Cognitive Studies, 14(2), 173-191. (June 2007)

● Research Paper ●

Syntactic Priming Effects on the Processing of Japanese Sentences with Canonical and Scrambled Word Orders

Jun-Ichi Tanaka[1,2], Katsuo Tamaoka[3], and Hiromu Sakai[1]

The present study conducted two experiments to examine the effects of syntactic priming in sentence comprehension, using a cross-modal priming task which required participants to make acceptability judgment of Japanese sentences with canonical and scrambled word orders. Experiment 1 investigated whether or not the speed of target sentence processing would be affected by the syntactic structure of prime sentences. Prime sentences matching target sentences in word order facilitated processing of target sentences even though prime-target pairs shared no content words, while prime-target pairs with mismatched word orders demonstrated weak facilitation effects. Experiment 2 examined the processing speed of target sentences primed by a sequence of nouns without any syntactic structure. The weak priming effects disappeared in the noun prime condition, which suggested that those observed in the mismatch condition in Experiment 1 were due to partial overlap of the syntactic structure. The overall results showed that the priming effects observed in these experiments were syntactic in nature and independent of lexical/semantic priming.

Keywords: syntactic structure, sentence comprehension, priming effects, scrambled word order, cross-modal priming

1. Introduction

An extension of the Modularity Hypothesis (e.g. Fodor, 1983; Forster, 1979) conceives the language faculty as being divided into subcomponents. Under this view, phonology, syntax, semantics and the lexicon are 'sub-modules' within the language module. The modularity of the syntactic parsing mechanism, among other aspects in sentence processing such as phonological/orthographic processing or lexical/semantic processing, has been a central research question of late. Many efforts to address this question use behavioral and physiological approaches.

In behavioral studies, there have been conflicting reports as to how the phonological, syntactic, and semantic levels of language affect each other. For example, Marslen-Wilson (1975) presented experimental data that phonological or lexical processes affect syntactic or semantic processes. However, Swinney (1979) reported experimental evidence for the independence of lexical processing from contextual information by using the cross-modal lexical priming method. In some ERP studies (e.g., Friederici, 2002; Friederici & Kotz, 2003), it was suggested that syntactic and semantic processing are independent of each other by presenting the existence of different ERP components sensitive to conceptual (i.e., semantic and pragmatic) violations (N400) or syntactic violations (LAN or Left Anterior Negativity and P600). In studies of aphasia (e.g., Hagiwara, 1998) and fMRI studies (e.g., Embick, Marantz, Miyashita, O'Neil, & Sakai, 2000;

1. Graduate School of Education, Hiroshima University, 2. Ph. D. Program in Linguistics, Graduate Center at the City University of New York, 3. International Student Center, Hiroshima University.

Hashimoto & Sakai, 2002; Suzuki & Sakai, 2003). a wealth of data demonstrated the functional independence of syntactic and semantic processing in terms of the brain area activated in certain specific processing, especially the Broca's area when engaged in syntactic processing.

Building upon these previous studies, the purpose of the present research is to provide a new set of data for the functional independence of syntactic parsing by considering syntactic priming effects in Japanese sentence processing. A large body of observational and experimental evidence indicates that people tend to use a particular syntactic structure if that structure has recently been employed. As an example of this tendency (i.e., syntactic priming) in sentence production, Bock (1986) reported syntactic priming effects by using the guise of a memory test. In her experiments, participants were instructed to repeat a prepositional object (PO) sentence like (1a) or a double object (DO) sentence like (1b) as prime.

(1) a. The rock star sold some cocaine to an undercover agent.
b. The rock star sold an undercover agent some cocaine.

Participants were presented a picture that was not semantically related with a prime sentence and could be represented by using PO or DO sentences immediately after repeating one of these sentences. Then participants tended to describe the picture by using the same syntactic form as prime sentence. Bock (1986) also found priming effects with active and passive sentences. Other studies have demonstrated syntactic priming effects by using sentence completion (e.g., Pickering & Branigan, 1998; Pickering, Branigan, & McLean, 2002), sentence recall (e.g., Potter & Lombardi, 1998) and picture description (e.g., Branigan, Pickering, & Cleland, 2000; Cleland & Pickering, 2003). Syntactic priming effects were observed not only in English but also in Dutch (e.g., Hartsuiker & Kolk, 1998) and Japanese (e.g., Yamashita, Hirose, & Chang, 2003).

There have been efforts to investigate syntactic priming effects in sentence comprehension. In terms of materials and design, these previous experiments, however, were not sufficient to separate syntactic information and lexical information, and results on syntactic priming effects in sentence comprehension were inconsistent. For instance, Frazier, Taft, Roeper, Clifton, & Ehrlich (1984) reported shorter reading times for the second clause of a conjoined sentence when the syntactic forms of first and second clause were similar than when these were different. However, since the same verbs were used in two clauses in this experiment, the results could be interpreted as the facilitative effect of not only syntactic processing but also lexical processing. Likewise, Branigan, Pickering, Liversedge, Stewart, & Urbach (1995) reported syntactic priming effects in sentence comprehension only for sentences with local syntactic ambiguities. Although they claimed that the priming effects appeared when the parser has to choose among competing syntactic alternatives, they also implied that the syntactic priming effects could be observed in the absence of competition.

In addition, in the field of brain imaging research, Noppeney & Price (2004) demonstrated syntactic priming effects by using behavioral and physiological (BOLD signal in fMRI) measures. In their fMRI study, activity in the left temporal pole decreased when subjects read a series of sentences with similar syntactic form than dissimilar syntactic form. These authors argued that when successive sentences followed the same syntactic structure, it was less demanding for the reader to assign thematic roles to the sentence arguments. However, this study relied on large number of repetitions and that areas of the right-hemisphere that are not normally thought to be involved in syntactic parsing showed substantial activation. And they implied that further research would be needed to specify the contributions of lexical/sentential semantics and syntac-

tic frames in the processing of semantic-syntactic integration.

As such, there remains considerable scope for improvement upon previous studies of syntactic priming effects in sentence comprehension, especially with respect to experimental materials and methods. The most important point in investigating syntactic priming effects is to separate the effect of syntactic processing from other aspects of language processing.

The present study used Japanese sentences with canonical and scrambled word (or more precisely, phrase) order.

(2) a. Takashi-ga ringo-o tabeta.
Takashi-Nom apple-Acc ate
'Takashi ate an apple.'
b. Ringo$_i$-o Takashi-ga [t$_i$] tabeta.
apple-Acc Takashi-Nom gap$_i$ ate
'Takashi ate an apple.'

Studies in theoretical linguistics (e.g., Saito, 1985) suggested that the accusative NP in a scrambled sentence like (1b) is fronted in the initial position leaving a gap in its original position. That is, Japanese scrambled sentences like (2b) have a more complex structure than (2a).

This implication was supported by some experimental results that found the reading times or grammatical judgment times of scrambled sentences like (2b) were longer than canonical sentences like (2a) (e.g., Tamaoka, Sakai, Kawahara, Lim, Miyaoka, & Koizumi, 2005; Koizumi & Tamaoka, 2004; Mazuka, Ito, & Kondo, 2002; Miyamoto & Takahashi, 2002a, 2002b, 2004). For instance, Tamaoka et al. (2005) reported that the reaction times of canonical sentences were faster than scrambled sentences in Japanese active sentences with transitive verbs, active sentences with ditransitive verbs, passive sentences with transitive verbs and potential sentences. These consistent results supported the theoretical linguistic accounts provided by Saito (1985) and implied that the parser relates the initial position of the accusative NP with the original position. Miyamoto & Takahashi (2002a, 2002b, 2004) also suggested the existence of filler-gap dependencies in Japanese sentence processing by reporting longer reading times of scrambled sentences and priming effects by reactivation of a scrambled constituent at the gap position.

Since there is only a word order difference between (2a) and (2b), while phonological/orthographic and lexical/semantic processes are equivalent, the scrambling phenomenon in Japanese is ideal as an experimental stimuli for separating syntactic processes from other aspects of sentence processing such as phonological/orthographic or lexical/semantic processes. We thus use sentences with canonical and scrambled word order to investigate the nature of syntactic priming effects in sentence comprehension.

2. Outline of Experiments

In the present study, two experiments were conducted to examine whether the effects of syntactic priming could be extracted independently from the effects of lexical/semantic priming by using acceptability judgment task with a cross-modal priming paradigm. Experiment 1 investigated whether or not the speed of target sentence processing is different when the syntactic form of the target sentence and the prime sentence were congruent or incongruent. We predicted that priming effects could be observed when the syntactic form of the target sentence was identical to that of the prime sentence because participants would process the same syntactic form successively. In Experiment 1, however, all of the prime stimuli were sentences, which have syntactic structure, except the control baseline of white noise; that is to say, the effects of the prime sentence which have syntactic structure and the prime stimulus which has no syntactic structure could not be distinguished. It was not enough to conclude whether the effects of prime resulted from the similarity of the syntactic form by Experiment 1 itself. Therefore, Experiment 2 was conceived to further investigate this problem.

Experiment 2 examined whether or not the

speed of target sentence processing is different when the prime stimulus is a sentence or a sequence of nouns. We predicted that priming effects could be observed when the syntactic form of the prime sentence and the target sentence were identical, as in Experiment 1 and would not be evident when the prime was a sequence of nouns due to a lack of syntactic structure.

In either of these two experiments, a cross-modal priming design is used in order to avoid facilitation effects at the level of visual or auditory processing level. Acceptability judgment task was required in each trial to ensure processing of stimuli sentences. Although judgment component itself included lexical or semantic factors, these potential confounding factors are strictly controlled and counter-balanced by comparing reaction time for exactly the same target sentences with congruent primes or incongruent primes that contains exactly the same lexical or semantic contents. It is thus possible to say that syntactic processing can be separated from other aspects of language processing if priming effects could be observed only in the prime-and-target congruent condition.

3. Experiment 1

Using the priming paradigm, the first experiment tested whether or not native Japanese speakers take shorter reaction times for the prime-and-target congruent canonical (SOV) and scrambled (OSV) structures than for the prime-and-target incongruent canonical (SOV) and scrambled (OSV) structures. The first prediction is that reaction times of the congruent condition are significantly shorter than those of the control condition. The second prediction is that reaction times of the incongruent condition are significantly longer than those of the control condition or significant difference is not observed between two conditions. If the results tuned out as predicted, Japanese sentence comprehension would be shown to be affected by syntactic priming (i.e., priming effects). Furthermore, if the congruent condition showed larger priming facilitation effects than the incongruent condition, priming effects would be caused by the congruency of syntactic structure between primes and targets.

3.1 Method

3.1.1 Participants

Forty-eight graduate and undergraduate students (20 females and 28 males) at Hiroshima University in Japan, all native speakers of Japanese, participated in the first experiment. Ages ranged from 19 years and 1 month to 36 years and 6 months, with the average age being 21 years and 5 months on the day of testing.

3.1.2 Materials

120 correct and 120 incorrect sentences were prepared for the target sentence correctness decision task. Correct 'Yes' responses (i.e. acceptable Japanese sentences) consisted of 120 active sentences with transitive verbs. These 120 sentences were arranged in canonical order, and nominative case marked subjects (NP-*ga*) and accusative case marked objects (NP-*o*) were then swapped to create sentences of scrambled order. For example, the sentence *Ken-Ichi-ga shukudai-o wasureta* ('Kenichi forgot his homework') was altered to read *shukudai-o Ken-Ichi-ga wasureta* (same meaning, only in scrambled order). Since the canonical and scrambled sentences were identical in terms of word used, the difference in syntactic structure can be directly compared in reaction times and correct rates.

As shown in Table 1, six types of correct prime-target stimuli pairs were used in Experiment 1. The first and second types of stimuli were white noise primed sentences. The presentation time of white noise (1,990ms) was the same as the average of the presentation time of sentence primes. The third and fourth types of stimuli were canonical order (SOV) primed sentences, of which 40 were prepared. The same number of the fifth and sixth stimuli was scrambled order (OSV)

Table 1 Examples of stimuli in Experiment 1

prime	examples of prime	target	examples of target
White Noise	White Noise	SOV	Kenichi-ga shukudai-o wasureta. Kenichi-NOM homework-ACC forgot 'Kenichi forgot his homework'
		OSV	shukudai-o Kenichi-ga wasureta. homework-ACC Kenichi-NOM forgot 'Kenichi forgot his homework'
canonical order (SOV)	Shinya-ga kimono-o nurashita Shinya-NOM cloth-ACC wetted 'Shinya wetted the cloth'	SOV	Miyoko-ga gakkou-o yasunda. Miyoko-NOM school-ACC absented 'Miyoko was absent from school'
		OSV	gakkou-o Miyoko-ga yasunda. school-ACC Miyoko-NOM absented 'Miyoko was absent from school'
scrambled order (OSV)	shokubutsu-o Hitomi-ga sodateta. plants-ACC Hitomi-NOM grew 'Hitomi grew plants'	SOV	Nobuko-ga kaidan-o nobotta. Nobuko-NOM stairs-ACC climbed 'Nobuko climbed the stairs'
		OSV	kaidan-o Nobuko-ga nobotta. stairs-ACC Nobuko-NOM climbed 'Nobuko climbed the stairs'

Note: SOV refers to canonical word order (Subject-Object-Verb) while OSV refers to scrambled word order (Object-Subject-Verb). NOM refers to nominative case while ACC refers to accusative case.

primed sentences. These three types of white noise, SOV and OSV prime stimuli were further divided into SOV canonical or OSV scrambled target sentences. Classified in this way, the experiment examined the effects of syntactic priming on Japanese sentence processing.

It was expected that reading times would become faster when participants saw sentences containing the same words. Thus, to prevent the problem of repeatedly encountering the same words, a Latin-square design was used to assign different sentences to participants. Six lists of sentences were given to six groups of participants. Each list consisted of 20 sets of prime-target stimuli in each category. In other words, there was a total 120 sets of prime-target stimuli for correct 'Yes' responses in each list.

The equal number of correct 'No' responses (i.e. 120 unacceptable sentences) were constructed. Scrambled sentences were created on the basis of canonical sentences. For example, the phrase order of the canonical sentence *Kazushige-ga iwa-o matta* ('Kazushige waited for the rock') was rearranged to *iwa-o Kazushige-ga matta*. Six types of prime-target stimuli pairs were created in the same way as correct 'Yes' responses. The first and second types of stimuli were white noise primed sentences. The third and fourth types of stimuli were primed sentences that had the same syntactic form as target sentence. The fifth and sixth stimuli were primed sentences that had different syntactic forms than the target. These two types of white noise, congruent and incongruent prime stimuli were further divided into SOV canonical or OSV scrambled target sentences. A counter-balanced, Latin-square design was used to assign different sentences to participants. In other words, six lists of sentences were given to six groups of participants. Each list consisted of 20 sets of prime-target stimuli in each category. There was therefore a total 120 sets of prime-target stimuli for correct 'No' responses in each list.

In addition, as fillers, various types (e.g. transitive, intransitive, copular) of prime-target stimuli were prepared, with 60 sets of stimuli for both correct 'Yes' and 'No' responses used for each list. Consequently, a total of 360 sets of prime-target stimuli in each list consisted of 180 stimuli for correct 'Yes' responses and 180 stimuli for correct 'No' responses.

Table 2 Reaction Times (ms) and Correct Rates (%) in Experiment 1

target	prime	Reaction Times (ms)			Correct Rates (%)		
		M	SD	prime Δ	M	SD	prime Δ
SOV	White Noise	1,434	282		97.60	4.25	
	Cong. (SOV)	1,352	273	Δ82	96.46	4.49	Δ1.14
	Incong. (OSV)	1,388	263	Δ46	96.77	3.79	Δ0.83
OSV	White Noise	1,603	366		92.40	8.38	
	Cong. (OSV)	1,542	319	Δ61	90.73	8.57	Δ1.67
	Incong. (SOV)	1,563	337	Δ40	89.58	9.04	Δ2.64

Note: M refers to means while SD refers to standard deviations.

3.1.3 Procedure

The presentation was controlled by a computer program, Microsoft Visual Basic 6.0 + Microsoft DirectX 8. A cross-modal priming task was used in order to avoid surface effects of the phonological/orthographic process. For each trial, a row of crosses (++++++), indicating an eye fixation point, was first presented in the center of a screen. When subjects pushed the NEXT button, a prime sentence was aurally presented from headphones, immediately after which a target sentence appeared on the screen. Participants were instructed to respond as quickly and as accurately as possible in deciding whether or not the sentence made sense. Responses were registered by the pressing of keys marked 'Yes' or 'No'. The items were presented in random order. Twelve practice trials were given to the participants prior to the commencement of the actual testing.

3.2 Analysis and Results

Extremes among sentence correctness decision times (less than 500 milliseconds and longer than 5,000 milliseconds) were recorded as missing values. Only one data point fell into this extreme category. Since reaction times and error rates for correct 'No' response might include extra cognitive or emotional reaction caused by semantic anomaly and might not reflect natural processes of sentence processing, we only report results for correct 'Yes' responses. The means of correct 'Yes' reaction times and correct rates for sentence correctness decisions are presented in Table 2. Before performing the analysis, reaction times outside of 2.5 standard deviations at both the high and low ranges were replaced by boundaries indicated by 2.5 standard deviations from the individual means of participants in each category. A total of 122 data points of correct 'Yes' responses or 2.12 percent of the total of correct 'Yes' responses (120 responses × 48 participants = 5,760) were replaced in Experiment 1. The statistical tests which follow analyze both subject (F_1) and item (F_2) variability. Only stimulus items of correct responses were used in the analysis of reaction times and correct rates.

3.2.1 Reaction times for correct 'Yes' responses

The data for raw reaction times replicated findings by Tamaoka et al. (2005) and others. Repeated t-tests showed that reaction times for the white noise-SOV condition were significantly faster than those for the white noise-OSV condition in both subject analysis [$t_1(47) = 5.811$, $p < .001$] and item analysis, both in cases with [$t_2(119) = 7.151$, $p < .001$] and without strange or awkward items [$t_2(117) = 6.938$, $p < .001$]. This result revealed scrambling effects on the processing of Japanese unambiguous active sentences for correct 'Yes' responses.

The priming effects were calculated by subtracting the congruent and incongruent prime condition from the white noise prime condition. The averages of the priming effects are reported in Table 2. A series of a 2 (SOV or OSV target syntactic structure) × 2 (congru-

ent or incongruent priming effects) analyses of variance (ANOVA) with repeated measures for priming effects of reaction times of correct 'Yes' responses were conducted on reaction times (milliseconds), using subject (F_1) and item (F_2) variability. The main effect of the target syntactic structure was not significant either in subject analysis [$F_1(1, 47) = .290$, *n.s.*] or in item analysis [$F_2(1, 119) = .260$, *n.s.*]. The main effect of the prime-and-target congruency was significant in subject analysis [$F_1(1, 47) = 4.641$, $p < .05$], and marginally significant in item analysis [$F_2(1, 119) = 3.188$, $p = .077$]. Because the item analysis did not indicate any significant difference, we checked to see if there was any item that was particularly strange and found that there were two items whose error rates were over 50%[1]. After eliminating the strange items, the main effect of the prime-and-target congruency yielded significant in item analysis [$F_2(1, 117) = 4.339$, $p < .05$]. The present study suggests that the priming effects of the prime-and-target congruent condition (Δ 72ms) yielded significantly larger than those of the prime-and-target incongruent condition (Δ 43ms). The interaction between the target syntactic structure and the prime-and-target congruency was not significant in subject analysis [$F_1(1, 47) = .262$, *n.s.*] or in item analysis [$F_2(1, 119) = .245$, *n.s.*].

Since the main effect of the prime-and-target congruency was significant for correct 'Yes' responses, one-way ANOVA with repeated measures were conducted to make sure that priming conditions were significantly faster than the base line of the white noise SOV and OSV conditions. The prime-and-target SOV congruent (hereafter, SOV congruent) condition (1,352ms) was significantly faster than the base line of white noise SOV (hereafter, white nose SOV) condition (1,434ms) both in subject analysis [$F_1(1, 47) = 16.760$, $p < .001$] and in item analysis [$F_2(1, 119) = 14.647$, $p < .001$]. The SOV incongruent condition (1,388ms) was also significantly faster than the white noise SOV condition both in subject analysis [$F_1(1, 47) = 6.847$, $p < .05$] and in item analysis [$F_2(1, 119) = 4.508$, $p < .05$]. For the OSV conditions, the prime-and-target OSV congruent (hereafter OSV congruent) condition (1,542ms) was significantly faster than the white noise OSV condition (1,603ms) both in subject analysis [$F_1(1, 47) = 4.927$, $p < .05$] and in item analysis [$F_2(1, 119) = 5.375$, $p < .05$]. However, the OSV incongruent condition (1,563ms) was not significantly faster than white noise OSV condition in either subject analysis [$F_1(1, 47) = 2.550$, *n.s.*] or item analysis [$F_2(1, 119) = 2.659$, *n.s.*]. Consequently, these results suggest that syntactic priming facilitates the processing of target sentences in the prime-and-target congruent conditions. However, the SOV incongruent condition was also significantly faster than the white noise SOV condition. We will discuss about the reason why the SOV incongruent condition showed significant priming effects in 3.3.

3.2.2 Correct rates for correct 'Yes' responses

A 2 (SOV or OSV target syntactic structure) × 2 (congruent or incongruent priming effects) analyses of variance (ANOVA) with repeated measures were also applied to the correct rates of corrected 'Yes' responses. The main effect of the target syntactic structure was not significant in either subject analysis [$F_1(1, 47) = 1.011$, *n.s.*] or item analysis [$F_2(1, 119) = 1.460$, *n.s.*]. The main effect of the prime-and-target congruency was not significant in either subject analysis [$F_1(1, 47) = .279$, *n.s.*] or in item analysis [$F_2(1, 119) = .306$, *n.s.*]. The interaction between the target syntactic structure and the prime-and-target congruency was not significant in either subject analysis [$F_1(1, 47) = .756$, *n.s.*] or item analysis [$F_2(1, 119) = 1.141$, *n.s.*].

1) The deleted items are as follows.
"Junko-ga pinto-o awaseta. (Junko brought (a camera) into focus.)"
"Akira-ga noruma-o konashita (Akira managed his assigned work.)"

3.3 Discussion

The results of Experiment 1 indicated that priming effects of the prime-and-target congruent condition were significantly larger than those of the incongruent condition for correct 'Yes' responses. In other words, when the prime and target have identical syntactic structures, the prime items facilitated the speed of target sentence processing for correct 'Yes' responses. This means that syntactic priming effect was observed in the processing of Japanese sentences. In addition, reaction times of white noise-SOV condition were significantly faster than those of white noise-OSV condition. These results replicated studies which investigated processing of Japanese scrambled sentences (e.g., Tamaoka et al., 2005; Koizumi & Tamaoka, 2004; Mazuka et al., 2002; Miyamoto & Takahashi, 2002a, 2002b, 2004).

In Experiment 1, however, the prime-and-target incongruent condition (i.e., OSV-SOV incongruent condition) was significantly faster than the white noise condition. A possible explanation for this weak facilitation effect is as follows. Since any pair of sentences contains at least some degree of syntactic similarity, this similarity was enough to cause partial syntactic priming effects. In other words, the processing of any sentence in the Japanese language generally facilitates the processing of target sentences compared to the white-noise condition. Furthermore, in Experiment 1, it was maybe easy for participants to process the target sentences when the word orders of prime sentences are not identical to those of target sentences because participants often encountered prime-and-target incongruent items (i.e., one-third of the experimental materials). Another possibility is that weak facilitation effects are caused by activation of lexical/semantic processing mechanism. Since no linguistic processing is required for white-noise prime, lexical/semantic processing mechanism is not at all activated. In contrast, presentation of any prime sentences involves lexical/semantic processing. To decide between these two possibilities, an additional experiment was conducted to compare the priming effects of sentences and those of linguistic materials with lexico-semantic content but no syntactic structures, namely a sequence of nouns. In addition, we should investigate the effects of the ratio of the incongruent condition in the experimental materials to decrease the number of prime-and-target syntactically incongruent items. If the reaction times of the only prime-and-target syntactically congruent condition proved faster than those of the nouns priming conditions and white noise conditions, the present study could conclude that priming effects are created by the identical syntactic structure between prime and target sentences. In contrast, if the reaction times of both the prime-and-target congruent condition and the noun prime condition are faster than those of the white noise condition, the result would suggest the lexical/semantic processing mechanism is the source of weak priming effects.

4. Experiment 2

Experiment 1 indicated a general trend that, regardless of SOV or OSV word order, syntactic priming facilitates the processing of both SOV and OSV targets. Thus, Experiment 2 further compared two different conditions of lexical and SOV syntactic priming with SOV and OSV targets.

4.1 Method

4.1.1 Participants

Forty-eight graduate and undergraduate students (23 females and 25 males) at Hiroshima University in Japan, all native speakers of Japanese, participated in the second experiment. Ages ranged from 18 years and 11 months to 37 years and 11 months, with the average age being 24 years and 2 months on the day of testing. These participants were not the same as the ones in Experiment 1.

Table 3 Examples of stimuli in Experiment 2

prime	examples of prime	target	examples of target
White Noise	White Noise	SOV	Kenichi-ga shukudai-o wasureta. Kenichi-NOM homework-ACC forgot 'Kenichi forgot his homework'
		OSV	shukudai-o Kenichi-ga wasureta. homework-ACC Kenichi-NOM forgot 'Kenichi forgot his homework'
canonical order (SOV)	Shinya-ga kimono-o nurashita Shinya-NOM cloth-ACC wetted 'Shinya wetted the cloth'	SOV	Miyoko-ga gakkou-o yasunda. Miyoko-NOM school-ACC absented 'Miyoko was absent from school'
		OSV	gakkou-o Miyoko-ga yasunda. school-ACC Miyoko-NOM absented 'Miyoko was absent from school'
nouns	chikoku kudamono yuki lateness fruit snow 'lateness fruit snow'	SOV	Nobuko-ga kaidan-o nobotta. Nobuko-NOM stairs-ACC climbed 'Nobuko climbed the stairs'
		OSV	kaidan-o Nobuko-ga nobotta. stairs-ACC Nobuko-NOM climbed 'Nobuko climbed the stairs'

Note: SOV refers to canonical word order (Subject-Object-Verb) while OSV refers to scrambled word order (Object-Subject-Verb). NOM refers to nominative case while ACC refers to accusative case.

4.1.2 Materials

120 correct and 120 incorrect sentences used in Experiment 1 were also used for the target sentence correctness decision task in Experiment 2. Since the canonical and scrambled sentences were identical in terms of word used, the difference in syntactic structure can be directly compared in reaction times and correct rates.

As shown in Table 3, six types of correct prime-target stimuli pairs were used in Experiment 2. The first and second types of stimuli were white noise primed sentences. The presentation time of white noise (1,990 ms) was the same as the average of the presentation time of sentence primes. The third and fourth types of stimuli were SOV primed sentences, of which 40 were prepared. An equal number of the fifth and sixth stimuli consisted of sentences primed by a sequence of three nouns that had no obvious semantic relation to each other. The average presentation time of noun primes was matched with the average presentation time of sentence primes. These two types of white noise, SOV and nouns prime stimuli were further divided into SOV canonical or OSV scrambled target sentences. Classified in this way, the experiment examined the effects of syntactic priming on Japanese sentence processing.

To prevent the problem of repeatedly encountering the same words, a Latin-square design was used to assign different sentences to participants in the same way as Experiment 1. Six lists of sentences were given to six groups of participants. Each list consisted of 20 sets of prime-target stimuli in each category. In other words, there was a total 120 sets of prime-target stimuli for correct 'Yes' responses in each list. Correct 'No' responses and various types of fillers were created in the same way as Experiment 1. Consequently, a total of 360 sets of prime-target stimuli in each list consisted of 180 stimuli for correct 'Yes' responses and 180 stimuli for correct 'No' responses.

4.1.3 Procedure

The procedure was identical to Experiment 1.

4.2 Analysis and Results

Extremes among sentence correctness decision times (less than 500 milliseconds and longer than 5,000 milliseconds) were recorded as missing values. Three data points fell into this extreme cat-

Table 4 Reaction Times (ms) and Correct Rates (%) in Experiment 2

target	prime	Reaction Times (ms)			Correct Rates (%)		
		M	SD	prime Δ	M	SD	prime Δ
SOV	White Noise	1,284	256		96.35	4.58	
	SOV	1,242	248	Δ42	95.94	5.98	Δ0.41
	nouns	1,294	295	Δ − 10	96.77	5.30	Δ − 0.42
OSV	White Noise	1,393	290		91.46	8.81	
	SOV	1,426	390	Δ − 33	88.96	10.26	Δ2.50
	nouns	1,407	339	Δ − 14	91.46	9.73	Δ0.00

Note: M refers to means while SD refers to standard deviations.

egory. The means of correct 'Yes' reaction times and correct rates for sentence correctness decisions are presented in Table 4. Before performing the analysis, reaction times outside of 2.5 standard deviations at both the high and low ranges were replaced by boundaries indicated by the 2.5 standard deviations from the individual means of participants in each category. A total of 122 data points of correct 'Yes' responses or 2.12 percent of the total of correct 'Yes' responses (120 responses × 48 participants=5,760) were replaced in Experiment 2. The statistical tests which follow analyze both subject (F_1) and item (F_2) variability. Only stimulus items of correct responses were used in the analyses of reaction times and correct rates.

4.2.1 Reaction times for correct 'Yes' responses

Priming effects were calculated by subtracting SOV and nouns prime condition from the white noise prime condition. The averages of the priming effects are reported in Table 4. A series of 2 (SOV or OSV target syntactic structure) × 2 (SOV or nouns types of prime) analyses of variance (ANOVA) with repeated measures for reaction times of correct 'Yes' responses was conducted on reaction times (milliseconds), using subject (F_1) and item (F_2) variability. The main effect of the target syntactic structure was not significant in either subject analysis [$F_1(1, 47) = 4.020$, $p = .051$] or item analysis [$F_2(1, 119) = 1.524$, *n.s.*]. The main effect of the types of prime was not significant in either subject analysis [$F_1(1, 47) = 1.165$, *n.s.*] or item analysis [$F_2(1, 119) = 1.976$, *n.s.*]. The interaction between the target syntactic structure and the types of prime was significant both in subject analysis [$F_1(1, 47) = 4.346$, $p < .05$] and in item analysis [$F_2(1, 119) = 4.568$, $p < .05$]. The prime-and-target congruent condition (i.e., SOV SOV condition; Δ 42ms) yielded significantly larger priming effects than the prime-and-target incongruent condition (i.e., SOV OSV condition; Δ − 33). the noun SOV (Δ − 10) condition, and the noun OSV condition (Δ − 14).

Since the interaction between the target syntactic structure and the types of prime was significant for correct 'Yes' responses, one-way ANOVA with repeated measures were conducted to ascertain that only the prime-and-target SOV (hereafter, SOV congruent) conditions were significantly faster than the base line of the white noise SOV (hereafter, white nose SOV) conditions. For the SOV target conditions, the SOV congruent condition (1,242ms) was significantly faster than the white noise SOV condition (1,284ms) both in subject analysis [$F_1(1, 47) = 5.992$, $p < .05$] and in item analysis [$F_2(1, 119) = 6.011$, $p < .05$]. However, the condition of prime nouns and target SOV sentences (1,294ms) was not significantly faster than the white noise SOV condition in either subject analysis [$F_1(1, 47) = .339$, *n.s.*] or item analysis [$F_2(1, 119) = .314$, *n.s.*]. For the OSV target conditions, the prime-and-target OSV incongruent (hereafter OSV incongruent) condition (1,426ms) was not significantly slower than the white noise OSV

condition (1,393ms) both in subject analysis [$F_1(1, 47) = 1.609$, *n.s.*] and in item analysis [$F_2(1, 119) = .894$, *n.s.*]. The noun OSV condition (1,407ms) was not significantly slower than white noise OSV condition in either subject analysis [$F_1(1, 47) = .453$, *n.s.*] or item analysis [$F_2(1, 119) = .137$, *n.s.*].

As for the raw reaction times, repeated t-test showed that reaction times of white noise-SOV condition were significantly faster than those of white noise-OSV condition in both subject analysis [$t_1(47) = 5.788$, $p < .001$] and item analysis [$t_2(119) = 4.852$, $p < .001$]. This result replicated the result of Experiment 1.

4.2.2 Correct rates for correct 'Yes' responses

A 2 (SOV or OSV target syntactic structure) × 2 (SOV or nouns types of prime) analyses of variance (ANOVA) with repeated measures was also applied to the correct rates of corrected 'Yes' responses. The main effect of the target syntactic structure was not significant in either subject analysis [$F_1(1, 47) = .979$, *n.s.*] or item analysis [$F_2(1, 119) = .764$, *n.s.*]. The main effect of the types of prime was marginally significant in subject analysis [$F_1(1, 47) = 2.892$, $p = .096$], and significant in item analysis [$F_2(1, 119) = 5.249$, $p < .05$]. The interaction between the target syntactic structure and the types of prime was not significant in either subject analysis [$F_1(1, 47) = .984$, *n.s.*] or item analysis [$F_2(1, 119) = 1.134$, *n.s.*].

4.3 Discussion

The syntactically congruent condition (SOV prime and SOV target) showed larger priming facilitation effects than the incongruent condition (SOV prime and OSV target) and the noun prime condition in Experiment 2. These results did not replicate the results of Experiment 1, in which the OSV-SOV condition was significantly faster than white noise-SOV condition. As we discussed in 3.3, one possibility of the conflict results was caused by the effects of the ratio of the incongruent condition in the experimental materials. In other words, the number of incongruent conditions were 40 for correct 'Yes' responses and 40 for correct 'No' responses in Experiment 1, whereas 20 for correct 'Yes' responses and 20 for correct 'no' responses in Experiment 2. Because the chances for encountering the incongruent condition in Experiment 1 were twice as many as those of Experiment 2 and the processing load for the change of word orders was decreased in Experiment 1, it might cause the facilitation of the OSV-SOV condition. An implication of this result for the source of syntactic priming is discussed in general discussion. Since priming effects were observed only in the congruent condition in Experiment 2, we can assume that these priming effects were causes by the structural similarity between prime and target sentences. Experiment 2 showed significant interaction between the target and the types of prime of reaction times for correct 'Yes' responses as well. This meant that the priming effects of the congruent condition were larger than those of the incongruent condition and the sequence of noun SOV conditions, although the priming effects of the latter were not larger than that of the sequence of noun OSV condition. This result indicated that the priming effects of the prime-and-target congruent condition were significantly larger than those of the incongruent and the sequence of noun condition. Consequently, lexical/semantic processing does not facilitate the processing of target sentences. The comparison between reaction times of white noise-SOV condition and those of white noise-OSV condition for correct 'Yes' responses indicated that the processing of OSV sentences required more processing cost than that of SOV sentences. The results replicated those of previous studies on scrambling effects mentioned in section 3.3.

5. General Discussion

The purpose of the present study was to exam-

ine syntactic priming effects in Japanese canonical and scrambled sentence comprehension. To achieve this, two experiments to test these effects using cross-modal priming and target sentence correctness decision task were conducted.

Experiment 1 indicated that the priming effects of the prime-and-target congruent condition were significantly larger than those of the prime-and-target incongruent condition. In other words, the primed items facilitated the speed of the processing of target sentences when the prime and target shared an identical syntactic structure. However, the reaction times of the prime-and-target incongruent condition were significantly faster than those of the white noise condition. Since any two Japanese sentences share at least some degree of syntactic similarity, it might be deduced that sentence processing in the Japanese language generally facilitates the processing of target sentences. Alternatively, lexical/semantic processing involved in the mismatch condition was enough to yield weak facilitation effects. To decide between these two accounts, an additional experiment was conducted to compare the priming effects of the sentence prime and the noun prime.

Experiment 2 showed significant interaction between the target syntactic structure and the types of prime. The priming effects of the prime-and-target congruent condition (i.e., SOV prime and SOV target condition) were larger than those of the prime-and-target incongruent condition (i.e., SOV prime and OSV target condition) and the noun SOV conditions, although the priming effects of the incongruent condition were not larger than those of the noun OSV condition. In other words, compared with the incongruent and noun priming conditions, significantly larger priming effects of the prime-and-target congruent condition were observed.

The facilitation effect cannot be attributed to visual or auditory processing because prime sentences share no sensory input with target sentences. Neither can it be attributed to lexical or semantic priming effects because there is no overlap of lexical or semantic content between prime and target. Furthermore, syntactic priming effects appeared without syntactic ambiguities, because Japanese sentences with canonical and scrambling order were used as prime and target sentences and these sentences had no ambiguities at all. The present study has thus removed many potentially confounding factors of previous studies by using Japanese sentences with canonical and scrambled word orders. The fact that priming effects are still observed in the present study therefore supports the view that the source of priming is syntactic in nature. The overall results serve as a new basis for future research about the role of syntactic parsing mechanisms in human sentence processing.

However, there are some limitations of the present study that have to be overcome in future research. First, the question of what counts as a perfect baseline is one of the important issues in priming studies. It might be argued that nonlinguistic stimuli, such as the white noise used in this experiment, would cause inhibition effects for some reason and thus do not serve as an appropriate baseline. We are aware of the importance of comparison between various linguistic stimuli and took measures to compare between congruent and incongruent conditions in order to avoid such methodological criticism. At the same time, we thought that some nonlinguistic stimuli with absolutely no learning effects should be included to confirm that there are no priming effects in the baseline condition. Although white noise and a sequence of nouns are potential sources of inhibition, we did not find any priming effects in the OSV incongruent condition, the OSV white noise condition, or the OSV nouns condition in Experiment 2. These results suggested that white noise and a sequence of nouns do not cause inhibition in this kind of experiment design.

The second potential problem is the ratio of transitive sentences and intransitive sentences in

the experimental materials. The number of filler sentences was restricted to a minimum and the transitive/non-transitive sentences ratio was set as 2 to 1 in both experiments due to time limitations. The lower filler ratio and the higher ratio of transitive sentences might leave room to develop a particularly different strategy. At the same time, the lower filler ratio could not have caused a serious problem in the current experiment as it appears because experimental materials were simple transitive sentences, which the participants frequently encounter in their daily lives, and are less likely to develop strategies specific to experimental materials in this case. Future research is needed to eliminate these potential confounding factors and replicate the result of the present study.

Finally, the results of this study are by no means decisive evidence for functional independence of syntax module in human cognitive function. There are other potentially relevant lexical/semantic factors, repetition of case particles, effects of noun phrase animacy, etc., which were not considered in the present research. Despite such limitations, the present study made a unique contribution by removing many confounding factors of the previous researches by making use of the Japanese sentences with canonical and scrambled word orders. We hope that future research on this topic will push forward and reveal the role of syntactic parsing mechanisms in human sentence processing.

Acknowledgment

We thank anonymous reviewers of Cognitive Studies for their valuable comments and suggestions. This research was supported by Grant-in-Aid for Scientific Research on Priority Areas (Higher-Order Brain Functions) from the Ministry of Education, Culture, Sports, Science and Technology (#18020022, #17022030) and RISTEX 'Brain Science and Education' Project by Japan Science and Technology Agency (An Integrated study of language learning, brain development, and language education: Project Leader, Hiroko Hagiwara, Tokyo Metropolitan University).

References

Bock, J. K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, **18**, 355–387.

Bock, J. K. & Griffin, Z. M. (2000). The persistence of structural priming: Transient activation or implicit learning? *Journal of Experimental Psychology: General*, **129**, 177–192.

Branigan, H. P., Pickering, M. J., Liversedge, S. P., Stewart, A. J., & Urbach, T. P. (1995). Syntactic priming: Investigating the mental representation of language. *Journal of Psycholinguistic Research*, **24**, 489–506.

Branigan, H. P., Pickering, M. J., & Cleland, A. A. (2000). Syntactic co-ordination in dialogue. *Cognition*, **75**, B13–25.

Cleland, A. A. & Pickering, M. J. (2003). The use of lexical and syntactic information in language production: Evidence from the priming of noun-phrase structure. *Journal of Memory and Language*, **49**, 214–230.

Embick, D., Marantz, A., Miyashita, Y., O'Neil, W., & Sakai, K. L. (2000). A syntactic specialization for Broca's area. *Proceedings of the National Academy of Sciences USA*, **97**, 6150–6154.

Fodor, J. A. (1983). *The Modularity of Mind*. Cambridge, MA: MIT Press.

Forster, K. (1979). Levels of processing and the structure of the language processor. In W. E. Cooper and E. Walker (Ed.), *Sentence processing: Psycholinguistic Studies Presented to Merrill Garrett*, 27–85. Hillsdale, NJ: Lawrence Erlbaum Associates.

Frazier L., Taft, L., Roeper, T., Clifton, C., & Ehrlich, K. (1984). Parallel structure: A source of facilitation in sentence comprehension. *Memory & Cognition*, **12**, 421–430.

Friederici, A. D. (2002). Towards a neural basis of auditory sentence processing. *TRENDS in Cognitive Sciences*, **6**, 78–84.

Friederici, A. D. & Kotz, S. A. (2003). The brain basis of syntactic processes: functional imaging and lesion studies. *NeuroImage*, **20**, S8–S17.

Hagiwara, Y. (1998). *Noo-ni idomu gengogaku.* [Linguistics challenging to brain], Tokyo: Iwanami shoten (in Japanese).

Hartsuiker R. & Kolk, H. H. J. (1998). Syntactic persistence in Dutch. *Language and Speech*, 41, 143–184.

Hashimoto, R. & Sakai, K. L. (2002). Specialization in the left prefrontal cortex for sentence comprehension. *Neuron*, 35, 22–28.

Koizumi. M. & Tamaoka, K. (2004). Cognitive processing of Japanese sentences with ditransitive verbs. *Gengo Kenkyu (Journal of the Linguistic Society of Japan)*, 125, 173–190.

Marslen-Wilson, W. D. (1975). Sentence perception as an interactive parallel process. *Science*. 189, 226–228.

Mazuka, R., Ito, K., & Kondo. T. (2002). Costs of scrambling in Japanese sentence processing. In M. Nakayama (Ed.), *Sentence Processing in East Asian Languages*, 131–166. Stanford, CA: CSLI.

Miyamoto, E. T. & Takahashi, S. (2002a). Sources of difficulty in processing scrambling in Japanese. In M. Nakayama (Ed.), *Sentence Processing in East Asian Languages*, 167–188. Stanford, CA: CSLI.

Miyamoto, E. T. & Takahashi, S. (2002b). Antecedent reactivation in the processing of scrambling in Japanese. *MIT Working Paper in Linguistics*, 43, 123–138.

Miyamoto, E. T. & Takahashi. S. (2004). Filler-Gap dependencies in the processing of scrambling in Japanese. *Language and Linguistics*. 5, 153–166.

Noppeney. U. & Price, C. J. (2004). An fMRI study of syntactic adaptation. *Journal of Cognitive Neuroscience*, 16, 702–713.

Pickering, M. J. & Branigan, H. P. (1998). The representation of verbs: Evidence from syntactic persistence in written language production. *Journal of Memory and language*, 39, 633–651.

Pickering. M. J. & Branigan, H. P. (1999). Syntactic priming in language production. *Trends in Cognitive Science*, 3. 136–141.

Pickering. M. J., Branigan. H. P., & McLean, J. F. (2002). Constituent structure is formulated in one stage. *Journal of Memory and Language*, 46. 586–605.

Potter, M. C. & Lombardi. L. (1998). Syntactic priming in immediate recall of sentence. *Journal of Memory and Language*, 38. 265–282.

Saito, M. (1985). Some asymmetries in Japanese and their theoretical implications. Ph.D. dissertation, Cambridge, MA: MIT.

Suzuki, K. & Sakai, K. L. (2003). An event-related fMRI study of explicit syntactic processing of normal/anomalous sentences in constant to implicit syntactic processing. *Cerebral Cortex*, 13, 517–526.

Swinney, D. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior*, 18, 545–569.

Tamaoka, K., Sakai, H., Kawahara, J., Lim, H., Miyaoka, Y., & Koizumi, M. (2005). Priority information used for the processing of Japanese sentences: Thematic roles, case particles or grammatical functions? *Journal of Psycholinguistic Research*, 34, 281–332.

Yamashita, H., Hirose, Y., & Chang, F. (2003). The nature of grammatical encoding: syntactic-dependent formulation of constituent structure. *The proceeding of the 20th annual conference of Japanese cognitive science society*, 178–179.

(Received 28 June 2005)
(Accepted 30 March 2007)

Jun-Ichi Tanaka

Jun-Ichi Tanaka is a graduate student in the Linguistics Program at the Graduate Center of City University of New York and in the Language and Culture Education Program at the Graduate School of Education at Hiroshima University. He received an M.A. degree from the Graduate School of Education at Hiroshima University. He is interested in how native speakers incrementally process syntactic structures. In addition to a series of researches on sentence processing using syntactic priming paradigm, he conducted various types of experimental research on human language processing as collaboration with researchers in Japan and in the United States using behavioral measures such as cross-modal priming, self-paced reading, as well as neurophysiological measures such as event-related potential and functional magnetic-resonance imaging.

Katsuo Tamaoka

Katsuo Tamaoka is a Professor at the International Student Center, Hiroshima University, Japan. He received his Ph. D. from the University of Saskatchewan, Canada, focusing on the cognitive processing of the Japanese language by Grades 4-6 students. His current research involves psychological experiments with various factors of phonological, morphological, lexical and syntactic features in the construction of cognitive models for language processing (psycholinguistics). He also conducts studies on various aspects of Japanese and English foreign language acquisition, using both approaches of theory-driven experiments and language ability testing. By using pseudo-experimental design (paper-and-pencil questionnaires and testing), his studies further extend to examine various psycholinguistic and sociolinguistic theories such as newly-adapted shortened words (*tanshuku-go*), Japanized English loanwords (*wasei-eigo*), sequential voicing (*rendaku*) and politeness expressions. In addition, he also conducts mathematical and statistical analyses of corpus data to investigate linguistic features and theories.

Hiromu Sakai

Hiromu Sakai is an Associate Professor at the Graduate School of Education and a director of the Project Center for Brain Science of Language Acquisition and Language Learning, Hiroshima University, Japan. He received his Ph. D. from the University of California, Irvine with a theoretical linguistic study on the complex verb morphology of Japanese. His research focuses on how native and non-native speakers process and learn morphological/syntactic structures of typologically diverse languages in the world. He has been conducting theoretical linguistic studies aiming at constructing a model of speakers' linguistic knowledge and psycholinguistic studies to check the validity of the proposed model. He uses behavioral measures of reaction time or reading time, as well as neurophysiological measures such as EEG recording and functional magnetic-resonance imaging.

Appendix: Experimental materials for Experiment 1 & 2

1. マコトが 危険を 知らせた.
   Makoto-Nom alarm-Acc sounded
   "Makoto sounded an alarm."
2. イサオが 帽子を かぶった.
   Isao-Nom cap-Acc put on
   "Isao put on a cap."
3. ユウコが 占いを 信じた.
   Yuko-Nom fortune-telling-Acc believed in
   "Yuko believed in fortune-telling"
4. エミコが 赤ん坊を さらった.
   Emiko-Nom baby-Acc snatched away
   "Emiko snatch a baby away."
5. テツヤが 計画を 進めた.
   Tetsuya-Nom project-Acc advanced
   "Tetsuya advanced a project."
6. ヨシオが ひげを 伸ばした.
   Yoshio-Nom beards-Acc grew
   "Yoshio grew beards."
7. ヒロコが 畑を 荒らした.
   Hiroko-Nom a crop field-Acc devastated
   "Hiroko devastated a crop field."
8. マユミが コードを つなげた.
   Mayumi-Nom a cord-Acc connected
   "Mayumi connected a cord."
9. タケシが とうもろこしを ゆでた.
   Takeshi-Nom corns-Acc boiled
   "Takeshi boiled corns."
10. ジロウが 傘を 開いた.
    Jiro-Nom umbrella-Acc opened
    "Jiro opened an umbrella."
11. トモコが おはじきを 並べた.
    Tomoko-Nom marbles-Acc set in line
    "Tomoko set marbles in line."
12. ノブコが 階段を 昇った.
    Nobuko-Nom stairs-Acc went up
    "Nobuko went up stairs."
13. ケンイチが 宿題を 忘れた.
    Kenichi-Nom homework-Acc forgot
    "Kenichi forgot his homework."
14. イチロウが 失敗を 笑った.
    Ichiro-Nom mistake-Acc laughed at
    "Ichiro laughed at a mistake."
15. ヨウコが 演奏を 始めた.
    Yoko-Nom play-Acc began
    "Yoko began to play."
16. ヒデコが 呼び鈴を 鳴らした.
    Hideko-Nom bell-Acc rang
    "Hideko rang a bell."
17. マナブが 答えを 教えた.
    Manabu-Nom answer-Acc gave
    "Manabu gave the answer."
18. サブロウが 友だちを 誘った.
    Saburo-Nom friend-Acc invited
    "Saburo invited a friend."
19. レイコが 仕事を 探した.
    Reiko-Nom job-Acc looked for
    "Reiko looked for a job."
20. ナオキが ことわざを 覚えた.
    Naoki-Nom proverb-Acc memorized
    "Naoki memorized a proverb."
21. ケイコが かばんを かかえた.
    Keiko-Nom bag-Acc held
    "Keiko held a bag."
22. チエが 糸を 通した.
    Chie-Nom thread-Acc got through
    "Chie got the thread through."
23. トモミが 公約を 実現した.
    Tomomi-Nom promises-Acc realized
    "Tomomi realized her promises."
24. ミサが 上京を 決心した.
    Misa-Nom moving to Tokyo-Acc decided
    "Misa decided to move to Tokyo."
25. ケンゾウが アニメを 上映した.
    Kenzo-Nom cartoon-Acc put on the screen
    "Kenzo put a cartoon on the screen."
26. カズヒサが 処分を 決定した.
    Kazuhisa-Nom punishment-Acc made a decision
    "Kazuhisa made a decision on someone's failure."
27. アキが 夕食を 準備した.
    Aki-Nom dinner-Acc prepared
    "Aki prepared dinner."
28. ナミエが 会話を 記録した.
    Namie-Nom conversation-Acc saved
    "Namie saved a conversation."
29. アツヒロが 電波を 受信した.
    Atsuhiro-Nom electric waves-Acc received
    "Atsuhiro received electric waves."
30. マサキが 敵国を 攻撃した.
    Masaki-Nom enemy country-Acc attacked
    "Masaki attacked an enemy country."
31. チサトが カエルを 解剖した.
    Chisato-Nom frog-Acc dissected
    "Chisato dissected a frog."
32. アサミが 氏名を 記入した.
    Asami-Nom name-Acc wrote down

"Takuro puzzled out a difficult task."
65. ヒロオが 校内を 監視した.
Hiroo-Nom inside of the school-Acc kept an eye on
"Hiroo kept an eye on the school."
66. キョウコが 宝石を 盗んだ.
Kyoko-Nom jewels-Acc stole
"Kyoko stole jewels."
67. サユリが ひじを 怪我した.
Sayuri-Nom elbow-Acc injured
"Sayuri injured her elbow."
68. ユウキが 助手を 雇った.
Yuki-Nom assistant-Acc hired
"Yuki hired an assistant."
69. タカフミが 美容室を 経営した.
Takafumi-Nom beauty parlor-Acc ran
"Takafumi ran a beauty parlor."
70. ミヨコが 学校を 休んだ.
Miyoko-Nom school-Acc was absented from
"Miyoko was absent from school."
71. ワカコが 大舞台を 経験した.
Wakako-Nom big stage-Acc went through
"Wakako went through a big stage."
72. タカシが ゆりかごを 揺らした.
Takashi-Nom cradle-Acc rocked
"Takashi rocked a cradle."
73. ヒロトシが 保険を 契約した.
Hirotoshi-Nom insurance -Acc signed up for
"Hirotoshi signed up for an insurance."
74. ミチコが 紙ひこうきを 飛ばした
Michiko-Nom paper airplane-Acc flew
"Michiko flew a paper airplane."
75. マスミが 物理を 研究した.
Masumi-Nom physics-Acc studied
"Masumi studied physics."
76. タロウが 子ども達を どなった.
Taro-Nom children-Acc yelled at
"Taro yelled at the children."
77. サオリが 窓ガラスを 破壊した.
Saori-Nom windowpane-Acc broke
"Saori broke a windowpane."
78. ノリコが 国を 告発した.
Noriko-Nom country-Acc accused
"Noriko accused the country."
79. ヒトミが 予定を 決めた.
Hitomi-Nom plan-Acc decided
"Hitomi had her plan completed."
80. シンゴが 来客を 歓迎した.
Shingo-Nom visitor-Acc welcomed
"Shingo welcomed the visitor."
81. タダシが 困難を 避けた.
Tadashi-Nom difficulties-Acc avoided
"Tadashi avoided difficulties."
82. ナツミが 広島を 観光した.
Natsumi-Nom Hiroshima-Acc went sightseeing
"Natsumi went sightseeing in Hiroshima."
83. アカネが 紙くずを 捨てた.
Akane-Nom paper waste-Acc threw out
"Akane threw the paper waste out."
84. マサヒデが ビルを 管理した.
Masahide-Nom building-Acc managed
"Masahide managed the building."
85. シゲルが 恋人を ふった.
Shigeru-Nom girlfriend-Acc turned down
"Sigeru turned his girlfriend down."
86. ヒロシが 体を 休めた.
Hiroshi-Nom body-Acc rested
"Hiroshi rested his body."
87. カズコが 肉を 食べた.
Kazuko-Nom meat-Acc ate
"Kasuko ate meat."
88. エミが ベルトを ゆるめた.
Emi-Nom belt-Acc loosened
"Emi loosened her belt."
89. ツトムが 別荘を 建てた.
Tsutomu-Nom villa-Acc built
"Tsutomu built a villa."
90. ミノルが ふたを 開けた.
Minoru-Nom lid-Acc took off
"Minoru took the lid off."
91. サチコが 名札を 付けた.
Sachiko-Nom name tag-Acc pinned on
"Sachiko pinned on a name tag."
92. ミエコが 砂糖を 入れた.
Mieko-Nom suger-Acc added
"Mieko added sugar."
93. マサルが 敵を 負かした.
Masaru-Nom opponent-Acc beat
"Masaru beat an opponent."
94. イサムが 草花を 植えた.
Isamu-Nom flowers-Acc planted
"Isamu planted flowers."
95. エツコが 飼い犬を ほめた.
Etsuko-Nom her dog-Acc praised
"Etsuko praised her dog."
96. ナルミが 疑いを 受けた.
Narumi-Nom suspicion-Acc came under
"Narumi came under suspicion."
97. カズオが 勉強を やめた.
Kazuo-Nom study-Acc stopped
"Kazuo stopped studying."

"Asami wrote down her name."
33. キヨタカが 自宅を 改築した.
Kiyotaka-Nom his house-Acc remodeled
"Kiyotaka remodeled his house."
34. カズトシが 下水道を 工事した.
Kazutoshi-Nom sewer-Acc did the work of construction
"Kazutoshi did sewer work."
35. チナツが 小児科を 開業した.
Chinatsu-Nom pediatric-Acc entered practice
"Chinatsu entered practice as a pediatric."
36. マサコが 資産を 公開した.
Masako-Nom her assets-Acc disclosed publicly
"Masako publicly disclosed her asserts."
37. カオリが 結婚を 約束した.
Kaori-Nom marriage-Acc promised
"Kaori got engaged."
38. ミエが 殺害を 計画した.
Mie-Nom killing-Acc planned to
"Mie planned to kill someone."
39. ケンタが コートを 預けた.
Kenta-Nom coat-Acc put in
"Kenta put in his cort."
40. タカユキが 知識を 吸収した.
Takayuki-Nom knowledge-Acc absorbed
"Takayuki absorbed knowledge."
41. ミホが 切手を 集めた.
Miho-Nom stamp-Acc collected
"Miho collected stamps."
42. サヤカが 娘を 自慢した.
Sayaka-Nom daughter-Acc boasted about
"Sayaka boasted about her daughter."
43. サトシが 弟を 助けた.
Satoshi-Nom younger brother-Acc helped
"Satoshi helped her younger brother."
44. ハルフミが 議員を 辞職した.
Harufumi-Nom lawmaker-Acc resigned
"Harufumi resigned as a lawmaker."
45. クミコが 用件を 伝えた.
Kumiko-Nom business-Acc stated
"Kumiko stated her business."
46. ヒデキが 望みを 叶えた.
Hideki-Nom wish-Acc made it reality
"Hideki made his wish reality."
47. カズヤが 早起きを 続けた.
Kazuya-Nom early rising-Acc continued
"Kazuya continued to wake up early."
48. ミカが お札を 数えた.
Mika-Nom bills-Acc counted
"Mika counted bills."
49. ミキが 泥棒を 捕らえた.
Miki-Nom thief-Acc apprehended
"Miki apprehended a thief."
50. トオルが 涙を 拭いた.
Toru-Nom tears-Acc wiped
"Toru wiped his tears."
51. タツヤが 遠くを 眺めた.
Tatsuya-Nom away-Acc gazed
"Tatsuya gazed away."
52. タカハルが 服を 着替えた.
Takaharu-Nom clothed-Acc changed
"Takaharu changed his clothes."
53. リエが 子どもを 寝かせた.
Rie-Nom child-Acc sent to bed
"Rie sent a child to bed."
54. アツシが 筋肉を 鍛えた.
Atsushi-Nom muscle-Acc developed
"Atsushi developed his muscle."
55. タクヤが お金を 儲けた.
Takuya-Nom money-Acc made
"Takuya made money."
56. ユミが 心を 静めた.
Yumi-Nom mind-Acc calmed
"Yumi calmed herself down."
57. マイが ふろしきを 広げた.
Mai-Nom bundle handkerchief-Acc spread out
"Mai spread out a bundle handkerchief."
58. ダイスケが ピッチャーを 交代した.
Daisuke-Nom pitcher-Acc changed
"Daisuku changed pitchers."
59. キヨシが 意見を まとめた.
Kiyoshi-Nom thoughts-Acc focused
"Kiyoshi focused his thoughts."
60. テルヨシが 荒野を 開発した.
Teruyoshi-Nom wasteland-Acc brought under cultivation
"Teruyoshi brought a wasteland under cultivation."
61. アイコが ミスを 見つけた.
Aiko-Nom error-Acc found out
"Aiko found out an error."
62. マナミが 人質を 解放した.
Manami-Nom hostage-Acc released
"Manami released a hostage."
63. アズサが アサガオを 観察した.
Azusa-Nom morning glories-Acc looked on
"Azusa looked on morning glories."
64. タクロウが 難題を 解決した.
Takuro-Nom difficult task-Acc puzzled out

98. ススムが ミサイルを 発射した.
Susumu-Nom missile-Acc launched
"Susumu launched a missile."
99. セツコが 紙切れを ちぎった.
Setsuko-Nom a piece of paper-Acc tore
"Setsuko tore a piece of paper."
100. ヒサノリが 電話番号を 検索した.
Hisanori-Nom phone number-Acc searched for
"Hisanori searched for a phone number."
101. オサムが 悪人を 責めた.
Osamu-Nom bad person-Acc blamed
"Osame blamed a bad person."
102. リナが マンションを 建設した.
Rina-Nom a condominium-Acc built
"Rina built a condominium."
103. マヤが 品種を 改良した.
Maya-Nom breed variety-Acc improved
"Maya improved breed variety."
104. トシヒサが 研究会を 結成した.
Toshihisa-Nom workshop-Acc set up
"Toshihisa set up a workshop."
105. ツネトシが 展示会を 開催した.
Tsunetoshi-Nom exhibition-Acc held
"Tsunetoshi held an exhibition."
106. ユタカが 部屋を 変えた.
Yutaka-Nom rooms-Acc changed
"Yutaka changed rooms."
107. ミサトが 不良品を 回収した.
Misato-Nom defectives-Acc recalled
"Misato recalled defectives."
108. ミドリが りんごを かじった.
Midori-Nom apple-Acc munched
"Midori munched an apple."
109. ユウヤが 農地を 開拓した.
Yuya-Nom land for farming-Acc developed
"Yuya developed land for farming."
110. ノボルが 写真を 写した.
Noboru-Nom picture-Acc took
"Noboru took pictures."
111. リョウコが 携帯電話を 解約した.
Ryoko-Nom cell-phone-Acc cancelled
"Ryoko cancelled the contract of her cell-phone."
112. サトコが 迷惑を かけた.
Satoko-Nom trouble-Acc caused
"Satoko caused trouble."
113. クニヒロが プラモデルを 改造した.
Kunihiro-Nom a plastic model-Acc refurbished
"Kunihiro refurbished a plastic model."
114. ケンジが トンネルを くぐった.
Kenji-Nom tunnel-Acc passed through
"Kenji passed through a tunnel."
115. ヤヨイが 生活を 改善した.
Yayoi-Nom lifestyle-Acc improved
"Yayoi improved her lifestyle."
116. ユキエが お茶を 注いだ.
Yukie-Nom tea-Acc poured
"Yukie poured a cup of tea."
117. タツオが 外国人を 差別した.
Tatsuo-Nom foreigner-Acc discriminated
"Tatsuo discriminated against foreigners."
118. ユキオが 給料を 支給した.
Yukio-Nom salary-Acc paid
"Yukio paid a salary."
119. ジュンコが ピントを 合わせた.
Junko-Nom focus-Acc adjusted
"Junko brought a camera into focus."
120. アキラが ノルマを こなした.
Akira-Nom assigned work-Acc managed
"Akira managed his assigned work."

Note: All sentences in this appendix have canonical word order. Nominative case marked subjects (NP-Nom) and accusative case marked (NP-Acc) were swapped to create sentences of scrambled order.