の子をドアの前に立っていた2組の男の子がにらみつけた。
1-kumi-no on'nanoko-o doa-no mae-ni tatteita 2-kumi-no otokonoko-ga niramituketa.

6 A社の社員を5時で勤務時間が終わったB社の社員が連れ出した。
A-sya-no syain-o 5-ji-de kinmu zikan-ga owatta B-sya-no syain-ga turedasita.

7 A校の選手を青いユニフォームを着たB校の選手が追い抜いた。
A-koo-no sensyu-o aoi yunihoomu-o kita B-koo-no sensyu-ga oinuita.

8 A高校の生徒を黒い学生服を着たB高校の生徒が背負った。
A-kookoo-no seito-o kuroi gakuseihuku-o kita B-kookoo-no seito-ga seotta.

9 A社の社員を社員食堂で昼食をとっていたB社の社員が呼び出した。
A-sya-no syain-o syainshokudoo-de tyuusyoku-o totteita B-sya-no syain-ga yobidasita.

10 1組の男の子を白いTシャツを着た2組の男の子が蹴飛ばした。
1-kumi-no otokonoko-o syiroi T-syatu-o kita 2-kumi-no otokonoko-ga ketobasita.

11 2組の男の子を黒い半ズボンをはいた3組の男の子が泣かした。
2-kumi-no otokonoko-o hanzubon-o haita 3-kumi-no otokonoko-ga nakasita.

12 若い男性を紺色のズボンをはいた中年の男性が殺した。
Wakai dansei-o kon'iro-no zubon-o haita tyuunen-no dansei-ga korosita.

1.3 SOV sentences with the order of long before short

1 赤いリボンをしている白組の女の子が黄組の女の子を突き飛ばした。
Akai ribon-o siteiru sirogumi-no on'nanoko-ga kiigumi-no on'nanoko-o tukitobasita.

2 青いスカートをはいた若い女性が若い男性を驚かした。
Aoi sukaato-o haita wakai zosei-ga wakai dansei-o odorokasita.

3 黒いトレーニングウエアを着たB高校の生徒がA高校の生徒を脅した。
Kuroi toreeningu uea-o kita B-kookoo-no seito-ga A-kookoo-no seito-o odosita.

4 帰りの電車の中で窓側にすわっていたB子さんがA子さんを起こした。
Kaerino densya-no naka-de madogawa-ni suwatteita B-ko san-ga A-ko san-o okosita.

5 ドアの前に立っていた2組の男の子が1組の女の子をにらみつけた。
Doa-no mae-ni tatteita 2-kumi-no otokonoko-ga 1-kumi-no on'nanoko-o niramituketa.

6 5時で勤務時間が終わったB社の社員がA社の社員を連れ出した。
5-zi-de kinmuzikan ga owatta B-sya-no syain-ga A-sya-no syain-o turedasita.

7 青いユニフォームを着たB校の選手がA校の選手を追い抜いた。
Aoi yunihoomu-o kita B-koo-no sensyu-ga A-koo-no sensyu-o oinuita.

8 黒い学生服を着たB高校の生徒がA高校の生徒を背負った。
Kuroi gakuseihuku-o kita B-koo-no seito-ga A-koo-no seito-o seotta.

9 社員食堂で昼食をとっていたB社の社員がA社の社員を呼び出した。
Syain syokudoo-de tyuushoku-o totteita B-sya-no syain-ga A-sya-no syain-o yobidasita.

10 白いTシャツを着た2組の男の子が1組の男の子を蹴飛ばした。
Siroi T-syatu-o kita 2-kumi-no otokonoko-ga 1-kumi-no otokonoko-o ketobasita.

11 黒い半ズボンをはいた3組の男の子が2組の男の子を泣かした。
Kuroi hanzubon-o haita 3-kumi-no otokonoko-ga 2-kumi-no otokonoko-o nasasita.

12 紺色のズボンをはいた中年の男性が若い男性を殺した。
Kon'iro-no zubon-o haita tyuunen-no dansei-ga wakai dansei-o korosita.

1.4 OSV sentences with the order of long before short

1 赤いリボンをしている白組の女の子を黄組の女の子が突き飛ばした。
Akai ribon-o siteiru sirogumi-no on'nanoko-o kiigumi-no on'nanoko-ga tukitobasita.

2 青いスカートをはいた若い女性を若い男性が驚かした。
Aoi sukaato-o haita wakai zyosei-o wakai dansei-ga odokasita.

3 黒いトレーニングウエアを着たB高校の生徒をA高校の生徒が脅した。
Kuroi toreeningu uea-o kita B-kookoo-no seito-o A-kookoo-no seito-ga odosita.

4 帰りの電車の中で窓側にすわっていたB子さんをA子さんが起こした。
Kaeri-no densya-no naka-de madogawa-ni suwatteita B-kosan-o A-ko san-ga okosita.

5 ドアの前に立っていた2組の男の子を1組の女の子がにらみつけた。
Doa-no mae-ni tatteita 2-kumi-no otokonoko-o 1-kumi-no on'nanoko-ga niramituketa.

6 5時で勤務時間が終わったB社の社員をA社の社員が連れ出した。
5-zi-de kinmuzikan-ga owatta B-sya-no syain-o A-sya-no syain-ga turedasita.

7 青いユニフォームを着たB校の選手をA校の選手が追い抜いた。
Aoi yunihoomu-o kita B-koo-no sensyu-o A-koo-no sensyu-ga oinuita.

8 黒い学生服を着たB高校の生徒をA高校の生徒が背負った。
Kuroi gakuseihuku-o kita B-kookoo-no seito-o A-kookoo-no seito-ga seotta.

9 社員食堂で昼食をとっていたB社の社員をA社の社員が呼び出した。
Syainsyokudoo-de tyuusyoku-o totteita B-sya-no syain-o A-sya-no syain-ga yobidasita.

10 白いTシャツを着た2組の男の子を1組の男の子が蹴飛ばした。
Siroi T-syatu-o kita 2-kumi-no otokonoko-o 1-kumi-no otokonoko-ga ketobasita.

11 黒い半ズボンをはいた3組の男の子を2組の男の子が泣かした。
Kuroi hanzubon-o haita 3-kumi-no otokonoko-o 2-kumi-no otokonoko-ga nakasita.

12 紺色のズボンをはいた中年の男性を若い男性が殺した。
Kon'iro-no zubon-o haita tyuunen-no dansei-o wakai dansei-ga korosita.

2 Incorrect sentences used for the semantic decision (correct 'No' responses)

Note: These 12 incorrect sentences were used for all the subjects in Experiment 1.
In case of incorrect sentences, the numbers do not correspond with correct sentences.

1 1組の男の子が一緒に遊んでいた2組の男の子の頭を聞いた。
1-kumi-no otokonoko-ga issyo-ni asondeita 2-kumi-no otokonoko-no atama-o kiita.
2 若い女性が小さい女の子を連れた中年の女性を微笑みかけた。
Wakai zyosei-ga tyiisai on'nanoko-o tureta tyuunen-no zyosei-o hohoemikaketa.
3 警察官が黒いセーターを着て野球帽をかぶった犯人を閉めた。
Keisatukan-ga kuroi seetaa-o kite yakyuuboo-o kabutta han'nin-o simeta.
4 若い女性が紺色のスーツを着た若い男性によって歩み寄った。
Wakai zyosei-ga kon'iro-no suutu-o kita wakai dansei-ni yotte ayumiyotta.
5 若い女性が花柄のスカートをはいた中年の女性に引っ掻いた。
Wakai zyosei-ga hanagara-no sukaato-o haita tyuunen-no zyosei-ni hikkaita.
6 白組の男の子が自分より背の高い黄組の男の子になでた。
Sirogumi-no otokonoko-ga zyibun-yori se-no takai kiigumi-no otokonoko-ni nadeta.
7 赤いスカートをはいた白組の女の子が黄組の男の子がたたいた。
Akai sukaato-o haita syirogumi-no on'nanoko-ga kiigumi-no otokonoko-ga tataita.
8 白いユニフォームを着たBチームの選手にAチームの選手を負けた。
Siroi yunihoomu-o kita B-tyiimu-no sensyu-ni A-tyiimu-no sensyu-o maketa.
9 手に画用紙を持った2組の女の子が1組の女の子を咲いた。
Te-ni gayoosi-o motta 2-kumi-no on'nanoko-ga 1-kumi-no on'nanoko-o saita.
10 酒に酔った背の高い若い男性が警察官をつかみかかった。
Sake-ni yotta se-no takai wakai dansei-ga keisatukan-o tukamikakkata.
11 赤いコートを着た若い女性が中年の女性が歩いた。
Akai kooto-o kita wakai zyosei-ga tyuunen-no zyosei-ga aruita.
12 手に拳銃を持った背の高い警察官が犯人に取り押さえた。
Te-ni kenzyuu-o motta se-no takai keisatukan-ga han'nin-o toriosaeta.