Online Structural Analysis in the Processing of L1 Japanese and L2 English

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ABSTRACT

This thesis examines how Japanese EFL learners comprehend English, more specifically, how they draw upon various kinds of linguistic information for structural analysis and how it differs from that of native English speakers. Since Japanese is a head-final language and is considered to be typologically different from head-initial languages such as English, it is possible that Japanese speakers use linguistic information differently in processing syntactic structures. Past research demonstrated that in English, comprehenders can immediately use many kinds of information such as prosody and context in parsing. However, it is relatively little known whether the same kinds of linguistic information are immediately used in online structural analysis in Japanese. For example, it is known that English speakers use lexically specific meaning of a verb to make a prediction about an upcoming structure but this may not be the case in Japanese because the verb in Japanese does not appear until the end of a sentence.

Using eye-tracking technique, the first three experiments reported in this thesis investigated the influences of (1) prosody, (2) syntactic priming, and (3) semantic information and clause length respectively in processing temporarily ambiguous sentences in Japanese. With a relative clause sentence *ishi-ga hakui-o motteiru koukousei-o awatete oikaketa* ('the doctor hastily chased the high-school student who had a white coat'), readers tend to initially adopt an incorrect main clause analysis at the first verb *motteiru* (i.e., 'the doctor had a white coat') and are later forced to reanalyze it as the relative clause structure. The results of the experiments showed that (1) listeners predicted an upcoming structure using prosodic information before the sentence was disambiguated, (2) listeners were more likely to predict the same structure as in a

preceding sentence, and (3) semantic plausibility and clause length affected how strongly readers commit to the initial analysis and processing difficulty associated with structural revision. These results provided evidence that Japanese speakers construct syntactic structures online using various sources of linguistic information without delay.

This thesis next examined how Japanese EFL learners process English sentences in a reading experiment. Specifically, the experiment asked whether Japanese EFL learners resolve syntactic ambiguity using verb subcategorization information in the same way as native speakers do. The results showed that the EFL learners tend to incorrectly analyze the noun following an intransitive verb as its direct object. The results from a sentence completion test also revealed that the EFL learners were more likely to violate the subcategorization constraint for intransitive verbs. These results suggested that Japanese EFL learners did not possess the complete knowledge about intransitivity information and thus did not resolve the syntactic ambiguity in the same way as native speakers did.

The results of the experiments in this thesis together showed that various kinds of linguistic information are immediately used in processing temporarily ambiguous sentences in Japanese in a similar way as in English. However, in processing English as a second language, Japanese EFL learners process structural ambiguity differently from native English speakers possibly because they do not possess the complete form of these kinds of linguistic information.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

It is fairly common for one to speak more than one language. In one typical case, a person speaks one language as the first language (L1) and another language as a foreign or second language (L2). A great deal of research has so far looked at how L1 is processed and also how L2 is acquired but there have been relatively few attempts to compare the processing of L1 and L2 directly. One important question in the field of language research is how the processing of L2 differs from that of L1. In particular, it is not known whether there is any fundamental difference in how sentence structures are processed between L1 and L2 beyond the difference in the level of general language proficiency. To address this issue, this thesis examines native Japanese speakers' processing of Japanese as L1 and of English as L2.

In investigating the underlying mechanism of how humans understand language, a large number of studies have looked at the processing of syntactically ambiguous sentences, especially a particular kind of sentence in which an initially preferred analysis later turns out to be incorrect and thus readers experience processing difficulty for the revision of the incorrect analysis, known as *garden-path* sentence (Frazier & Fodor, 1978; Frazier & Rayner, 1982). This type of sentences has attracted researchers' attention and led to an understanding of how language comprehenders construct a syntactic analysis. Previous studies in English revealed influences of various kinds of linguistic information such as prosody (Schafer, Speer, Warren, & White, 2000; Snedeker & Trueswell, 2003), syntactic priming (Ledoux, Traxler, & Swaab, 2007; Traxler &

Pickering, 2005), discourse context (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995), and meaning of individual words (McRae, Spivey-Knowlton, & Tanenhaus, 1998; Garnsey, Pearlmutter, Myers, & Lotocky, 1997) on parsing processes and provided evidence that English speakers draw upon these types of linguistic information to construct syntactic structures in real time comprehension.

On the other hand, it is relatively unknown whether speakers of Japanese, a language that is typologically different from English, also use the same types of linguistic information as English speakers do. For example, past research on English demonstrated an influence of verb information on online structural analysis and showed that English speakers use lexically specific information of a verb to construct a syntactic structure (Arai & Keller, 2012; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Staub, 2007; Trueswell, Tanenhaus, & Kello, 1993). However, this may not be the case for the speakers of Japanese, as the main verb in Japanese appears at the end of a sentence. This suggests the possibility that the types of linguistic information that influence online structural analysis may differ across languages. Specifically, this thesis asks whether speakers of Japanese use the same kinds of linguistic information as English speakers do in processing structurally ambiguous sentences.

In order to investigate whether speakers of Japanese use the same kinds of linguistic information that are used by English speakers in online sentence comprehension, the studies in this thesis first examines immediate effects of prosody, syntactic priming, and meaning of lexical items as well as clause length in processing Japanese relative clause sentences. The results from these studies demonstrate that Japanese speakers use these kinds of information immediately to construct sentence

structures, suggesting that Japanese speakers access the same kinds of linguistic information as the ones accessed in the processing of English without delay. Following the results of the studies on Japanese sentence processing, this thesis next examines whether such information can be used to guide comprehenders' structural analysis when processing a second language, by testing Japanese learners of English as a foreign language (Japanese EFL learners, henceforth) for the use of verb subcategorization information in comprehending English. As mentioned earlier, past research on the use of verb information showed that English speakers use verb specific argument structure information to guide their initial analysis but such information may possibly not play a major role in the processing of Japanese. As a consequence, it suggests the possibility that the Japanese EFL learners' processing of English sentences may be less constrained by verb specific information compared to that of native English speakers.

The results from the study on the processing of English as L2 reveals that Japanese EFL learners process structural ambiguity differently from native English speakers do; the EFL learners tended to incorrectly analyze the noun following an intransitive verb as its direct object whereas the native speakers did not show such a tendency. The results from a sentence completion test reveal also that the EFL learners were more likely to violate the constraint of subcategorization information for intransitive verbs. These results indicate that the difference in processing temporarily ambiguous sentences is most likely due to the fact that Japanese EFL learners do not possess the complete knowledge of verb subcategorization.

To conclude, the research conducted in this thesis shows the immediate effects of prosody, syntactic priming, and meaning of lexical items as well as clause length on

online structural analysis in Japanese. The results are comparable with previous studies on English, which showed that English speakers immediately use these kinds of linguistic information in building sentences structures. On the other hand, the study on the processing of structurally ambiguous sentences in English as L2 shows that Japanese EFL learners use verb information differently from native English speakers do and this is due to the EFL learners' lack of complete knowledge about verb subcategorization information for intransitive verbs, perhaps because of EFL learners' shortfall of linguistic input compared to native speakers.

1.2 Chapter highlights

In this thesis, Chapter 2, 3, and 4 report the results of the studies on immediate influences of prosody, syntactic priming, and semantics of lexical items as well as clause length on online syntactic analysis with structurally ambiguous sentences in Japanese. Chapter 2 reports the study that focuses on prosodic information. Numerous studies have reported the effect of prosodic information on parsing (Schafer, et al., 2000; Snedeker & Trueswell, 2003) but whether prosody can impact even the initial parsing decision is still not clear. In a visual world eye-tracking experiment, the study in Chapter 2 investigates the influence of contrastive intonation and visual context on processing temporarily ambiguous relative clause sentences in Japanese. The results from the study show that listeners used the prosodic cue to make a structural prediction before hearing disambiguating information. Importantly, the effect was limited to cases where the visual scene provided an appropriate context for the prosodic cue, thus eliminating the explanation that listeners have simply associated marked prosodic information with a less frequent structure. Furthermore, the influence of the prosodic information was also

evident following disambiguating information, in a way that reflected the initial analysis. The results from this experiment demonstrate that prosody, when provided with an appropriate context, influences the initial syntactic analysis and also the subsequent cost at disambiguating information. The results also provide first evidence for pre-head structural prediction driven by prosodic and contextual information with a head-final construction.

Chapter 3 reports the study on syntactic priming. A number of previous studies showed that access to a particular syntactic structure is facilitated by past experience with the same structure (Bock, 1986, 1989; Bock & Loebell, 1990; Bock, Loebell, & Morey, 1992; Pickering & Branigan, 1998). This phenomenon, called s*yntactic priming*, is known to influence the processing cost that is associated with structural ambiguity. However, it is still not known exactly how this facilitatory effect is caused. In particular, the study in Chapter 3 investigates whether the facilitatory effect is, at least partly, driven by the prediction of an upcoming structure. The study reports the results from two eye-tracking visual world experiments, in which the predictive effect of syntactic priming in the processing of Japanese main clause and relative clause structure was tested. The results show that participants predicted a relative clause structure more at the verb, viz. prior to any disambiguating information, when they had experienced a relative clause sentence in an immediately preceding sentence. Crucially, the anticipatory priming effect was observed only when the verb was repeated between the prime and target sentences. The results demonstrate that comprehenders of Japanese access the syntactic representation for the relative clause structure at the verb and the representation is accessed in a lexically associated manner at least in comprehension.

Chapter 4 reports the study on the influences of semantics of lexical items and clause length. Previous research reported that language comprehenders tend to preserve the initial incorrect analysis with temporarily ambiguous sentences following structural reanalysis (Christianson et al., 2001; van Gompel et al., 2006). One possible criticism is that the sentences tested in previous studies allow comprehenders to pragmatically infer that the initial misanalysis may be true. It is thus unclear whether the tendency can still be observed where such inferences are not possible. The study in Chapter 4 therefore tests the relative clause sentences in Japanese, which are temporarily ambiguous between the main clause and relative clause analysis. Crucially, the sentences differ from those in the past studies in that the correct interpretation following reanalysis makes an interpretation of the initial analysis pragmatically incompatible. The results demonstrate that an interpretation of the initial analysis persists even without pragmatic inference and that such incomplete syntactic representation occurs most likely due to large processing load.

Following the findings of the immediate effects of various types of linguistic information in Japanese sentence processing, Chapter 5 reports the study that investigates whether language learners can use such linguistic information in processing an L2 in the same way as native speakers do. Specifically, the study in this chapter explores the difference between Japanese EFL learners and native English speakers in the use of verb subcategorization information in processing ambiguous syntactic structures in English. In the experiment, sentences with early or late closure ambiguity with two types of verbs, optionally transitive verbs and intransitive verbs are tested, and the reading times are measured using a self-paced reading paradigm. The results show that the EFL learners experienced processing difficulty due to structural ambiguity following both types of

verbs, which contrasted the results of the native speakers who experienced such difficulty only following the optionally transitive verbs. In addition, the response accuracy of the questions about subordinate clause interpretation differed depending on the verb type for the native speakers but not for the EFL learners. Furthermore, an additional analysis reveals that the EFL learners who got higher scores on the questions about subordinate clause interpretation were more similar to the native speakers in the use of verb subcategorization information compared to those who got lower scores. For the participants with higher scores, the processing cost due to structural ambiguity was greater in the optionally transitive verb condition than in the intransitive verb condition. On the other hand, for the participants with lower scores, the cost did not differ depending on the verb type. Together with the results from the sentence completion test, the study in this chapter demonstrate that the difference in processing temporarily ambiguous sentences between native English speakers and Japanese EFL learners is due to EFL learners' incomplete intransitivity information, which lead them to often adopt, or coerce, a transitive analysis with the intransitive verbs and to experience processing difficulty at disambiguating information.

In the final chapter, brief summaries of the findings in each study and their implications are provided.

CHAPTER 2

IMMEDIATE USE OF PROSODY AND CONTEXT IN PREDICTING A SYNTACTIC STRUCTURE

2.1 Introduction

To comprehend spoken language, listeners need to analyze the speech signal according to the language-specific structure of *prosody,* which includes cues such as tone, intonation, rhythm, and stress. Previous research showed that speakers provide prosodic cues to disambiguate structures and that listeners use these cues to guide their structural analysis (Schafer et al., 2000; Snedeker & Trueswell, 2003). For instance, Snedeker and Trueswell (2003) found that speakers prosodically distinguish between the alternative structures of globally ambiguous phrases such as *Tap the frog with the flower* and that the location of the prosodic boundary directly affects listeners' syntactic analyses (see also Kjelgaard & Speer,1999; Schafer et al., 2000; Speer, Kjelgaard & Dobroth, 1996; Snedeker & Casserly, 2010). Schafer, Carter, Clifton and Frazier (1996) demonstrated that focal accent influences how listeners resolve attachment ambiguity of a complex NP followed by a relative clause modifier such as *the propeller of the plane that….* These results demonstrate that prosodic information is used online in resolving structural ambiguities (see also Marslen-Wilson, Tyler, Warren, Grenier, & Lee, 1992). However, it is not yet certain whether it is used immediately for predicting a syntactic structure prior to disambiguating information. The current study addresses this issue by examining the influence of contrastive intonation in combination with contextual information on predictive structural processing with temporarily ambiguous relative clause sentences in Japanese. The finding of such an anticipatory effect would provide clear evidence for an

influence of prosodic information on the initial syntactic analysis. It would also provide the first evidence for pre-head structural prediction driven by prosodic and contextual information with a head-final construction (cf. Kamide, Altmann, & Haywood, 2003).

Most previous studies do not provide evidence for the immediate and truly interactive influence of prosodic information on initial syntactic analysis because they either relied on offline measures or examined the processes following disambiguating information. An exception is a study by Weber, Grice and Crocker (2006), who tested SVO and OVS structures in German. The two types of sentences were identical (thus temporarily ambiguous) up to the verb due to the case-ambiguous sentence-initial NP but carried different intonation patterns, (the nuclear stress accent was on the verb in the SVO structure whereas it appeared on the initial NP in the OVS structure). Their results revealed different patterns of eye-movements between the two structures prior to the disambiguating sentence-final NP, demonstrating the influence of prosodic information on structural prediction. However, it is possible that the different looking patterns for the two structures reflected a difference between the default looking pattern associated with the canonical SVO structure and the disrupted pattern due to the non-default (i.e., marked) intonation pattern for the less frequent OVS structure. This implies that the difference may be due to an absence of SVO prediction with the OVS-type prosody rather than the presence of OVS prediction itself. It therefore remains unclear whether prosody can indeed drive a structural prediction (see also Snedeker & Trueswell, 2003).

The current study examined the influence of contrastive intonation in predicting a syntactic structure. Previous studies showed that contrastive pitch accents evoke a notion of contrast in a discourse context and facilitate the processes of identifying an upcoming

referent in spontaneous dialogue (Ito & Speer, 2008; Ito, Jincho, Minai, Yamane, & Mazuka, 2012; Weber, Braun, & Crocker, 2006). This study examined the impact of the contrastive intonation placed on the relative clause (underlined below) on the processing of temporarily ambiguous relative clause sentences in Japanese such as (2.1).

(2.1) 男の子が<u>三輪車に乗っていた</u>女の子を見つめた。

Otokonoko-ga *<u>sanrinsha-ni notteita</u>* *onnanoko-o* *mitsumeta*.
Boy-NOM [tricycle had being riding] girl-ACC stared at
'The boy stared at the girl who had been riding the tricycle.'

In Japanese, relative clauses precede lexical heads without an overt complementizer or any grammatical marking on the verb within the relative clause (henceforth RC verb). This creates a local syntactic ambiguity: The sentence is ambiguous between the main clause (henceforth MC) and the relative clause (RC) structures up to the RC verb. Due to the strong preference for the MC structure, people typically analyze the VP (*sanrinsha-ni notteita*. 'had been riding the tricycle') as part of the MC for which the sentence-initial NP (*otokonoko-ga*, 'boy') is the subject (Inoue & Fodor, 1995; Mazuka & Itoh, 1995)[1]. They are forced to revise the analysis for the RC on encountering the RC-head (*onnanoko-o*, 'girl').

In addition to prosody, visual context was also manipulated using the visual world eye-tracking technique (Cooper, 1974). It was designed either to support the use of contrastive intonation (Contrastive context, Figure 2.1b) or not to support it (Non-

[1] Japanese aspectual marker *–te i-* in the RC verb *notteita* can also indicate progressive meaning ('was riding') as well as resultative meaning as in the example. It is known that the choice of its meaning is highly dependent on context and verb sense (Shirai, 1998). In this study, the visual scene provides sufficient information to disambiguate the meaning.

Contrastive context, Figure 2.1a). Both types of context depicted four entities, three of which corresponded to the referents in the sentence; subject (boy), RC object (tricycle), and RC-head (girl). The fourth entity in the Contrastive context stood as a contrast to the RC-head entity (another girl on a hobbyhorse, Figure 2.1b); in the Non-Contrastive context it was a distractor that did not stand as a contrast (an adult woman on a bicycle, Figure 2.1a).

(a) Non-Contrastive context (b) Contrastive context

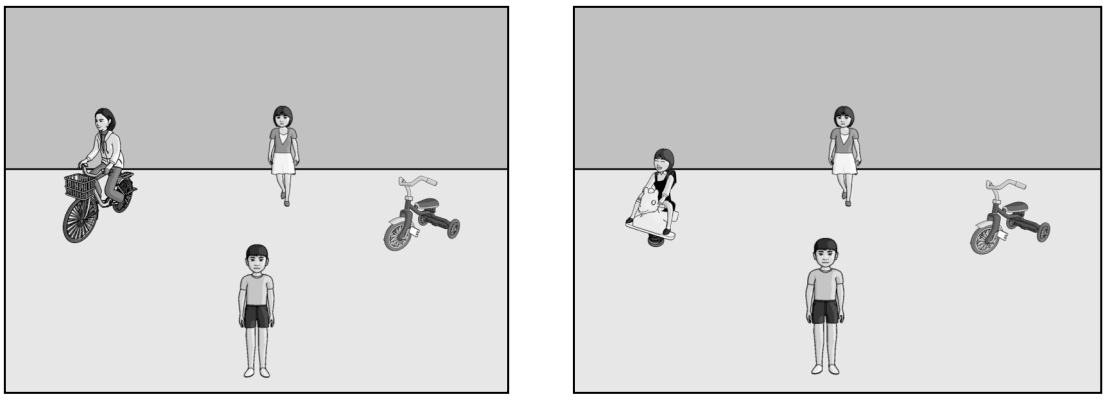

Figure 2.1: Example visual scenes for Non-Contrastive context (a) and Contrastive context (b)

The manipulation of visual context is in essence similar to the study of Tanenhaus, Spivey-Knowlton, Eberhard and Sedivy (1995), which showed that contrastive context facilitated the processing of an ambiguous *postnominal* modifier, a prepositional phrase following a head noun (i.e., *on the towel* in 'Put the apple on the towel in the box'). With the head-final construction, it is possible that contrastive context would drive listeners' expectation for a *prenominal* modifier even before hearing the head. However, due to the strong preference for the MC structure, contextual information alone may not be able to

activate the infrequent RC analysis. Thus, it is expected that contrastive intonation on the relative clause would play a critical role: When a contrast in the visual scene is highlighted by contrastive intonation on the relative clause (i.e., emphasizing that someone had been riding a tricycle but not a hobbyhorse), the modifier interpretation (i.e., the RC analysis) may be accessed even before the referent is mentioned as it tells listeners which girl is being referred to. Therefore, anticipatory eye-movements toward the to-be-mentioned referent (i.e., the girl who is not on the hobbyhorse) would indicate the prediction of an RC-head and thus reflect the listeners' RC analysis before the sentence was disambiguated because the alternative MC interpretation (i.e., 'The boy had been riding the tricycle') does not require any further linguistic material following the verb. On the other hand, it is expected that prosody would not affect eye-movements in the Non-Contrastive context because the prosodic cue in absence of a contrastive pair would likely be interpreted as a simple emphasis of the dative NP in the default MC analysis (i.e., emphasizing that the boy had ridden the tricycle but not other things).

Furthermore, the current study also investigated the influence of the prosodic cue following the disambiguating RC-head NP to see whether structural prediction would affect the subsequent cost at the disambiguating information. Such an effect is predicted by processing models such as Hale's (2001) surprisal model, which estimates processing cost based on the change in the probability distribution over possible analyses from one word to the next (see also Levy, 2008).

2.2 Experiment: Visual world eye-tracking study using contrastive intonation

2.2.1 Method

Participants

Twenty-eight native speakers of Japanese with normal visual acuity and hearing participated in the experiment for monetary compensation.

Materials

Twenty-eight experimental items were created. Each item consisted of an auditory sentence and a corresponding scene (see Appendix A for the full set of experimental items). The auditory stimuli were recorded by a female native speaker of Japanese with standard accent. Figure 2.2 shows the F0 contours of the sentence (2.1) without the contrastive intonation (Figure 2.2a) and with it (Figure 2.2b)[2].

[2] The difference in F0 peaks between the sentence-initial NP and the following NP was significantly larger for the items with contrastive intonation compared to those without (t (27) = 15.17, $p < .001$ by a paired t-test). There was also a difference in the pause length prior to the RC between the items with contrastive intonation and those without (mean difference 52 ms; t (27) = 2.65, $p = 0.01$ by a paired t-test). This pause may possibly affect syntactic analysis with this structure independently of visual context. As shown in the result section, however, I found no evidence to support this. There is another possible confound for the prosodic manipulation: The pitch range is usually reset prior to a new clause in Japanese (cf. Uyeno, Hayashibe, Imai, Imagawa, & Kiritari, 1980; Venditti, 1994), which could also affect syntactic analysis independently. However, again, no supporting evidence was observed.

(a) Sentence without contrastive intonation (b) Sentence with contrastive intonation

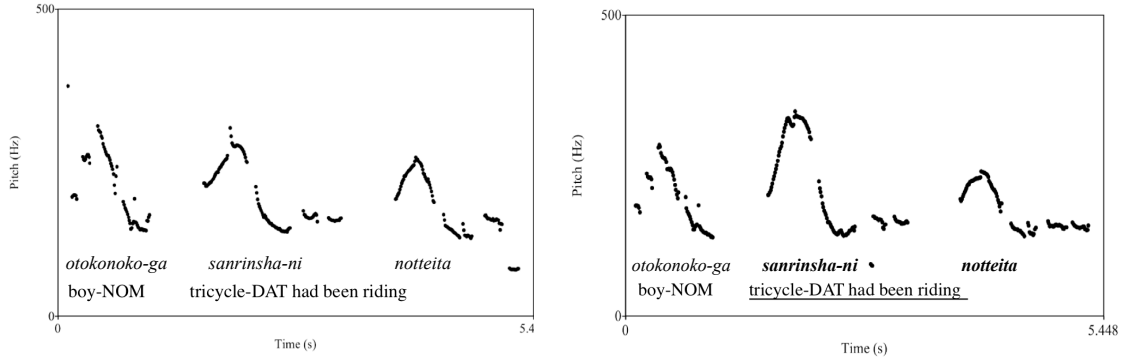

Figure 2.2: F0 contour of the sentence (2.1) without contrastive intonation (a) and with it (b).

The visual scenes were prepared using commercial clipart images. The position of objects was counter-balanced across the pictures.

It is known that the difference across individuals and the order of presentation of experimental items can bias the outcome. Therefore, for all the experiments reported in thesis, these variables were controlled by using appropriate experimental methods and statistical analysis. First, in order to control the order effects, experimental lists in which each experimental item appears only once in a particular condition were created. For example, in an experiment of 2 x 2 design with two levels for each factor, four experimental lists were created ensuring that each item is tested equally often in each condition and that each participant receives an equal number of items in each condition. Each experimental list also contains filler sentences that are structurally unrelated to the experimental target items in order to mask the objectives of the experiments.

Also, the individual difference was dealt with by statistical approach; participants were included as random factor for the base performance (intercept) and the sensitivity to

experimental manipulations (slope). It is certainly likely that different populations would not produce the same results. In fact, some studies reported that older adults exhibit greater difficulty in recovering from initial incorrect analysis than younger adults, most likely due to the difference in working memory capacity (Christianson, Williams, Zacks, & Ferreira, 2006; Yoo & Dickey, 2011). However, such group differences can in principle be regarded as of the same nature as individual differences. Therefore, the effects revealed by the statistical analysis in this thesis should be generalizable across different individuals and different groups although the magnitude of the effects may vary across them.

For the experiment in the current study, four experimental lists were created following a Latin square design including 56 fillers. The 84 items in each list were presented in pseudo-random order with a constraint that at least two fillers preceded each experimental item. In addition, 12 comprehension questions were included.

Procedure

Participants were first given a brief instruction and underwent a calibration procedure. They were told to listen to auditory sentences carefully while paying attention to the picture on the computer monitor. In each trial, an auditory sentence was presented 2500 ms after the picture onset. Participants' eye-movements were recorded, while the picture was presented, with EyeLink Arm Mount (SR Research) at the sampling rate of 500 Hz. The whole experimental session took approximately 30 minutes.

2.2.2 Data analysis and results

The fixation coordinates from the eye tracker were mapped onto four entities in the visual scene and were then converted to gazes. Following standard definitions, a gaze was defined as the accumulation of all consecutive fixations on an entity until another entity (or background) was fixated (Arai, van Gompel, Scheepers, 2007). The onset and offset of the RC verb (*notteita*, 'had been riding'), those of the RC-head (*onnanoko*, 'girl'), and the onset of the case-marker for the RC-head (*-o*) in each target sentence were manually marked. Firstly, the gazes to the RC-head entity for the duration of the RC verb were analyzed. Figure 2.3 shows the probability of gazes to the RC-head entity from the RC verb onset until 1300 ms. The first vertical line marks the mean offset of the verb (822 ms, *SD* = 133) and the second line (dotted) the mean onset of the RC-head (1289 ms, *SD* = 131).

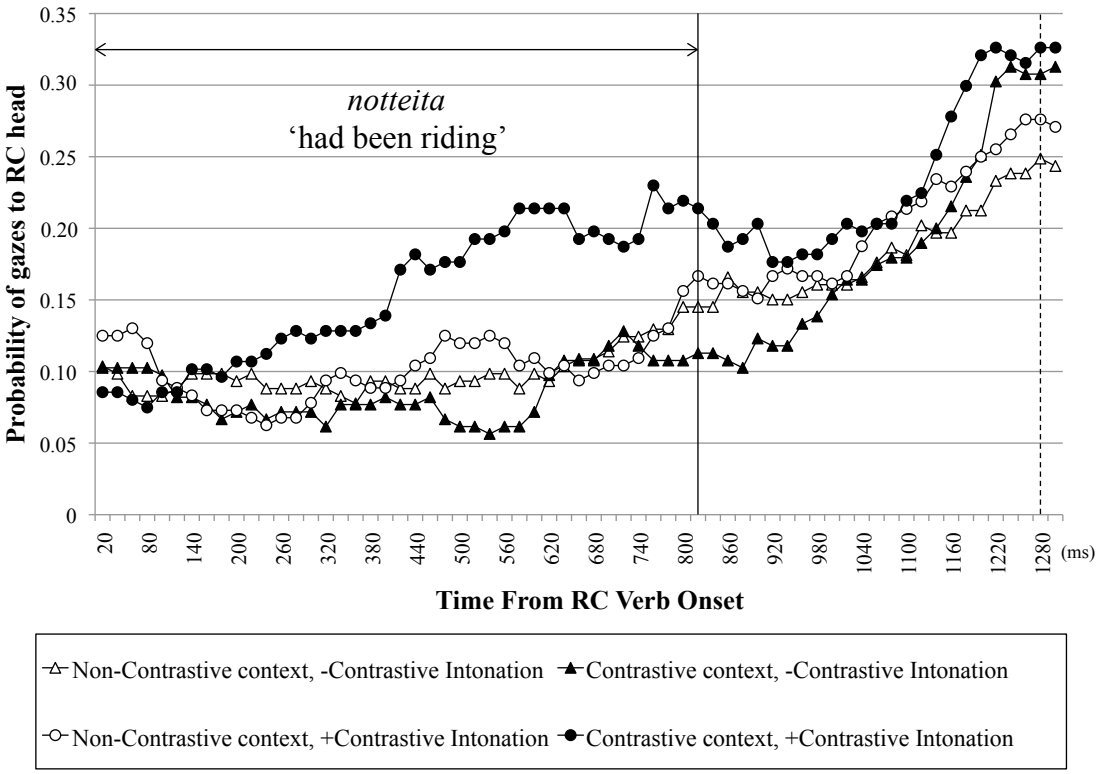

Figure 2.3: Probability of gazes to the RC-head entity from the RC verb onset to 1300 ms

For the analysis, the gazes to each object in the scene, which were sampled every 20 ms, for the 700 ms time interval of 100-800 ms following the RC verb onset were summed and the logit of looks to the RC-head entity out of looks to all the objects in a scene (including background) was calculated[3] and the statistical analysis was conducted.

All the statistical analyses reported in this thesis used Linear Mixed-Effects (LME) models (e.g., Baayen, Davidson, & Bates, 2008). The analysis using LME models provides several advantages over the traditional analysis of variance. First, there is no need to conduct two separate statistical tests on means for participants (F1) and those for

[3] The empirical logit using the function $\eta' = \ln \frac{(y + 0.5)}{(n - y + 0.5)}$ was calculated where y is the number of looks to the RC-head entity and n is the total number of looks to all the objects in a scene and background (Barr, 2008).

items (F2), as both subjects and items can be included in a model simultaneously as random variables at separate levels. Second, LME models are robust in handling missing data points resulting in unbalanced design between the conditions, which are fairly common in eye-movement measures. For all analysis reported in this thesis, coefficients (β), *t*-values (*t*), and *p*-values (*p*) for all the fixed factors and interactions are reported. *P*-values are computed based on Markov-chain Monte Carlo sampling. When the variance of the data is binomial (e.g., for the analysis on comprehension questions), generalized linear mixed effects models are used and z-values (*z*) are reported instead of *t*-values.

For the statistical analysis using LME models in the current study, Prosody (with or without contrastive intonation) and Visual Context (Contrastive or Non-Contrastive) were included as fixed effects with the interaction between the two factors allowed; participants and items were random factors. All the fixed factors were centered with deviation coding. It was also checked whether the model improved its fit by adding random slopes for each participant and item with a forward-selection approach. Table 2.1 shows coefficients (β), *t*-values, and their *p*-values from the model. Exact values for *p* are reported except when it is less than 0.001.

Table 2.1: Analysis of looks to the RC-head entity from 100 ms to 800 ms following the RC verb onset.

	β	t	p
Intercept	-2.94		
Visual Context	0.07	1.04	0.30
Prosody	0.13	1.88	0.06
Prosody × Visual Context	0.15	2.27	0.02

The results showed that there was a marginal effect of Prosody ($p = 0.06$), suggesting a tendency for participants to look more at the RC-head entity with contrastive intonation than without. Most importantly, there was a significant interaction between Prosody and Visual Context. Separate analyses for each context type revealed that the effect of Prosody was significant in the Contrastive context ($\beta = 0.28$, $t = 2.86$, $p = 0.005$) but not in the Non-Contrastive context ($\beta = -0.03$, $t = 0.28$, $p = 0.78$). This demonstrates that participants looked more at the RC-head entity with contrastive intonation only in the Contrastive context. Furthermore, separate analyses for each prosody pattern revealed a significant effect of Visual Context with contrastive intonation ($\beta = 0.22$, $t = 2.22$, $p = 0.03$) but not without ($\beta = 0.08$, $t = 0.91$, $p = 0.37$). Since an additional analysis revealed no difference in the looks to the distractor/contrastive entity in this time interval across conditions ($\beta = -0.02$, $t = 0.99$, $p = 0.33$ for Visual Context, $\beta = -0.00$, $t = 0.08$, $p = 0.94$ for Prosody, $\beta = -0.02$, $t = 0.87$, $p = 0.39$ for their interaction), this provides evidence for an effect of visual context on the prediction of a syntactic structure, which has not been demonstrated previously. In previous studies, the influence of referential context was observed only after a head NP and a following modifier were encountered but not in

prediction (Tanenhaus, et al., 1995; Trueswell, Sekerina, Hill, & Logrip, 1999; Spivey, Tanenhaus, Eberhard, & Sedivy, 2002). It is important to note that the finding cannot be an artifact due to the referential ambiguity for the RC-head entity in the Contrastive context (two girls in Figure 2.1). If participants had difficulty in identifying the correct RC-head entity, there should have been fewer looks to the RC-head in the Contrastive context than in the Non-contrastive context. The results however showed the opposite pattern. It also does not explain the effect of prosody in the Contrastive context as it occurred for the identical visual context.

The current study next analyzed the gazes following the RC-head onset to examine the influence of the prosodic cue at the disambiguating information. Figure 2.4 shows the probability of gazes to the RC-head entity from the RC-head onset to 1700 ms. The first vertical line marks the mean onset of the head noun case-marker (565 ms; *SD* = 183), and the second line that of the MC verb (719 ms; *SD* = 197).

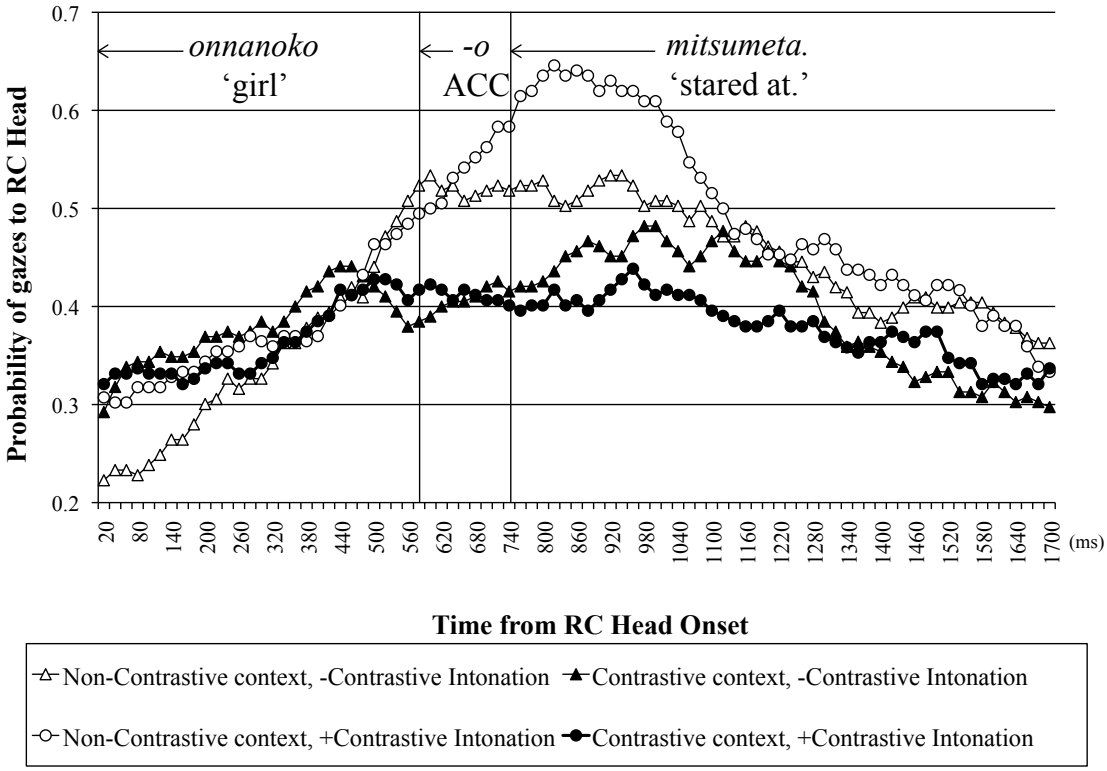

Figure 2.4: Probability of gazes to the RC-head entity from the RC-head onset to 1700 ms.

Following the same procedure, the logit of looks to the RC-head entity was analyzed using the same function as in the earlier analysis, for the duration of the RC-head noun (100–600 ms interval following the onset). The results showed no effects or interaction of the two factors (β = -0.01, t = 0.32, p = 0.76 for Visual Context, β = -0.01, t = 0.29, p = 0.81 for Prosody, β = -0.05, t = 1.46, p = 0.14 for their interaction). One possibility is that participants may have delayed structural (re)analysis until they heard a case-marker as it informs the grammatical role of the RC-head NP in a matrix clause. This is consistent with previous studies that showed that case-markers play a critical role in pre-head

syntactic analysis in Japanese (e.g., Miyamoto, 2002)[4]. Therefore, another analysis on the logit of looks to the RC-head entity from 100 ms to 800 ms following the case-marker onset was conducted. The 700 ms interval was selected for compatibility with the earlier analysis for the RC verb duration. Table 2.2 summarizes the results.

Table 2.2: Analysis of looks to the RC-head entity from 100 ms to 800 ms following the case-marker onset.

	β	t	p
Intercept	-0.06		
Visual Context	-0.43	4.50	<.001
Prosody	-0.02	0.16	0.88
Prosody × Visual Context	-0.21	2.20	0.03

The results showed a main effect of Visual Context, suggesting that participants looked at the RC-head entity more in the Non-Contrastive context than in the Contrastive context. This likely reflects the fact that there was only one entity that matches the RC-head noun in the Non-Contrastive context whereas there were two in the Contrastive context (i.e., two girls in the scene). This was supported by an additional analysis on the gazes to the distractor/contrastive entity for this duration, which showed a main effect of Visual Context ($\beta = 0.72$, $t = 5.04$, $p < .001$) but neither an effect of Prosody ($\beta = 0.09$, t

[4] Another possibility is that syntactic analysis was delayed until the MC verb was encountered. Although this view is consistent with a head-driven parsing model (Pritchett, 1991), it is clear from Fig. 2.4 that gaze probabilities across conditions started to diverge before the MC verb onset, suggesting that analysis initiated prior to the verb.

= 1.15, p = 0.25) nor an interaction (β = -0.04, t = 0.52, p = 0.60)[5]. Most importantly, the analysis of looks to the RC-head entity for this time window revealed an interaction between Prosody and Visual Context. Separate analyses for each context type showed that neither of the simple effects of Prosody reached significance although they showed trends in opposite directions and the effect for the Contrastive context was somewhat stronger (β = 0.20, t = 1.45, p = 0.16 for Non-Contrastive context; β = -0.23, t = 1.72, p = 0.08 for Contrastive context)[6]. The coefficients suggest that in the Contrastive context, participants looked less at the RC-head entity with contrastive intonation than without, which inversely reflected more anticipatory looks to the same entity with contrastive intonation in the earlier time period. In contrast, they looked more at the RC-head entity with contrastive intonation than without in the Non-Contrastive context. This likely indicates that participants interpreted the cue as a simple emphasis in this context, leading to a stronger commitment to the MC analysis in the earlier time period, and that they were more surprised to hear the disambiguating information.

2.3 General discussion

The current study demonstrated that participants used contrastive intonation to predict a syntactic structure when processing relative clause sentences in Japanese. Crucially, the influence of the prosodic cue was observed only when the visual scene provided an

[5] The best-fit model included a by-item random slope for Prosody. *P*-values were computed using the likelihood-ratio (LR) tests.

[6] In contrast with the further analyses, Figure 2.4 appears to show a larger difference for the Non-contrastive context than for the Contrastive context. This possibly reflects the difference in temporal location for the effect of Prosody between the two visual contexts; it occurs earlier in the Non-contrastive context than in the Contrastive context. One possible reason is that the eye-movements in the Contrastive context relate to the shift away from the RC-head entity whereas those in the Non-contrastive context relate to the shift toward it (hence the former occurring later than the latter).

appropriate context. In the contrastive context, participants made more anticipatory eye-movements toward the RC-head entity immediately on hearing the RC verb when the relative clause had contrastive intonation than when it did not. This suggests that the relative clause analysis was accessed because the manipulated prosodic cue was interpreted in light of the appropriate visual context and not because the cue was marked and thus associated with a less preferred structural analysis (cf. Snedeker and Trueswell, 2003; Weber et al., 2006).

Furthermore, the results also showed a late influence of the prosodic cue after disambiguating information was encountered. The pattern of results was the opposite of what was observed in prediction for the contrastive context: In the Contrastive context, participants looked less at the RC-head entity when the relative clause had contrastive intonation than when it did not. This demonstrates that participants experienced less difficulty at the head as the relative clause structure was already anticipated. This indicates that the probability of the relative clause analysis was inversely correlated with its processing difficulty and thus provides empirical support for processing models that employ predictions to calculate processing cost (Hale, 2001; Levy, 2008). On the other hand, in the Non-Contrastive context, there were more looks to the RC-head entity following the disambiguating head NP when the relative clause carried contrastive intonation than when it did not. This most likely reflects the stronger commitment to the main clause analysis in the earlier time period; the prosodic cue in absence of a contrastive pair was initially interpreted as a simple emphasis but not as contrastive, which corroborated the main clause analysis, and participants experienced more difficulty at the disambiguating information, resulting in more looks to the head entity.

To conclude, the current study provides evidence for the influence of contrastive intonation in both predicting and integrating the RC-head with the relative clause structure in Japanese. The results demonstrate that listeners can use prosody in combination with visual context to make a structural prediction and also that such a prediction is related to the processing cost at the disambiguating information. This study also provides the first evidence for pre-head structural prediction driven by prosodic and visual information in a head-final language.

CHAPTER 3

EFFECT OF SYNTACTIC PRIMING IN PREDICTING A SYNTACTIC STRUCTURE

3.1 Introduction

There is a large body of research investigated how language users correctly analyze the syntactic structure during online sentence comprehension. In particular, research objectives of many previous studies have centered on whether the initial structural analysis is guided primarily by grammatical category information of linguistic input or it is also influenced by other types of information such as lexically-specific information. This issue is often framed as the evaluation of two influential sentence processing models; the garden-path model and lexicalist constraint-based models (Frazier, 1987; MacDonald, Pearlmutter, & Seidenberg, 1994). The former posits that only grammatical category information can guide the initial structural building while the latter does that any types of linguistic information such as lexically-specific structural frequency information as well as non-linguistic information such as discourse context can influence the process of determining the initial structural analysis. For example, using an eye-tracking reading method, Trueswell, Tanenhaus, and Kello (1993) investigated the influence of verb-specific structural preference in processing temporarily ambiguous sentences such as (3.1).

(3.1) The student hoped the solution was in the back of the book.

Their results showed that the processing of this structure was easier when the verb prefers a sentence complement over a direct object such as *hope* than when the verb has an opposite preference such as *forget*. Trueswell et al. (1993) thus argued in support of constraint-based models that lexically-specific information can immediately influence online structural analysis. There are many reports with similar findings but at the same time there are quite a few studies that found contradictory results (for similar findings, Clifton, Frazier, & Connine, 1984; Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Stowe, Tanenhaus, & Carlson, 1991; Trueswell & Kim, 1998; Trueswell, Tanenhaus, & Kello, 1993, for contradictory findings, Ferreira & Henderson, 1990; Frazier, 1987; Kennison, 2001; Pickering & Traxler, 2003; Pickering, Traxler, & Crocker, 2000; Mitchell, 1987). The presence of these mixed results makes it somewhat difficult to make a strong claim so as to the immediate access of lexically-specific information.

Another approach to this issue is to exploit the phenomenon of syntactic priming. It has been shown that after experiencing particular syntactic structure comprehenders tend to access the same syntactic structure in subsequent processing. For example, Ledoux et al., (2007) reported that the ERP response that can be attributed to processing cost due to structural ambiguity (P600) with reduced relative clause sentences such as (3.2) was attenuated when it was proceeded by another reduced relative clause sentence (e.g., *The speaker proposed by the group would work perfectly for the program*) compared to when it was by a main clause sentence (e.g., *The speaker proposed the solution to the group at the space program*.)

(3.2) The manager proposed by the directors was a bitter old man.

Importantly, most of previous studies demonstrated that syntactic priming in comprehension is dependent on the repetition of the verb between prime and target sentences (Arai et al., 2007; Branigan et al., 2005; Ledoux et al., 2007; Traxler & Pickering, 2005; Tooley, Traxler, & Swaab, 2009; Traxler & Tooley, 2008, but see Thothathiri & Snedeker, 2007). This suggests that the representation of syntactic structures are activated in relation with individual verbs and accessed via identifying the same verb, providing evidence for the influence of lexically-specific information on online structural analysis. However, the results from these studies are based on the processing difficulty at disambiguating information (e.g., *was* in (3.2)), not an effect at the verb where the access to its lexically-specific information should take place. Therefore, these results are unclear regarding when exactly the effect of priming occurred, to be more precise, it is unclear whether priming influenced the initial structural analysis or only the later integration process in revising an incorrect analysis. The objective of the current study is to investigate an influence of priming on the initial structural analysis in sentence comprehension.

There is some evidence that an effect of syntactic priming occurs as early as it influences the prediction of upcoming argument structures. Arai, van Gompel, and Scheepers (2007) showed that comprehenders predicted the same structure (either prepositional object or double objects structure) as in the prime as soon as they heard the verb. Since they observed the effect only when the verb was repeated between prime and target sentences but did not when it was not, their results indicate that the syntactic representations that were accessed through priming are associated with individual verbs. Also, since the effect was observed before hearing any postverbal element, their study

provides evidence for the influence of priming on the initial structural analysis. There, however, has been no study so far that reported a similar immediate priming effect with garden-path sentences. One possibility, which was originally implied by Traxler and Tooley (2008), is that the effect of syntactic priming, especially in comprehension, is relatively weak so that it is unlikely to cause comprehenders to immediately access the structurally dispreferred structure before a sentence is disambiguated. Alternatively, however, it is also possible that previous studies did not use an appropriate experimental setting as well as did not test an appropriate structure for this purpose. To investigate this, the current study adopted the visual world paradigm and tested relative clause sentences in Japanese. The visual world paradigm provides an excellent environment to investigate predictive processes, with a number of studies showing the influence of various sources of information on predictions of syntactic structures such as verb semantics (Altmann & Kamide, 1999), postpositional case-markers (Kamide, Altmann, & Haywood, 2003), prosody (Nakamura, Arai, & Mazuka, 2012; Weber, Grice, & Crocker, 2006), and verb-specific frequency information (Arai & Keller, 2012). Japanese is a head-final language and unlike English, the grammatical head appears following its relative clause, which can provide an ideal setting to investigate an immediate effect of syntactic priming prior to the disambiguation of the sentence structure.

The study in this chapter tested relative clause sentences in Japanese such as (3.3).

(3.3) 女優がシャンパンを飲んでいるロックスターと意気投合した。

Joyuu-ga shanpan-o nondeiru rokkusutaa-to ikitougoushita.
actress-NOM [champagne-ACC drinking] rock star-ACC clicked
'The actress clicked with the rock star who was drinking the champagne.'

As discussed in Chapter 2, relative clauses in Japanese precede lexical heads without an overt complementizer or any grammatical marking on the verb within the relative clause (*nondeiru*, 'drinking'; henceforth RC verb), creating a local syntactic ambiguity between the main clause (MC) and the relative clause (RC) structures on hearing the RC verb. It is known that people typically analyze the verb phrase (*shanpan-o nondeiru*, 'drinking champagne') as a part of the MC structure and are later forced to revise the analysis for the RC analysis on encountering the RC head noun (*rokkusutaa-to*, 'rock star' in (3.3)) (Inoue & Fodor, 1995; Mazuka & Itoh, 1995). Given the results in Chapter 2 that a prosodic cue, provided in an appropriate context, can lead listeners to predict an RC structure as soon as they listened to the first verb in similar RC sentences, it is predicted that if listeners previously experienced the RC structure, they would become more likely to predict the same structure in subsequent processing.

In the current study, predictions in a visual world setting was measured by recording eye-movements of listeners within visual scenes such as Figure 3.1 while listening to auditorily presented sentences. Each picture depicted four objects in a scene, three corresponding to the referents mentioned in the sentence (i.e., actress, champagne, and rock star) and one distractor (toddler).

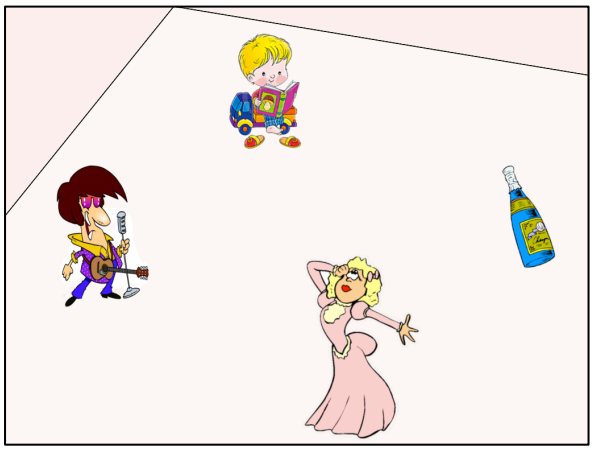

Figure 3.1: An example target picture.

The visual scene contained a distractor that is implausible as an RC-head candidate (the toddler in the above example as toddlers do not drink champagne). Therefore, the anticipatory looks toward the plausible RC-head candidate but not to the implausible candidate would reflect the prediction of the RC structure. On the other hand, if a listener predicted the MC structure instead, there should not be such a bias because the RC-head entity and the distractor are both perfectly plausible as a continuation following the conjunction *toki* 'when' (e.g., *Joyuu-ga shanpan-o nondeiru toki, otokonoko ha hon-o yondeita,* 'When the actress was drinking the champagne, the boy was reading the book').

The current study asked whether the prediction is modulated by the type of the structure that comprehenders previously experienced. Of course, it is possible that listeners only predict a grammatical category of the relative clause head, not considering the thematic fit between the grammatical head and the relative clause. If this is the case, any difference in looks between the plausible and implausible candidates would be observed even if listeners anticipated a relative clause head. This possibility was checked by examining the looks to the implausible candidate entity (i.e., distractor).

Furthermore, the current study also examined whether the effect of priming is dependent on the repetition of the verb between prime and target sentences. As mentioned above, an effect of priming was often observed only when the verb was repeated between prime and target sentences but not when it was not. Also, previous research showed that the repetition of the verb but not of others is crucial for observing syntactic priming (Traxler & Tooley, 2008). Following these results, some argued that this reflects relatively bottom-up nature of processing in comprehension (Arai et al., 2007). If this holds true for typologically different languages, the same pattern of results should be found in the current study. An alternative possibility is that lexical dependence of syntactic priming is a consequence of the head-initial word order of languages such as English. In these languages, the verb arrives prior to its complements constraining upcoming post-verbal constituents and thus plays an important role in syntactic processing. On the other hand, in head-final languages like Japanese, the verb arrives after the complement phrases. Therefore, other source of information such as case is informative for the pre-head structural analysis (e.g., Miyamoto, 2002; Kamide et al., 2003). This may predict that the repetition of the verb across trials may matter less in priming of syntactic structures in Japanese compared to that in English and that priming may be observed in the absence of lexical repetition as well as in its presence.

Finally, the current study further examined the processing of prime sentences in order to explore the source of a priming effect. It has been argued that syntactic priming underlies the process of implicit learning (Bock & Griffin, 2000; Chang, Dell, & Bock, 2006). In particular, Chang et al.'s SRN-based computational model implemented an error-based learning mechanism and successfully simulated the results of various studies

on syntactic priming. Although theirs is in principle a production model, Fine and Jaeger (in press) demonstrated that a comparable error-based learning model can account for the effect of syntactic priming in comprehension. Thus, if priming with the relative clause structure occurs due to the prediction error in processing prime sentences, evidence that relative clause prime sentences caused larger error than main clause prime sentences should be found.

In order to address these issues, the current study conducted two experiments; in Experiment 1, the first verb was always repeated between prime and target sentences and it was not in Experiment 2.

3.2 Pretest

A sentence completion test was conducted to examine the preference for the main structure over the relative clause structure. Participants were required to come up with continuations to sentence fragments, taken from the experimental items used as target sentences in the experiments. The sentence fragments were composed of a nominative NP, a NP with an accusative marker *o*, and a verb without morphological inflection such as (3.4).

(3.4) 女優がシャンパンを飲んでい……
Joyuu-ga shanpan-o nondei…...
Actress-NOM champagne-ACC drink

The verb was not presented in complete form (i.e., *nondeiru* 'is drinking' or *nondeita* 'was drinking') to avoid participants from simply adding a punctuation mark to complete

the fragment as a main clause sentence. The fragments could either be completed in the main clause structure with or without a conjunction or in the relative clause structure. Two lists were created in the Latin-square design with twenty-eight items. Each list included forty-six fillers and was presented in a pseudo-random order. The session always started with two practice trials. Twenty-four participants took part in this task.

The results showed that participants completed the fragments in the main clause structure for 97.4% and in the relative clause structure for 2.6% with no completion in other structures or incorrect response. A chi-square test showed that the main clause completions were significantly more frequent than the relative clause completions (χ^2 = 613.3, df = 1, $p < .001$), confirming a strong preference for the main clause structure over the relative clause structure.

3.3 Experiment 1: Study with the repetition of the verb between prime and target sentences

Experiment 1 investigated an influence of syntactic priming on the prediction of an upcoming structure in processing the MC and RC structures in Japanese. The first verb was always repeated across the pairs of prime and target sentences (see Appendix B for the full set of experimental items).

3.3.1 Method

Participants

Twenty-eight participants, who were recruited from the student community at University of Tokyo, took part in the experiment in exchange for monetary compensation. All the participants were native speakers of Japanese with normal or corrected-to-normal vision.

Materials

Twenty-eight experimental items were prepared, each of which consists of a pair of a prime and target stimulus. The prime is a written sentence and the target was a pre-recorded auditory sentence combined with a visual scene. Prime and target sentences were either the MC structure (3.5a, 3.6a) or the RC structure (3.5b, 3.6b), resulting in a fully crossed 2 x 2 design.

(3.5a) MC Prime

王様がお酒を飲んでいる時、女王様に話しかけた。

Oosama-ga osake-o nondeiru toki, jouoosama-ni hanashikaketa.

king-NOM alcohol-ACC drinking when queen-DAT talked to

'When the king was drinking alcohol, he talked to the queen.'

(3.5b) RC Prime

王様がお酒を飲んでいる女王様に話しかけた。

Oosama-ga osake-o nondeiru jouoosama-ni hanashikaketa.

king-NOM [alcohol-ACC drinking] queen-DAT talked to

'The king talked to the queen who was drinking alcohol.'

(3.6a) MC Target

女優がシャンパンを飲んでいる時ロックスターと意気投合した。

Joyuu-ga shanpan-o nondeiru toki rokkusutaa-to ikitougoushita.

actress-NOM champagne-ACC drinking when rock star with clicked

'When the actress was drinking the champagne, she clicked with the rock star.'

(3.6b) RC Target

女優がシャンパンを飲んでいるロックスターと意気投合した。

Joyuu-ga shanpan-o nondeiru rokkusutaa-to ikitougoushita.

actress-NOM [champagne-ACC drinking] rock star with clicked

'The actress clicked with the rock star who was drinking the champagne.'

As can be seen above, the two versions of prime and target sentences are identical up to the first verb (*nondeiru*, 'was drinking' in (3.5) and (3.6) and are structurally ambiguous between MC and RC structures before a following element is encountered.

The target sentences in the RC structure were adopted from the experiment reported in Chapter 2 and the MC version was created simply by adding *toki* ('when') following the first verb. Eighteen verbs were used, and 8 verbs of which were repeated twice across items. As shown in (3.5) and (3.6), there was no lexical overlap between prime and target sentences except the first verb for all conditions and the conjunction *toki* only for the MC prime - MC target condition. The target sentences were recorded by a female speaker with a standard Tokyo accent. The recordings were saved as wav format at 44 kHz and presented through satellite-speakers. The visual scenes are created using commercially available clipart images and graphic software. They were saved as 16-bit color bitmap in 1024×768 pixels resolution. Each picture contains easily recognizable four entities, which correspond to the sentence initial subject noun, direct object noun,

head noun (RC) / post-conjunction noun (MC), and a distractor and were arranged in a rhombus fashion. Across items, all the entities appeared equally often in each of the four positions, thus counterbalancing a potential effect due to scanning preferences.

Design and procedure

The experiments in this study combined the methodology of syntactic priming with the visual-world paradigm (Arai, van Gompel, & Scheepers, 2007; Scheepers & Crocker, 2004). Participants first read a prime sentence silently and next listened to a target sentence while seeing a corresponding target picture. Besides the twenty-eight experimental items, participants also saw seventy fillers, none of which was in the RC structure. Fourteen fillers were written sentences and fifty-six fillers were spoken sentences accompanying visual scenes. Using a Latin-square design, four lists were created in which each item appeared only once in one of the four conditions and the equal number of items appeared in each condition. The items and fillers were presented in a quasi-random order, in which at least one filler always intervened between experimental items. Participant's eye-movements were recorded during both prime and target trials with EyeLink Arm Remote (SR Research) at the sampling rate of 500 Hz, which had the spatial resolution of less than 0.01°.

In the experimental session, participants first received a brief instruction form and sat approximately at a 70 cm distant from the 17" computer monitor. Next, they went through a brief calibration procedure, which typically took less than one minute. The calibration procedure was repeated during an experimental session if the recording appeared inaccurate but it was never performed between prime and target trials. Before

each reading trial, for both experimental items and fillers, participants saw a small circle at the center of the screen (fixation cross), which performed an automatic drift correction. When participants finished reading, they pressed a button to proceed to the next trial. In target trials, on the other hand, visual scenes were presented immediately following previous trials without the fixation cross. Auditory sentences were then presented with a delay of 2500 ms, which ensured that participants fully apprehended the visual scene. To keep participants focused, 12 comprehension questions following reading trials were included. Each experiment session typically took approximately 30 minutes to complete.

3.3.2 Data analysis and results

3.3.2.1 Reading times in prime trials

Firstly, the reading times for prime sentences were examined to see whether participants experienced processing difficulty with the RC structure due to its structural ambiguity. Such a finding would indicate that the processing of RC prime sentences resulted in prediction errors due to their initial misanalysis for the MC structure and support error-based learning models in that the priming of the RC structure would occur because of these errors. Two regions of the sentences were analyzed; the postverbal *RC head noun/MC subject noun* region (*rokkusutaa-to*, 'with the rock star') to see processing cost at a disambiguating region and the following *sentence-final verb* region (*ikitougoushita*, 'clicked') because an effect of structural revision may be spilled over in the next region. For the analysis of fixation data, fixations that were either extremely long (1200 ms or over) or extremely short (80 ms or under) were removed (Sturt, Pickering & Crocker, 1999). This resulted in the exclusion of 6.0% of the whole data. For results, the reading times from the measure of Fist-pass reading time, which is the sum of fixations in a

particular region following the first entry in the region until the first fixation outside the region (either to the left or the right), are reported. First-pass reading times are generally assumed to reflect the early stage of processing and are thus suited for examining immediate processing difficulty at the disambiguating information. Table 3.1 shows the mean First-pass reading times for the two regions.

Table 3.1: Mean reading times (Standard Error) in prime sentences.

	Main clause	Relative clause
Region 4	438 (13)	393 (17)
Region 5	586 (24)	699 (27)

For statistical analysis, Structure Type (MC or RC) was included as a fixed factor and participants and items were included as random factors in the model. The fixed factor was centered with deviation coding. The best-fit model was selected with an optimal random slope structure using a backward selection approach. Where the best-fit model includes more than one random slope, *p*-values for fixed factors were computed using likelihood-ratio (LR) tests.

The analysis of the postverbal *RC head noun/MC subject noun* region (Region 4) showed a marginally significant main effect of Structure Type; participants tended to read this region more slowly in the MC sentences than in the RC sentences (β= -22.58, t = 2.02, p = 0.05). This pattern of the result is opposite from what was predicted by expected processing cost at the disambiguating region for the RC structure. Therefore, the regression-out rates in this region was examined to see whether the shorter First-pass

times for the RC condition may be due to greater occurrences of regressive eye-movements, reflecting looking back at earlier region to revise structural analysis. The analysis indeed revealed that there occurred more regressions in the RC condition than in the MC condition (Mean Regression-out rate for MC sentences = 30.6%, for RC sentences = 38.6%; $\beta = 0.20, z = 2.12, p = 0.03$).

The analysis in the *sentence-final verb* region (Region 5) showed a significant main effect of Structure Type; participants took longer to read this region in the RC condition than in the MC condition ($\beta = 55.08$, $t = 2.94$, $p = 0.01$). This spill-over effect most likely reflects the processing cost associated with the revision of the incorrect initial analysis in processing RC sentences.

The results together showed evidence for processing difficulty associated with the RC structure and suggest that comprehenders tend to initially adopt a main clause analysis and are forced to revise it when the sentence later turned out to be the RC structure.

3.3.2.2 Eye-movements in target trials

The spatial coordinates of fixations are automatically mapped onto one of the four objects in the scene (subject, RC object, RC head, and distractor) or background. The area for the four objects was manually defined while allowing approximately 30 pixels around the contour of each object. These fixations were then converted to gazes. A gaze was defined as the accumulation of all consecutive fixations on one object until another object (or the background) was fixated. To analyze the gazes with reference to linguistic input, the

onset and offset of the RC verb (*nondeiru*, 'drinking') and those of the RC head (*rokkustaa*, 'rock star') were manually marked in each target sentence.

For analysis, it was examined whether the participant's prediction about the syntactic structure would be influenced by the structure of an immediately preceding prime sentence. As illustrated earlier, in the current experimental setting, the prediction of the RC structure would be reflected in increased looks toward the RC-head entity but not to the distractor. Since such a prediction is expected to occur on encountering the first verb, the gazes to the RC-head entity from the onset of the RC verb was analyzed. Figure 3.2 shows the probability of gazes to the RC-head entity (i.e., *bijinesuman* 'businessman') for the 1800 ms interval starting from the initial verb onset. The three vertical lines correspond to the mean onset of the conjunction *toki* in the MC target (662 ms, *SD* = 120), that of the RC head noun (1105 ms, *SD* = 132) for the MC targets, and that of the RC head for the RC targets (1596 ms, *SD* = 145) respectively. Thus, the point of disambiguation is indicated by the first vertical line for the MC target sentences whereas it is by the second line for the RC target sentences.

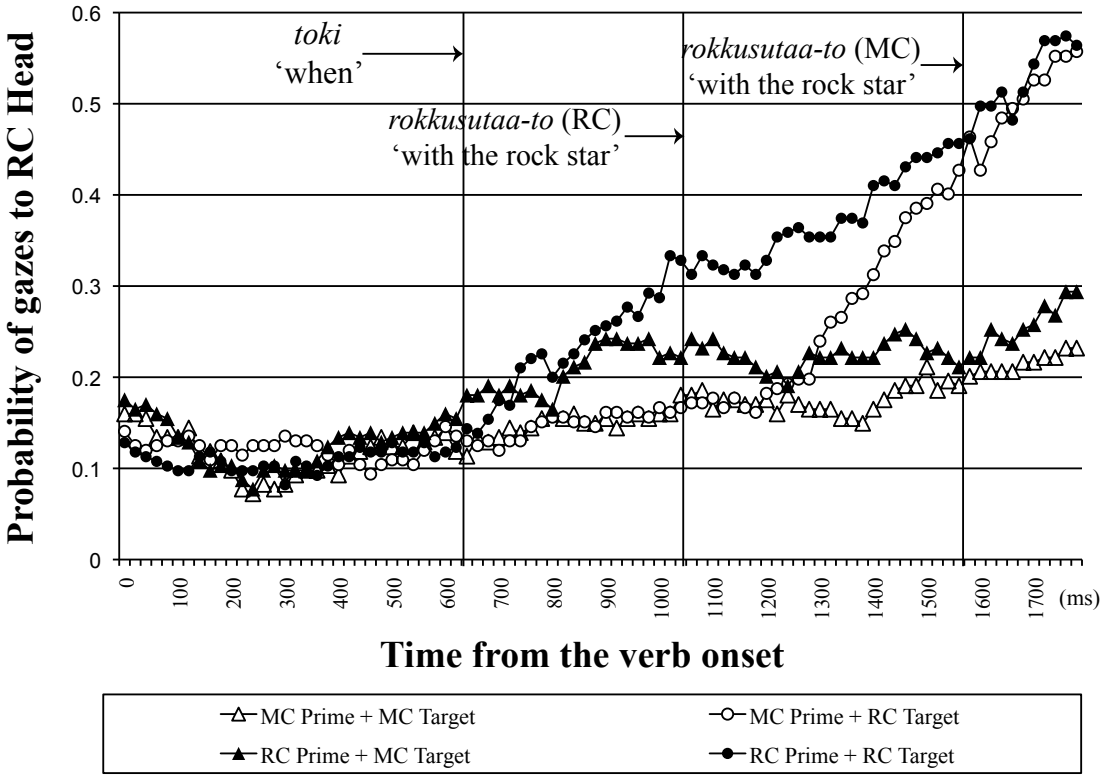

Figure 3.2: Probability of gazes to the RC-head entity for 1800 ms following the onset of the first verb (Experiment 1).

For analysis, the logit of the looks to the RC-head entity out of the looks to all other objects in a scene was calculated, including background, over the interval from 200 ms to 1100 ms following the onset of the initial verb (*nondeiru*, 'drinking') using LME models. The first 200 ms was left out from the analysis because it is highly unlikely that the eye-movements during this period would reflect response to the input of the verb (note that the uniqueness point for identifying the verb is later than its onset). The end point of the interval roughly corresponds to the mean onset of the RC head noun in an RC target sentence, where the structure was fully disambiguated. In the models, Prime Type (MC prime or RC prime) and Target Type (MC target or RC target) as well as nine 100 ms

time windows as a continuous variable (Time Window) were included as fixed factors, allowing all the interactions between these factors. Time Window was included to examine a shift of visual attention during this time interval. If syntactic priming occurs with the RC structure, it is predicted that participants would make more anticipatory eye-movements toward the RC-head entity following an RC prime than following an MC prime, more specifically, they would increase the looks to the RC-head entity over the course of this time interval. Target Type was included as a factor because the two types of target sentences differed following the first verb, i.e., participants heard the conjunction *toki* for the MC targets but not for the RC targets. It is thus possible that the effect of priming interacts with the type of the target structure. As in the earlier analysis on reading times for prime sentences, participants and items were included as random factors and the best-fit model was chosen with an optimal random slope structure using a backward selection approach. Table 3.2 showed the summary of the results.

Table 3.2: Analysis of the looks to the RC-head entity for the 200 ms – 1100 ms interval following the onset of the first verb (Experiment 1).

Factor	β	t	p
(Intercept)	-1.37		
Prime Type	0.09	1.68	0.10
Target Type	0.02	0.45	
Time Window	0.19	4.07	< .001
Prime Type × Target Type	0.02	0.35	
Prime Type × Time Window	0.10	2.80	0.01
Target Type × Time Window	0.01	0.31	
Prime Type × Target Type × Time Window	0.04	2.15	0.03

There was a significant main effect of Time Window, suggesting that participants increased the looks to the RC-head entity over this time interval. The main effect of Prime Type was only marginally significant. However, importantly, a significant interaction between Prime Type and a covariate Time Window was observed, providing evidence for the effect of priming with this structure. The coefficient suggests that the participants increased the looks to the RC-head entity more over this time period following RC primes than following MC primes. Furthermore, the interaction between Prime Type and Target Type and a covariate Time Window was observed. In order to examine the pattern of this interaction, the interaction between Prime Type and Time Window for each target type was analyzed. The results of this analysis showed that the Prime Type × Time Window interaction was reliable only for the RC targets ($\beta = 0.14$, $t = 2.30$, $p = 0.02$) but not for the MC targets ($\beta = 0.06$, $t = 1.12$, $p = 0.26$). This is not

surprising given that in the RC target condition participants heard the conjunction '*toki*' about the halfway during this time interval, which disambiguated the target sentence. The results suggested that participants quickly canceled the prediction of the RC structure on hearing this disambiguating information, resulting in a weaker effect of priming compared to when such disambiguating information was not yet provided.

This study next examined whether the effect of priming indeed occurred as prediction prior to the resolution of structural ambiguity, that is, before participants heard any disambiguating information about the RC structure. Since an influence of Target Type on the effect of priming was observed, the gazes made prior to the onset of the RC head were analyzed only for the RC target condition. Figure 3.3 shows the probability of gazes to the RC-head entity for 1000 ms preceding the onset of the head noun.

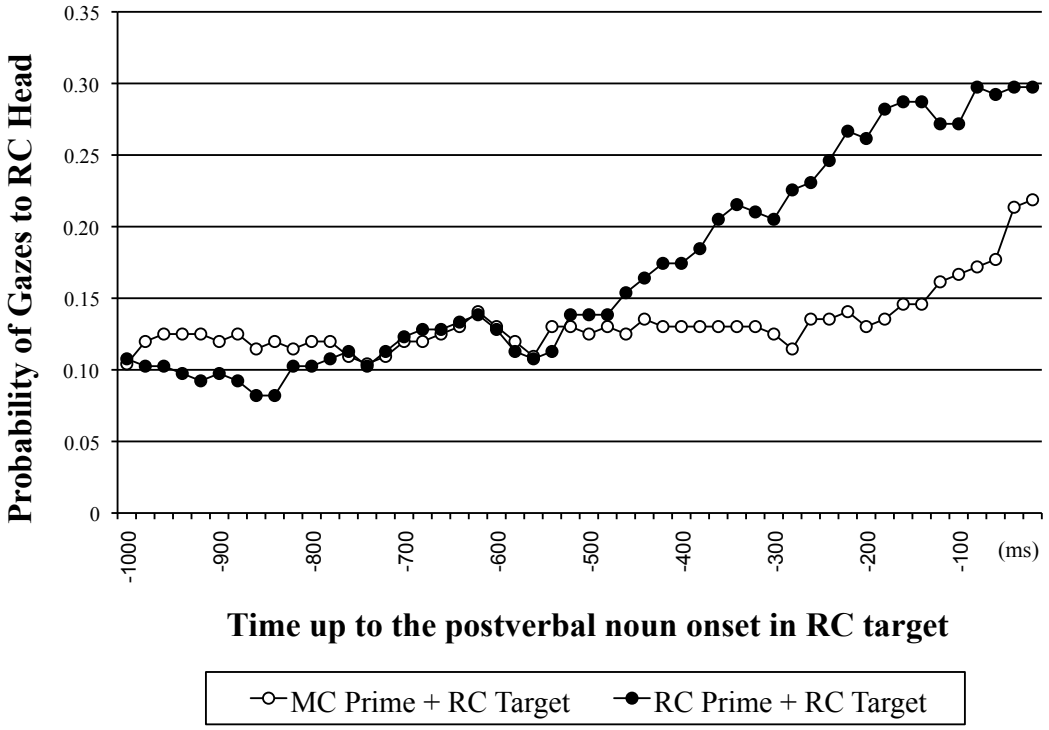

Figure 3.3: Probability of gazes to the RC-head entity for 1000 ms preceding the onset of the head noun of the RC target.

An analysis on the gazes from -400 ms to the onset of the RC head noun for the RC target sentences was conducted using the LME models. The logit of gazes for the 400 ms time interval was calculated. Prime Type was included as a single main factor in the models. The results showed that a significant effect of Prime Type ($\beta = 0.34, t = 3.06, p = 0.00$), confirming that the effect of the prime sentence structure indeed occurred before the disambiguating information was encountered.

In addition, to examine whether the prediction reflected the evaluation of thematically most appropriate entity, constrained by the semantic content of the preceding relative clause, the looks to the distractor entity were analyzed (toddler in

Figure 3.1) using the LME models with the same fixed effect structure as the earlier analysis for the same time interval.

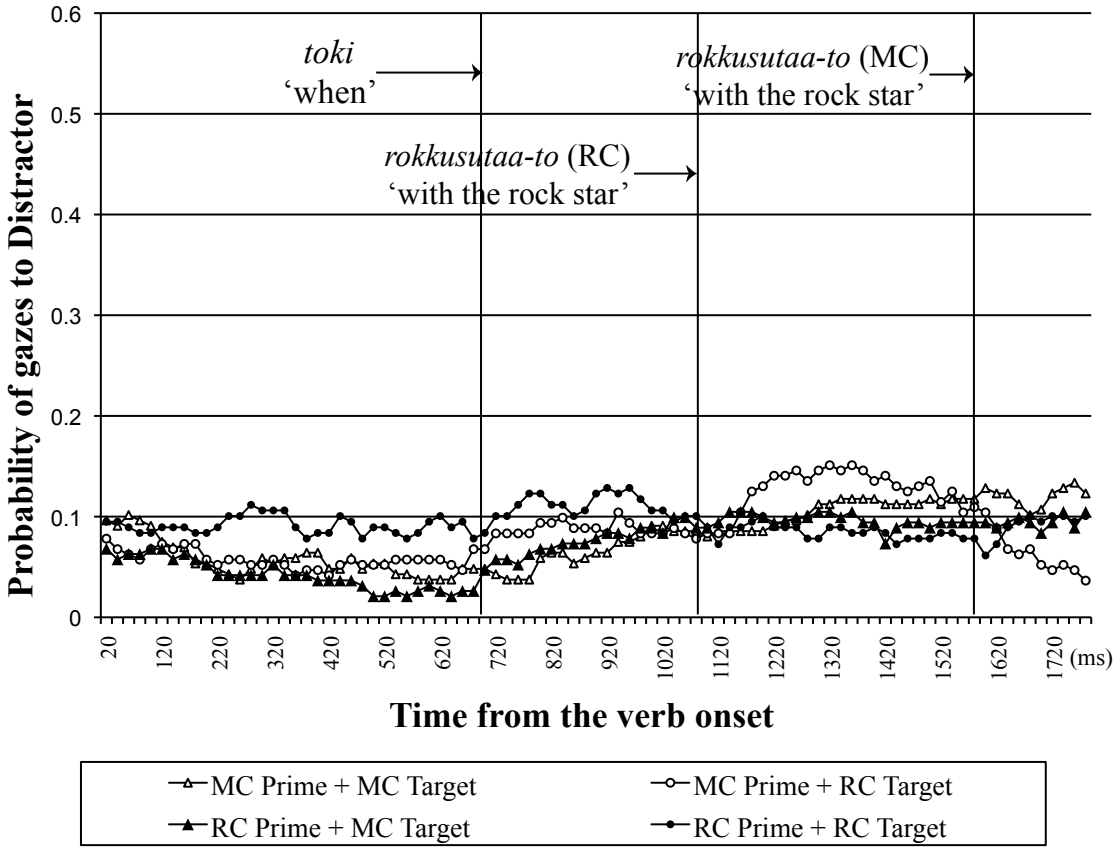

Figure 3.4: Probability of gazes to the Distractor entity for 1800 ms following the onset of the first verb.

The results showed a main effect of Target Type (β= 0.08, t = 2.33, p = 0.02). There was neither an effect of Prime Type (β= 0.02, t = 0.67), that of Time Window (β= 0.05, t = 1.53) nor an interaction between Prime Type and Time Window (β= 0.00, t = 1.37). Since the effect of the prime structure was only found for the looks to the RC-head entity but not for the looks to the distracter, the results were not due to the fact that comprehenders just predicted any unmentioned object in the scene, but due to the fact

that they predicted the object that is structurally required by the predicted structure and also semantically plausible.

3.3.3 Discussion

The results from Experiment 1 showed evidence for syntactic priming in the comprehension of Japanese relative clause sentences: After participants experienced a relative clause sentence, they became more likely to predict the relative clause structure in subsequent processing. The results confirmed that the effect occurred truly as prediction because the anticipatory eye-movements were observed immediately following the onset of the first verb and before the sentence structure was disambiguated. Furthermore, an additional analysis showed that the prediction was not simply a reflection of the structural prediction based on syntactic categories but it reflects the evaluation of the thematic fit between the entities in a visual scene and the predicate represented by the relative clause.

In Experiment 1, the verb was always repeated between prime and target sentences. Given the priming effect was observed at the verb, it is possible that the lexical overlap was crucial for observing the priming effect with this structure. In fact, such lexically dependent priming effects had been reported in many previous studies on English. Thus, the study next examine whether the priming of this structure still occurs without the repetition of the verb between prime and target sentences.

3.4 Experiment 2: Study without the repetition of the verb

In Experiment 2, the first verb in the target sentence was always different from that in the prime sentence.

3.4.1 Method

Participants

Twenty-eight new native speakers of Japanese, recruited from the same University of Tokyo student community, took part in the experiment in exchange of monetary compensation.

Materials and Procedure

Both the linguistic and visual materials were identical to those in Experiment 1 except that the target items were paired with the primes with a different verb. The experimental set-up and procedure were the same as those in Experiment 1.

3.4.2 Data analysis and results

3.4.2.1 Reading times in prime trials

The same analysis on the reading times in the prime trials as in Experiment 1 was conducted. The first-pass reading times in the head-noun (RC) / post-conjunction noun (MC) region and the sentence-final verb region were analyzed. Unlike Experiment 1, the trend of the main effect of Structure Type was not observed (β= -16.63, t = 0.59, p = 0.56). In the sentence-final verb region, the same effect as in Experiment 1 was found: Participants took longer to read this region in the RC condition than in the MC condition (Mean reading time for MC sentences = 560.56, for RC sentences = 624.36; β = 70.18, t = 2.19, p = 0.03), reflecting the processing difficulty associated with RC structure.

3.4.2.2 Eye-movements in target trials

Figure 3.5 shows the probability of gazes to the RC-head entity for 1800 ms starting from the onset of the first verb. The three vertical lines correspond to the mean onset of the conjunction *toki* in the MC target and that of the RC head noun for the MC targets and for the RC targets respectively.

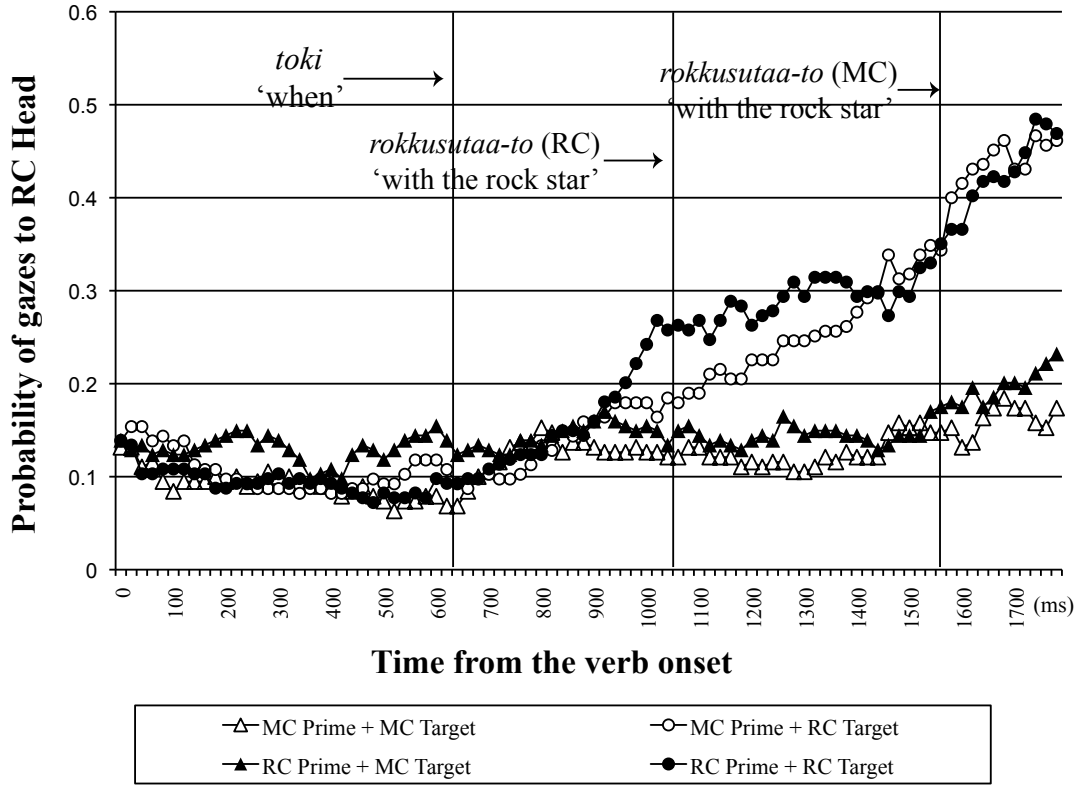

Figure 3.5: Probability of gazes to the RC-head entity for 1800 ms following the onset of the first verb (Experiment 2).

As in Experiment 1, the logit of gazes over the time course from 200 ms to 1100 ms following the first verb onset was analyzed using the LME models including the same factors; Prime Type, Target Type, and Time Window as main factors along with subjects

and items included as random factors. Table 3.3 shows the summary of the results from the best-fit model.

Table 3.3: Analysis of the looks to the RC-head entity for the 200 ms – 1100 ms interval following the onset of the first verb (Experiment 2).

Factor	β	t	p
(Intercept)	-2.99		
Prime Type	0.04	1.40	
Target Type	0.07	2.20	0.93
Time Window	0.12	4.96	<.001
Prime Type × Target Type	-0.00	0.18	
Prime Type × Time Window	0.02	0.77	
Target Type × Time Window	0.09	4.38	0.02
Prime Type × Target Type × Time Window	0.02	1.41	

A main effect of Time Window, which suggests that participants increased the looks toward the RC-head entity over this time period was observed. There also was a significant interaction between Target Type and Time Window, suggesting that participants increased the looks to the RC-head entity more over this time period on hearing the RC target than hearing the MC target. Crucially, a significant contribution of Prime Type was not observed[7].

[7] As in Experiment 1, the looks to the distractor entity were also analyzed using the same LME models as in the earlier analysis. Prime Type, Target Type and Time Window were

3.4.3 Discussion

In Experiment 2 in which the relative clause verb was not repeated between prime and target sentences, the results failed to show an effect of syntactic priming. The result is consistent with many previous studies on English and supports the view that syntactic priming in comprehension is lexically dependent. It also suggests that the structural representation of Japanese relative clause structure is associated with individual verbs, implying that despite of typological differences in the specifications of grammar, syntactic structures are likely to be represented in a similar manner for both head-initial and head-final languages.

3.5 General discussion

The results from Experiment 1 demonstrated a clear priming effect for the prediction of a syntactic structure; on hearing the initial verb, participants looked more at an entity for the lexical head of the relative clause analysis following a relative clause prime than following a main clause prime. Following relative clause primes, participants were more likely to predict the relative clause structure than following the main clause primes. An additional analysis confirmed that the eye-movements reflecting the prediction of the relative clause structure were indeed made before hearing any disambiguating information, demonstrating that predictive eye-movements were not driven by the post verbal information. In contrast, in Experiment 2 in which the verb was not repeated between prime and target, no evidence for a priming effect was observed. As revealed by the pretest, the main clause structure is strongly favored over the relative clause structure.

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included as fixed factors as well as their interaction. The results did not show a significant contribution of any factors or interactions.

Thus, the current study demonstrated that the effect of syntactic priming can influence the process of generating the initial structural analysis.

Together with the results from the reading times in prime sentences, the findings in this study fit well with error-based learning models. The observed processing difficulty in reading relative clause prime sentences most likely indicates that comprehenders initially adopted the main clause analysis and were later forced to revise it on encountering the disambiguating information, which resulted in prediction errors. According to these models, these errors cause changes in the weight of the network for the relative clause structure and as a consequence, they became more likely to predict the relative clause structure in subsequent processing compared to when they previously see a main clause prime, which presumably cause little prediction errors. Although the current study was not designed to evaluate the processing cost at the disambiguating region and thus provide no evidence for it, these models predict that predictions should be reflected in the processing cost for integrating the disambiguating information. Together with the results from past studies that showed facilitatory effects of syntactic priming at the disambiguating information and the results of the current study, it is likely that syntactic priming affects both processes in understanding structurally ambiguous sentences; the process of estimating the probabilities of upcoming possible structures are calculated using various sources of information including the type of the structure previously encountered prior to any disambiguating information and the process of integrating the disambiguating information against these probabilities.

Also, the results of the current study are consistent with previous studies in head-initial languages that observed a priming effect only with verb repetition (Arai, et al.,

2007; Branigan, Pickering, & McLean, 2005; Traxler & Pickering, 2005). This suggests that not only in head-initial languages but also in head-final languages like Japanese, the verb plays a key role to access argument structure information and also that the syntactic representation for the relative clause structure is accessed at the verb despite the fact that comprehenders in Japanese likely start building a syntactic structure before seeing the verb. The results also suggest that although the verb uses the same monotransitive argument structure in both the main clause and relative clause sentences, these two structures are represented differently and that these representations are lexically associated.

One possibility that needs to be considered is that the absence of a priming effect in Experiment 2 may be due to the fact that the effect is simply too weak to be observed without the boost of the lexical overlap. In fact, the figure for the gazes from the onset of the first verb and the results of the analysis on these gazes in Experiment 2 seem to imply a trend of syntactic priming. Some suggested that the reason why syntactic priming may be lexically dependent in comprehension is because syntactic representations are accessed predominantly in a bottom-up fashion. However, if it is the case that the effect was simply weak in the absence of lexical overlap, it would suggest that syntactic representations are at least partly accessed independently of lexical entries. Unfortunately, the current study could not solve this issue and more research is needed for this matter.

Another important question is whether syntactic priming in comprehension is generally dependent on the repetition of the verb between prime and target sentences or not. There is one study by Arai and Mazuka (2010), who demonstrated a lexically independent priming effect in comprehension with Japanese active and passive structures.

In these structures, case markers play a critical role in decision of grammatical relations. One plausible possibility is that priming appears lexically dependent when argument structure information is accessed following the verb but it appears lexically independent when it is accessed prior to the verb.

To conclude, the current study examined structural priming in the comprehension of Japanese relative clause structure, more specifically, whether an effect of priming can influence the expectation of an upcoming syntactic structure before the sentence structure is disambiguated. The results from our visual world study showed that participants made more looks to the relative clause head entity before hearing the noun phrase when they previously experienced the relative clause structure, reflecting the anticipation of an upcoming relative clause structure. This is the first clear demonstration for the influence of syntactic priming on the prediction of a dispreferred structure. The results from reading times for prime sentences showed that relative clause prime sentences were harder to process than main clause prime sentences, most likely reflecting the processing cost due to structural reanalysis for the former. It is argued that the results fit well with error-based learning models. The prediction error that occurred in processing a prime sentence of relative clause structure likely resulted in the learning of this structure, leading participants to become more likely to expect the relative clause structure in subsequent processing. Importantly, the current study also found that the effect of syntactic priming with this structure was limited to the case where the relative clause verb was repeated between prime and target sentences. This finding is consistent with the results of many previous studies in head-initial languages, suggesting that the syntactic representation of the relative clause structure is lexically associated in Japanese. It also

suggests the possibility that syntactic priming in comprehension is lexically dependent in general, regardless of whether it is a head-initial or head-final language.

CHAPTER 4

EFFECTS OF SEMANTIC INFORMATION AND CLAUSE LENGTH ON THE PERSISTENCE OF THE INITIAL MISANALYSIS

4.1 Introduction

It is known that structurally ambiguous sentences such as *While the man hunted the deer ran into the woods* cause readers to experience difficulty at the point where the structure is disambiguated (i.e., *ran*), which indicates that they initially adopted an incorrect analysis (i.e., the transitive analysis). Past research showed that in processing this type of ambiguous sentences, language comprehenders tend to preserve an interpretation of the initial incorrect analysis even after they adopted the correct analysis following reanalysis and often end up with incomplete, or so-called *good-enough* sentence representations (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, Bailey & Ferraro, 2002). In Christianson et al. (2001), for instance, participants read sentences like (4.1) and were next shown comprehension questions like (4.2). Their results showed that participants often answered incorrectly by responding "yes". Christianson et al. (2001) argued that the reanalysis of ambiguous sentence structures is not always complete and the initial incorrect analysis often remains preserved and not fully suppressed.

(4.1) While Anna dressed the baby spit up on the bed.

(4.2) Did Anna dress the baby?

However, in their study as well as their follow-up studies (e.g., Christianson, Williams, Zacks, & Ferreira, 2006; Ferreira et al., 2002 for the review), it is arguable that

the initial incorrect analysis, even though it was suppressed following reanalysis, may have been re-activated by processing the question sentences. Another criticism for their argument of incomplete representations is an influence of pragmatic inference. For example, even with their items with reflexive verbs such as (4.1), it is still possible to infer that the baby spit up while being dressed by Anna even though such an interpretation is not syntactically licensed. The first issue was addressed by van Gompel, Pickering, Pearson, and Jacob (2006), who reported an effect of syntactic priming for the initial incorrect analysis. In their study, participants first read a prime sentence that was either structurally ambiguous (4.3a) or unambiguous with a comma following the subordinate clause verb (4.3b). Next, they completed a sentence fragment such as *When the doctor was visiti….*

(4.3a) While the man was visiting the children played outside.
(4.3b) While the man was visiting, the children played outside.

Their results showed that participants produced more transitive sentences following (4.3a) than following (4.3b), providing evidence that the initial incorrect analysis remained activated. However again it is possible to infer that in the example (4.3a) the man was visiting the children who played outside. It is therefore unclear from previous studies that the initial incorrect analysis would still remain activated and its interpretation would persist even where such pragmatic inferences are not possible.

To address this issue, the current study tested Japanese relative clause structure such as (4.4).

(4.4) 赤ちゃんが飲み物をこぼした女優をじっと見つめた。

Akachan-ga nomimono-o koboshita joyuu-o jitto mitusmeta.

baby-NOM [drink-ACC spilled] actress-ACC fixedly stared at

'The baby stared fixedly at the actress who spilled the drink.'

As discussed in Chapter 2 and 3, relative clauses in Japanese precede lexical heads without an overt complementizer and without any grammatical marking on the verb, creating local syntactic ambiguity between main clause (MC) and relative clause (RC) structures up to the first verb (*koboshita,* 'spilled'; RC verb). It is known that people initially analyze the first verb as a part of main clause and construct a sentence representation of the sentence-initial NP (*akachan*, 'baby') to be the agent-subject of the verb, as in (4.4a). On encountering another noun phrase (NP) following the verb (i.e., *joyuu,* 'actress'), readers are forced to reanalyze the sentence for a correct RC structure in which the initial verb phrase is a part of an embedded relative clause that modifies the RC-head NP as in (4.4b).

(4.4a) [*Akachan-ga nomimono-o koboshita*]

(4.4b) *Akachan-ga* [*nomimono-o koboshita*] *joyuu-o*

Crucially, the correct interpretation following reanalysis with Japanese relative clause sentences makes the interpretation of the initial misanalysis pragmatically incompatible. For the example (4.4), it is impossible to infer that the baby spilled milk after readers correctly reanalyze the structure.

Using this structure, this study manipulated the semantic bias of the direct object noun within the relative clause. Past research demonstrated that readers integrate non-structural information without delay in processing similar ambiguous sentences (e.g., McRae et al., 1998; Garnsey et al., 1997). McRae et al. (1998) showed that when a subject noun is plausible as patient but implausible as agent (e.g., *The crook arrested by the detective was guilty*…), readers were more likely to consider the infrequent relative clause structure on encountering the verb and the preposition *by* within the relative clause. Also, Garnsey et al. (1997) demonstrated that plausibility of post-verbal nouns as a direct object immediately affected the processing of temporary ambiguous sentence complement sentences (e.g., *The senior senator regretted the decision/reporter had ever*…). Importantly, the plausibility effect interacted with structural bias of individual verbs; when the verb was biased toward the sentence complement, there was no ambiguity cost irrespective of whether the post-verbal noun was plausible as a direct object or not. These results indicate that the verb introduces possible thematic roles within its event semantics and readers check the fit with those roles for each candidate phrase and assess the probabilities of possible structures. Importantly, as Garnsey et al. (1997) suggests, the verb bias appears to exert a stronger influence than the thematic-fit of post-verbal elements in English.

On the other hand, in Japanese, the semantics of any arguments may affect parsing since the head does not appear until the end of a clause or sentence. This is rather likely as many studies now demonstrated evidence for pre-head structural analysis (Kamide, Altmann, & Haywood, 2003; Miyamoto, 2002). In fact, Inoue (2006) observed greater processing difficulty with similar relative clause sentences when the subject noun

was biased toward the main clause analysis than when it was not. The current study adopted a similar manipulation on the relative clause direct object and examined whether the preservation of the initial incorrect analysis would be observed where there is no room for pragmatic inference and, if it is, whether the difference in processing difficulty due to the manipulation of semantic bias would in any way be related to the tendency to preserve the initial analysis.

4.2 Pretest

A norming study was conducted to check the strength of semantic bias of our material in three conditions (*Subject-biased*, *Neutral*, or *Object-biased*). In this study, participants saw a verb phrase in each condition (e.g., *nomimono-o koboshita*, 'spilled the drink') on the top of a computer monitor and below they also saw two words; one is of the subject noun (e.g., *akachan*, 'baby') and the other was of the relative clause (RC) head (e.g., *joyuu*, 'actress') in the original material. Participants were asked to judge which of the two words is more plausible as an agent for the verb phrase from the scale of 1 ('baby' is most plausible as the agent for 'spilled the drink') to 5 ('actress' is most plausible as the agent for 'spilled the drink'). The positions of the two nouns were counterbalanced across items. Each experimental list included 48 unrelated fillers besides the 24 experimental items and were presented in a pseudo-random order. Each experimental session always started with two practice trials.

Twenty-four Japanese native speakers took part in the study. Figure 4.1 shows the mean ratings for the three conditions. The rating for the subject noun (e.g., baby) was on average 1.27 in the subject-biased condition (e.g., spilled the milk), 3.03 in the neutral condition (e.g., spilled the drink), and 4.64 in the object-biased condition (e.g., spilled the

champagne). The results were analyzed using ordinal logistic regression models. The analysis confirmed that participants rated the subject noun more plausible as an agent of the relative clause in the subject-biased condition than in the neutral condition, and more implausible in the object-biased condition than in the neutral condition (β = -3.62, z = 13.35, $p < .001$ for Neutral vs. Subject-biased, $\beta = 3.15$, $z = 12.69$, $p < .001$ for Neutral vs. Object-biased).

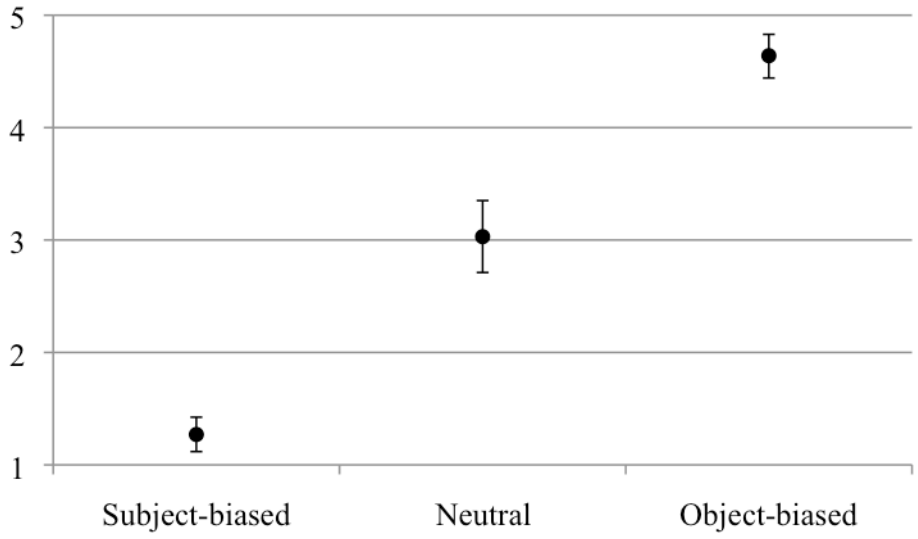

Figure 4.1: Plausibility rating for the nouns in each condition as a nominative subject of the verb phrase. Error bars represent 95% confidence intervals.

4.3 Experiment 1: Self-paced reading study with short relative clauses

A moving window self-paced reading experiment with word-by-word presentation was conducted.

4.3.1 Method

Participants

Twenty-four native speakers of Japanese, recruited from the student community at University of Tokyo, participated in the experiment in exchange for small remuneration.

Materials

24 sets of experimental items such as (4.5) were created. The semantic bias of the direct object was manipulated for the two alternative analyses at three levels; *Subject-biased* (the RC object is more plausible to the subject noun as in 4.5a), *Neutral* (the RC object is equally plausible to the subject and RC-head nouns as in 4.5b), and *Object-biased* (the RC object is highly implausible to the subject noun as in 4.5c). See Appendix C for the full set of experimental items.

(4.5a) *Subject-biased*

赤ちゃんがミルクをこぼした女優をじっと見つめた。

Akachan-ga miruku-o koboshita joyuu-o jitto mitusmeta.

baby-NOM [milk-ACC spilled] actress-ACC fixedly stared at

'The baby stared at the actress who spilled the milk.'

(4.5b) *Neutral*

赤ちゃんが飲み物をこぼした女優をじっと見つめた。

Akachan-ga nomimono-o koboshita joyuu-o jitto mitusmeta.

'The baby stared at the actress who spilled the drink.'

(4.5c) *Object-biased*

赤ちゃんがシャンパンをこぼした女優をじっと見つめた。

Akachan-ga shanpan-o koboshita joyuu-o jitto mitusmeta.

'The baby stared at the actress who spilled the champagne.'

If the manipulation of the semantic bias has an influence on processing the relative clause sentences before the RC head is encountered, the sentences in the Subject-biased condition and the Neutral condition should initially be analyzed as an MC structure and exhibit processing difficulty at the disambiguating region. People may commit more strongly to the main clause with the former condition than the latter condition because the MC analysis is highly plausible. In contrast, the sentences in the object-biased condition may be initially analyzed as a relative clause or be reanalyzed easier because of the MC analysis is less plausible and the RC analysis is highly plausible.

Design

Three experimental lists were created using a Latin square design, in which each experimental item appears only once in one condition in each list. Each list contained 72 fillers. The comprehension questions followed all the 24 experimental items and 72 fillers. All the questions following the experimental items inquired about the agent of the event

denoted by the relative clauses with two options shown below the questions (e.g., *Who spilled the milk? BABY / ACTRESS* for (4.5a)).

Procedure

Before each trial, participants saw a star that appeared on the left edge of the screen. They then pressed the space bar to reveal the first word in the sentence. They pressed the space bar to reveal the next word, following which the previous one was masked again. They continued doing so until they reached the end of the sentence. The experimental session began with two practice items.

4.3.2 Data analysis and results (Experiment 1)

Reading Times

All trials including a region with a reading time that was either extremely long (8000 ms or over) or extremely short (250 ms or under) were removed. This resulted in the exclusion of 5.0% of the whole data. For the remaining data, all reading times over 2.5 standard deviations either side of the mean for each participant and each region were replaced with the cut-off value (Sturt, Pickering & Crocker, 1999). The reading times were analyzed using LME models, including Semantic Bias as a fixed effect with Number of Characters as a covariate. participants and items were included as random effects. Figure 4.2 shows the mean reading times in the disambiguating region; the RC head (e.g., actress-ACC) per condition.

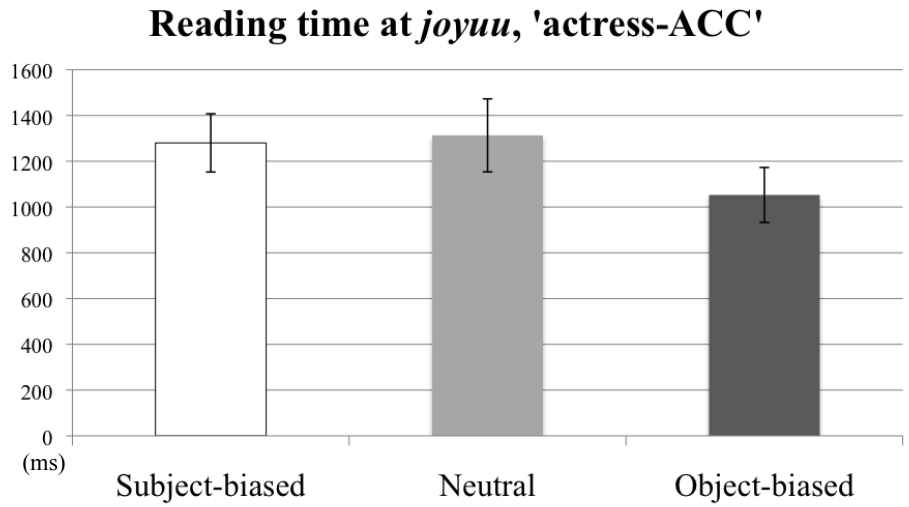

Figure 4.2: Mean reading times for each condition (Experiment 1). Error bars represent 95% confidence intervals.

The analysis on the reading time in the disambiguating region revealed significant differences between the conditions. In the object-biased condition, the disambiguating region was read faster compared to the other two conditions (β = -217.9, t = 2.94, p = 0.00 for Object-biased vs. Subject-biased; β = -245.9, t = 3.33, p < .001 for Object-biased vs. Neutral). There was no difference between the Subject-biased and the Neutral conditions ($\beta = 27.95, t = 0.37, p = 0.71$).

Comprehension Accuracy

Table 4.1 shows the percentage of correct answers for comprehension questions. The log-odds of the correct answers were analyzed using LME models with a binomial function. The results showed no difference between the conditions (β = -1.53, z = 1.70, p = 0.12 for Object-biased vs. Neutral; β = -0.13, z = 0.22, p = 0.83 for Subject-biased vs. Object-biased, $\beta = 1.40, z = 1.54, p = 0.12$ for Object-biased vs. Neutral).

Table 4.1: Percentage of Correct Answers for the Comprehension Questions (Experiment 1).

Subject-biased	96.1
Neutral	95.6
Object-biased	98.9

4.4 Experiment 2: Self-paced reading study with long relative clauses

In Experiment 1, the difference in reading times due to bias of the RC direct object were observed but there was no such difference between the conditions in the responses to the comprehension questions. One possibility for this is that processing of the RC structure may have been relatively easy despite the difference in the reading times (i.e., a ceiling effect). In Experiment 2, the study thus used sentences with the longer ambiguous region in an effort to increase the processing cost by leading participants to commit to the MC analysis for a prolonged period.

4.4.1 Method

Participants

Thirty native speakers of Japanese were recruited from the same population as in Experiment 1. None of them participated in the previous experiment.

Materials, Design, and Procedure

The material and design were identical to those in Experiment 1, except that two adverbial phrases (underlined) were added to lengthen the ambiguous region in the relative clause as in (4.6).

(4.6a, b, c) *Subject-biased / Neutral / Object-biased*

赤ちゃんがミルク／飲み物／シャンパンをテーブルで派手にこぼした女優をじっと見つめた。

Akachan-ga miruku / drink / shanpan-o te-buru-de hade-ni koboshitajoyuu-o jitto mitusmeta.

'The baby stared at the actress who spilled the milk / drink / champagne wildly on the table.'

4.4.2 Data analysis and results (Experiment 2)

The reading time at the disambiguating region and the responses to the comprehension questions were analyzed following the same procedure as in Experiment 1.

Reading Times

Figure 4.3 shows the mean reading time in the disambiguating region; the RC head (e.g., actress-ACC) for each condition.

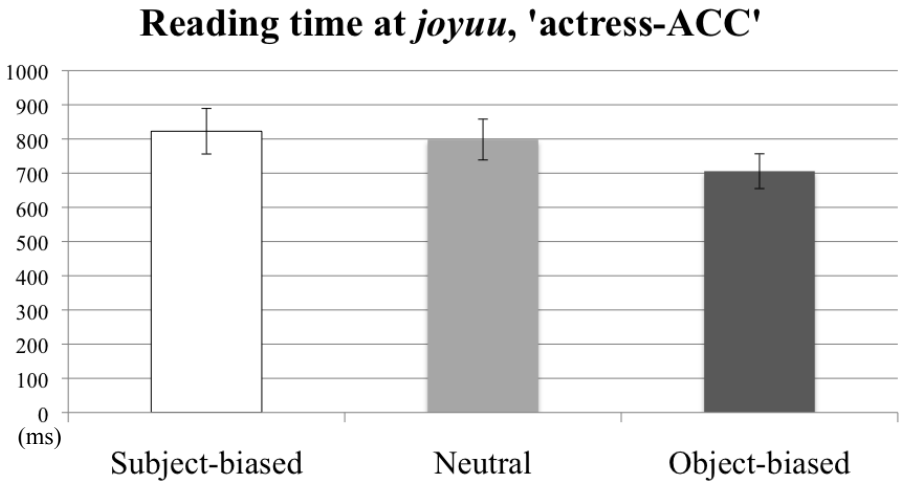

Figure 4.3: Mean reading times for each condition (Experiment 2). Error bars represent 95% confidence intervals.

Invalid trials were removed with the same criteria as in Experiment 1, which resulted in exclusion of 8.3% of the whole data. The results showed that the reading time in the disambiguating region was significantly longer in the Subject-biased and the Neutral conditions compared to that in the Object-biased condition (β = -108.78, t = 3.63, p < .001 for Object-biased vs. Subject-biased; β = 83.79, t = 2.97, p = 0.00 for Object-biased vs. Neutral). There was no difference between the Subject-biased and the Neutral conditions (β = 14.55, t = 0.52, p = 0.61).

Comprehension Accuracy

Table 4.2 shows the percentage of correct answers for the comprehension questions in Experiment 2. The analysis revealed that participants answered more incorrectly in Subject-biased condition than in Object-biased condition (β= -0.99, z = 2.02, p = 0.04). No significant difference was observed between the Neutral and Object-biased conditions (β= 0.85, z = 1.69, p = 0.09), or between the Subject-biased and Neutral conditions (β=

0.14, $z = 0.37$, $p = 0.71$). The results demonstrate that when the RC direct object was biased toward the Subject and the Object was relatively long, participants tended to preserve the initial incorrect analysis compared to when it was biased toward the RC. The Neutral condition showed a similar pattern to the MC-biased condition but the effect was weaker and did not turn out to be significant.

Table 4.2: Percentage of Correct Answers for the Comprehension Questions (Experiment 2).

Subject-biased	92.9
Neutral	93.8
Object-biased	97.1

4.5 Experiment 3: Eye-tracking study with short and long relative clauses

Experiment 2 revealed both the difference in the reading time and that in the question accuracy, suggesting that preservation of the initial analysis is related to the processing cost. However, the results from Experiment 1, which showed only the difference in reading time, are inconsistent with the results from Experiment 2. Since the semantic bias and the length of ambiguous region were not tested in a single experiment, it is not clear if the processing cost was any greater in Experiment 2 than that in Experiment 1. Thus, in the next experiment, the two factors were crossed to examine the interaction of the two manipulations. Also, since participants could not make any regressions to earlier regions with the self-paced reading task and it is arguable that they may have adopted some task-

specific strategy to deal with the structural ambiguity. The next experiment therefore examined eye-movements in normal reading of these sentences.

4.5.1 Method

Participants

Twenty-eight native speakers of Japanese were recruited from the same population as in experiment 1 and 2. None of them participated in the previous experiments.

Materials and Design

Twenty-four sets of experimental items such as (4.6) were created with a 2 × 2 design (Semantic Bias [*Subject-biased*, *Object-biased*]) × RC Length [*Short RC*, *Long RC*]). For the analysis, each sentence was divided into six regions as shown below, separated by vertical lines (|).

(4.6a) *Subject-biased + Short RC*

赤ちゃんが|ミルクを|こぼした|女優を|じっと|見つめた。

Akachan-ga | *miruku-o* | *koboshita* | *joyuu-o* | *jitto* | *mitusmeta*.

'The baby stared at the actress who spilled the <u>milk</u>.'

(4.6b) *Subject-biased + Long RC*

赤ちゃんが|ミルクを|テーブルで派手に|こぼした|女優を|じっと|見つめた。

Akachan-ga | *<u>miruku</u>-o* | *te-buru-de hade-ni koboshita* | *joyuu-o* | *jitto* | *mitusmeta*.

'The baby stared at the actress who spilled the milk wildly on the table.'

(4.6c) *Object-biased + Short RC*

赤ちゃんが|シャンパンを|こぼした|女優を|じっと|見つめた。

Akachan-ga | *shanpan-o* | *koboshita* | *joyuu-o* | *jitto* | *mitusmeta*.

'The baby stared at the actress who spilled the champagne.'

(4.6d) *Object-biased + Long RC*

赤ちゃんが|シャンパンを|テーブルで派手にこぼした|女優を|じっと|見つめた。

Akachan-ga | *shanpan-o* | *te-buru-de hade-ni koboshita* | *joyuu-o* | *jitto* | *mitusmeta*.

'The baby stared at the actress who spilled the champagne wildly on the table.'

Procedure

Four lists of items were created following a Latin square design. Each list included 72 fillers and was presented in pseudo-random order. The eye-movements were recorded using Eye-Link II (SR Research) at the sampling rate of 500 Hz. Participants first underwent a brief calibration procedure. Before each trial, participants were required to fixate a square box that appeared in the position of the first character of the sentences, which triggered the presentation of sentences. They pressed the space bar when they finished reading each sentence. Thirty-two comprehension questions were included to keep the participants focused.

4.5.2 Data analysis and results (Experiment 3)

Fixations that were either extremely long (1200 ms or over) or extremely short (80 ms or under) were removed. For statistical analysis, two eye-movement measures were used; first-pass reading times and second-pass reading times. *First-pass reading times* are the sum of the fixations in the region following the first entry in the region until the first

fixation outside the region, either to the left or the right (i.e., 1 + 2 in Figure 4.4). *Second-pass reading times* are the sum of fixations made in a region after the region has already been exited to the right (i.e., 4 + 6 in Figure 4.4).

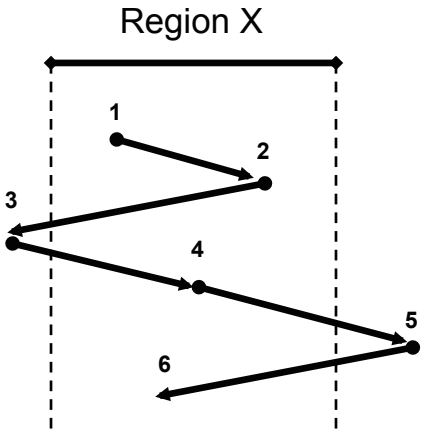

Figure 4.4: Eye-tracking reading measure.

It is generally assumed that first-pass reading times reflect the early stage of processing and second-pass the late stage. Table 4.3 shows mean reading times from Region 2 to Region 5 per condition. In the LME model, Semantic Bias (Subject-biased vs. Object-biased) and RC Length (Short RC vs. Long RC) were included as well as the interaction of the two factors as fixed factors, and participants and items as random factors. Random slopes of the two fixed factors and of the interaction were included for participants and items.

Table 4.3: Mean reading times for first-pass and second-pass.

	Region 2 *shanpan/miruku-o*	Region 3 *(teeburu-de hadeni) koboshita*	Region 4 *joyuu-o*	Region 5 *jitto*
First-pass reading time				
Subject-biased + Short RC	283	260	262	316
Subject-biased + Long RC	288	701	265	275
Object-biased + Short RC	330	283	283	278
Object-biased + Long RC	356	735	265	313
Second-pass reading time				
Subject-biased + Short RC	337	353	253	239
Subject-biased + Long RC	464	1462	329	331
Object-biased + Short RC	281	251	182	159
Object-biased + Long RC	403	1006	249	244

First-pass reading times

In Region 2, there was an effect of Semantic Bias (β = 29.2, t = 3.64, p < .001). Participants read this region slower with the sentences in the object biased than in the subject biased condition. In Region 3, an effect of RC Length (β = 22.6, t = 10.86, p < .001) was found, which simply reflects that the longer region took longer to read. In Region 5, which is the spill-over region following the disambiguating phrase, there was an interaction between the two factors (β = 19.2, t = 3.21, p < .001). Further analysis on the effect of Semantic Bias for each level of RC Length showed that the two simple effects were in the opposite direction and were both marginally significant (β = -19.2, t = 1.93, p = 0.06 for Short RC condition; β = 18.7, t = 9.93, p = 0.07 for Long RC condition); Participants tended to read this region faster in the subject-biased than in the object-biased condition when the relative clause was long, but they did slower in object-

biased condition than in subject-biased condition when the relative clause was short. In fact, the mean fast-pass time in the Subject-biased + Long RC condition was shortest across conditions and this appears prima facie at odds with the prediction. However, an additional analysis on the regression-out rate (the probability of regressive eye-movements) revealed that participants made the highest rate of regressive eye-movements in this region in the Subject biased + Long RC condition (0.42). The analysis with the LME model showed an effect of Semantic Bias ($\beta = 0.5$, $z = 4.59$, $p < .001$) showing that there were more regressions in the Long RC condition than in the Short RC condition. There also was a marginally significant effect of Semantic Bias ($\beta = -0.2$, $z = 1.88$, $p = 0.06$), showing that there were more regressions in the subject-biased condition than in the object-biased condition. This indicates that the shortest first-pass time in the Subject-biased + Long RC condition was not a reflection of reduced processing difficulty but on the contrary it reflected the excessive processing difficulty that forced participants to immediately regress to the previous region for reanalysis.

Second-pass reading times

In Region 2, there was a main effect of RC Length ($\beta = 61.2$, $t = 4.65$, $p < .001$). This suggests that in this region participants experienced greater cost for reanalysis when the relative clause was long than it was short. From Region 3 to Region 5, there were effects of Semantic Bias ($\beta = -138.4$, $t = 5.40$, $p < .001$ in Region 3; $\beta = -37.75$, $t = 3.75$, $p < .001$ in Region 4; $\beta = -44.2$, $t = 3.60$, $p < .001$ in Region 5) and those of RC Length although that in Region 5 was marginal ($\beta = 455.1$, $t = 8.67$, $p < .001$ in Region 3; $\beta = 35.84$, $t = 3.56$, $p < .001$ in Region 4; $\beta = -41.2$, $t = 3.46$, $p = 0.07$ in Region 5). This

suggests that in these regions participants experienced greater cost for reanalysis when the RC direct object was biased toward the subject noun than when it was toward the object noun and also did so when the relative clause was long than when it was short. Importantly, there was an interaction between the two factors in Region 3 (β= -88.27, t = 3.44, p < .001). Further analysis revealed that the effect of Semantic Bias was larger when the relative clause was long (β=-224.9, t = 3.63, p < .001) compared to when it was short (β=-50.9, t = 2.41, p = 0.008).

4.6 General discussion

Experiment 1 showed that participants experienced greater difficulty at the disambiguating information when the direct object in the relative clause was biased toward the main clause compared to when it was toward the relative clause. However, there was no effect of the manipulation on the responses to comprehension questions. Experiment 2 showed the same pattern of results for reading times when the relative clause was lengthened. Importantly, the results from the comprehension questions showed the effect of semantic biases; participants responded less accurately when the direct object was biased toward the main clause compared to when it was toward the relative clause. In Experiment 3, the results of eye-tracking reading data showed participants had more difficulty for reanalysis when the direct object was biased toward the main clause than when it was toward the relative clause. It also showed that the reanalysis cost was greater when the relative clause was longer than when it was short. Importantly, the effect of semantic biases was larger when the relative clause was long than when it was short. The results taken together provided evidence that the initial incorrect analysis persisted even in absence of pragmatic inference and that it is related to

how much people commit to the initial analysis and how much difficulty they experience for reanalysis.

In previous studies, there was no clear evidence for the effect of phrase or clause length on the persistence of the initial incorrect structure (Experiment 1 in van Gompel et al., 2006) and also for that of the manipulation of plausibility (Experiment 2 in the same study). One possible reason for this discrepancy can be because these two factors were tested independently. Yet, another possibility is that this is due to a qualitative difference in how these ambiguous sentences were processed between English and Japanese. With English, it has been shown that readers adopt an inappropriate transitive analysis even when the post-verbal noun phrase is semantically inappropriate as a direct object (Pickering & Traxler, 1998). It is likely that this is at least partly due to head-driven parsing; speakers of English check the fit as a direct object for a post-verbal noun phrase regardless of the verb type (except unaccusative verbs; see Staub, 2007). On the other hand, in the head-final Japanese, it is possible that the plausibility of arguments influences the pre-head structural analysis independently of the verb. That is, in some trials under the object-biased condition, participants may have not adopted the main clause analysis even as an initial analysis and this may have resulted in the higher accuracy to the comprehension questions in Experiment 1 and 2 and in the less reanalysis cost compared to the MC-bias condition in Experiment 3.

To summarize, the current study provided evidence that comprehenders tend to preserve the initial analysis even when the sentence structure does not permit pragmatic inferences. The finding of the effects of semantic biases and clause length revealed that such a tendency is related to the degree of processing difficulty that reflects how much

people committed to the misanalysis. The results of eye-tracking data showed that participants indeed experienced excessive processing cost with the sentences when both the semantic bias and clause length encourage the main clause analysis. The current study also provided evidence for pre-head processing in Japanese and also demonstrated that the persistence of initial misanalysis that has been reported in a head-initial language such as English occurs in a typologically different head-final language.

CHAPTER 5

THE USE OF VERB SUBCATEGORIZATION INFORMATION IN L2 SENTENCE PROCESSING

5.1 Introduction

Previous research have shown that in processing garden-path sentences, readers typically adopt an incorrect analysis and are later forced into reanalyzing it, which is often reflected in increased reading time at the point where the structure is disambiguated. For instance, when native speakers of English read a sentence such as (5.1), they would experience processing difficulty at the second verb *was*.

(5.1) The student forgot the solution was in the back of the book. (Trueswell, Tanenhaus, & Kello, 1993)

Such garden-path effect at the second verb demonstrates that people initially analyze the postverbal NP *the solution* as a direct object of the first verb *forgot* and later reanalyze the NP as the subject within a sentence complement. As discussed in Chapter 3, Trueswell et al. (1993) examined the influence of verbs' structural preference by comparing sentences with the verbs that are biased toward an NP complement as *forget* in (5.1) and those with the verbs that are biased toward a sentence complement such as *hope* in (5.2).

(5.2) The student hoped the solution was in the back of the book.

If the verb bias information is immediately used, readers should adopt the sentence complement analysis at the verb *hoped* in (5.2), thus avoiding the garden-path. Their results showed that processing difficulty occurred only with (5.1) but not with (5.2), suggesting that readers used the verb specific argument structure information to guide their initial analysis in processing this type of ambiguous sentences (but see Ferreira & Henderson, 1990; Mitchell, 1987; Pickering, Traxler, & Crocker, 2000; Pickering & Traxler, 2003; van Gompel & Pickering, 2001 for the null effect of such verb information). There is increasing evidence for the use of such verb specific information (Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Trueswell, 1996). More recently, Staub (2007) showed that comprehenders did not analyze the postverbal NP as a direct object when the verb was unaccusative. Also, Arai & Keller (2012) found that verb subcategorization information as well as morpho-syntactic frequency information is used in predicting an upcoming structure. These results, together with the studies that failed to show the effect of verb specific information, may suggest that verb specific information is initially accessed but may be overridden by lexically independent structural preference information in some cases.

The current study examines the degree to which the processing in second languages (L2) is constraint by the verb subcategorization information. There are only a few studies that examined the influence of verb information on ambiguity resolution in L2 and it is still unclear how L2 learners use such information in processing temporarily ambiguous sentences. Dussias and Cramer Scaltz (2008) examined how structural preference of subcategorization frames influence L2 parsing with Spanish-English L2 speakers. Their results showed that L2 speakers keep track of relative frequencies of

verb-subcategorization alternatives and use this information in L2 processing. Similarly, using eye-tracking reading technique, Frenck-Mestre and Pynte (1997) also showed that verb subcategorization information affected the on-line parsing of sentences in L2. These studies suggest that L2 learners use verb specific information to resolve syntactic ambiguity in a similar way as native speakers do and that L2 learners can access appropriate argument structure information associated with L2 lexical entries to guide their structural analysis (see also Juffs & Harrington, 1996; Papadopoulou, 2005 for review).

Processing difficulty at the disambiguating information shows what structural analysis was initially adopted and whether revision of the initial misanalysis took place or not, but it does not provide a whole picture of the ambiguity resolution. More specifically, what is relatively little known is whether L2 learners successfully revised the incorrect initial interpretation and adopted the correct analysis and it is still unclear whether L2 learners constructed the same sentence representations as native speakers do. Previous studies on L1 processing revealed an important aspect of sentence representations with these temporarily ambiguous sentences. As discussed in Chapter 4, some studies on L1 sentence processing showed that reanalysis of temporarily ambiguous sentences is not always complete, and that people tend to retain the interpretation of the initial analysis even after the sentence structure was fully revised and often end up with incomplete, so-called *good-enough*, sentence representation (Christianson et al., 2001). In Christianson et al. (2001), participants read sentences such as (5.3), with which readers tend to initially analyze *the deer* as the direct object of *hunted* and they are forced to reanalyze *the deer* as the subject of the main clause on encountering *ran* (see Clifton, 1993; Pickering &

Traxler, 1998; Sturt, Pickering, & Crocker, 1999 for the influence of semantic plausibility in processing this type of sentences). Their participants next answered a comprehension question such as (5.4) and the results showed that participants often incorrectly answered *yes* to the question. Christianson et al. (2003) therefore argue that readers often preserve the initial misanalysis even after the correct analysis was adopted.

(5.3) While the man hunted the deer ran into the woods.

(5.4) Did the man hunt the deer?

As is already pointed out in Chapter 4, one possible criticism on their study is that the effect may be at least partly driven by readers' inferences: Their participant may have pragmatically inferred that the initial interpretation was true (i.e., the man hunted the deer and the deer ran into the woods). Christianson et al. (2001, Experiment 3) addressed this issue by using a reflexive verb as in *When Anna dressed the baby spit up on the bed*, with which the correct direct object is Anna herself and cannot be the baby after the correct reanalysis takes place. They found that participants still showed the same tendency to preserve the initial analysis with these sentences. Another possible criticism is that the question itself re-activated the initial analysis. This was addressed by van Gompel et al (2006), who showed the preservation of the initially misanalyzed structure by using syntactic priming.

On the other hand, there is no study that examined whether L2 learners would exhibit a similar tendency in L2 sentence processing (but see Roberts & Felser, 2011 for the results on L2 learners' correct interpretation) and such a study may reveal a

qualitative difference in processing temporarily ambiguous sentences between native speakers and L2 learners. Thus, the current study compared English native speakers and Japanese students who study English as a foreign language (Japanese EFL learners) in processing English garden-path sentences by manipulating the verb subcategorization information. It is likely that both the processing difficulty and the persistence of the initial analysis occur due to the fact that the verb can take a direct object and encourage the readers to adopt the transitive structure analysis upon encountering the postverbal NP. Therefore, with an intransitive verb, it is expected that readers would not take the postverbal NP as a direct object and neither an initial structural misanalysis nor a processing difficulty would be observed. Therefore, if Japanese EFL learners use the information about whether a specific verb is either transitive or intransitive in resolving structural ambiguity, the processing difficulty and the persistence of the initial analysis that occurs due to the structural misanalysis should be observed only when the verb in the subordinate clause is optionally transitive and not when it is intransitive. The study investigated this by testing native speakers of English (Experiment 1) and Japanese EFL learners (Experiment 2) using a self-paced reading paradigm.

5.2 Experiment1: Study on the processing of native speakers of English

A moving window self-paced reading experiment was conducted with word-by-word presentation (Just, Carpenter, & Woolley, 1982) over the web using the WebExp experimental software (see Keller, Gunasekharan, Mayo, & Corley, 2009 for technical details).

5.2.1 Method

Participants

Eighty-two native speakers of English participated in the study. Twenty-two participants were excluded as they indicated that they were not native speakers of the standard varieties of English, which was restricted to British, Canadian, American, and Australian English. They were recruited using Amazon Mechanical Turk (www.mturk.com/mturk/welcome) and received a small remuneration in exchange for their participation.

Materials and Design

Twenty-four of experimental items such as (5.5) was created with a 2 × 2 design (presence of a comma [without a comma, with a comma] × verb type [intransitive, optionally transitive]).

(5.5a) *Intransitive verb without comma*

While the audience cried the actor rested behind the curtain.

(5.5b) *Optionally transitive verb without comma*

While the audience watched the actor rested behind the curtain.

(5.5c) *Intransitive verb with comma*

While the audience cried, the actor rested behind the curtain.

(5d) *Optionally transitive verb with comma*

While the audience watched, the actor rested behind the curtain.

The subordinate clauses in the experimental items contained either an intransitive verb (5.5a, 5.5c) or an optionally transitive verb (5.5b, 5.5d). Twelve intransitive and twenty-four optionally transitive verbs were selected by consulting the COMLEX syntactic dictionary (Grishman, Macleod, & Meyers, 1994; see Appendix D for the full set of experimental items) with criteria that optionally transitive verbs have a transitive entry as well as an intransitive entry and intransitive verbs only have an intransitive entry[8]. Each intransitive verb was used twice in the items. The sentences were either without a comma (5.5a, 5.5b) or with a comma (5.5c, 5.5d) following the verb in the subordinate clause. The sentence with a comma is structurally unambiguous and therefore forms a baseline condition, the reading time of which is compared to that of the sentence without a comma. Four experimental lists were created using a Latin square design, in which each experimental item appeared only once in a particular condition in each list. Each experimental list contained 36 fillers. To avoid a possible priming effect, all the filler sentences were structurally unrelated copular sentences such as *The boy and the girl were very shy*.

In addition, comprehension questions were asked following the 24 experimental items and 18 fillers. For the experimental items, half of the questions were about the

[8] The frequency of transitive use and intransitive use for individual verbs in the experimental items were examined with the written part of British National Corpus (data obtained from ftp://ftp.itri.bton.ac.uk/bnc/) by counting the number of sentences in which the verb was directly followed by a NP for transitive use whereas the number of sentences in which the verb was directly followed by a period, a comma, or a preposition for intransitive use. The percentage of the transitive use out of the total number of the transitive use and the intransitive use was calculated. The mean percentage was 64.9% for the optionally transitive verbs and 13.4 % for the intransitive verbs. The transitive counts for the intransitive verbs were either due to sentences with specific nouns (e.g., *shouted slogans*) or those in which the order of the subject and the verb was inverted (e.g., *shouted Dad*).

interpretation of the subordinate clause (e.g., *Did the manager help the competitor?* following the sentence *When the manager helped(,) the competitor became really angry*.) to examine whether they had correctly revised the initial incorrect analysis. The other half of the questions was about the interpretation of the main clause (e.g., *Did the actor rest behind the curtain?* following (5.5a-5.5d)). The questions for the interpretation of the subordinate clause (subordinate clause questions, henceforth, as opposed to main clause questions) in the intransitive verb condition had an additional preposition (e.g., *Did the manager shout <u>at</u> the competitor?* following *When the manager shouted(,) the competitor became really angry*).

In order to examine the knowledge and the preference of subcategorization information of native speakers for the individual verbs used in the experiment, an additional sentence completion test was conducted[9]. Another 60 native English speakers who did not participate in the experiment were asked to produce a continuation for sentence fragments such as (5.6). The sentence fragments included all the 48 verbs that were used in the reading experiment. Two lists in which each item appeared only once in a particular condition (optionally transitive or intransitive) in each list were created. Participants were presented one of the two lists in a pseudo random order.

(5.6) When the audience watched ……

[9] Note that the sentence completion test examines the preference of subcategorization frames with the optionally transitive verbs as the sentence fragments can be completed either as a transitive or intransitive structure. On the other hand, it examines the knowledge of verb subcategorization information with the intransitive verbs as the fragments can only be completed grammatically as an intransitive structure.

The completed sentences were later coded manually according to the following criteria. If the verb was directly followed by a NP and the NP was unambiguously a direct object of the subordinate clause, the sentence was coded as *Transitive*. If an NP, either directly or indirectly followed the subordinate clause verb, was unambiguously the subject of a main clause, it was coded as *Intransitive*. The completions coded either as *Transitive* or *Intransitive* were all grammatical sentences. All other incomplete or ungrammatical completions were coded as *Other*. Table 5.1 shows the raw numbers for each type of completions.

Table 5.1: Raw Number and percentages of each type of completions (Native speakers of English).

	Completions		
	Intransitive	Transitive	Other
Intransitive verbs	705 (97.9%)	11 (1.5%)	4 (0.6%)
Transitive verbs	185 (25.7%)	533 (74.0%)	2 (0.3%)

The log-odds of transitive completions against all the completions were calculated and an analysis using LME models with a binomial function was conducted. Verb Type was included as a single fixed factor and participants and items were included as random factors. The results showed a strong effect of Verb Type (β = -3.34, z = 16.46, p < .001), demonstrating that the native English speakers produced far more transitive sentences with the optionally transitive verbs than with the intransitive verbs, and they produced only a few transitive completions with the intransitive verbs.

Procedure

At the beginning of each trial, participants saw a series of underscores on the screen, which corresponds to letters in the sentence. They were asked to press the space bar to reveal the first word in the text by replacing the underscores with a corresponding word. When they pressed the space bar again, the next word was revealed while the previous one was replaced with the underscores again. The participants continued to read this way until they reached the end of the sentence. The experimental session began with four practice items. Figure 5.1 illustrates an example of sentence presentation of this task.

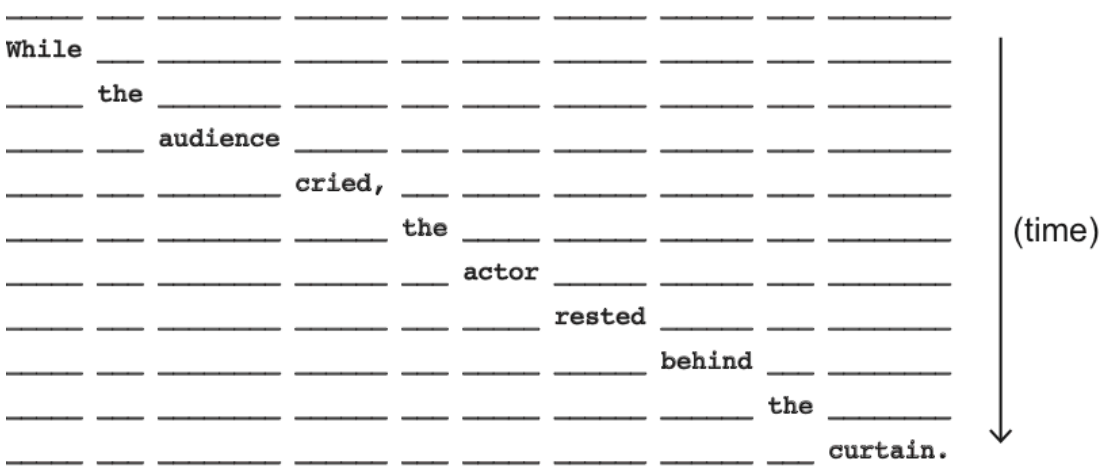

Figure 5.1: Illustration of the moving-window self-paced reading paradigm.

5.2.2 Results

First, the results for the comprehension questions are reported and next the reading times for the regions that are of the interest are examined.

5.2.2.1 Comprehension accuracy

Table 5.2 shows the percentage of correct answers on the subordinate clause questions and main clause questions in each condition. First, the answers on the main clause questions were analyzed using LME models. In the model, Clause Type (without or with a comma after the subordinate clause verb) and Verb Type (intransitive or optionally transitive) were included as fixed factors, and participants and items were included as random factors. The results revealed no effect of the two factors. This showed that the percentage of correct answers on the main clause questions was affected neither by the presence of a comma nor the verb type.

Table 5.2: Percentage of correct answers for the comprehension questions (Native speakers of English).

	Subordinate clause question	Main clause question
Intransitive without comma	40.0% (*SD* = 0.27)	98.1% (*SD* = 0.08)
Transitive without comma	52.1% (*SD* = 0.34)	95.1% (*SD* = 0.12)
Intransitive with comma	39.1% (*SD* = 0.29)	96.6% (*SD* = 0.15)
Transitive with comma	58.9% (*SD* = 0.31)	96.6% (*SD* = 0.12)

Next, the number of correct answers on the subordinate clause questions was analyzed using the same method. The results showed a main effect of Verb Type ($\beta = 0.35$, $z = 4.30$, $p < .001$). Participants produced less correct answers in the intransitive verb condition than in the optionally transitive verb condition. This is probably because the interpretation of the initial misanalysis and that of the correct analysis are often compatible in the intransitive verb condition. For example, with the sentence *When the*

manager shouted(,) the competitor became really angry, one could infer that it is the manager that shouted at the competitor although not explicitly implied. On the other hand, the two interpretations were almost always incompatible in the optionally transitive verb condition (e.g., with the sentence *While the audience watched(,) the actor rested behind the curtain*, the actor cannot be watched by the audience when he was resting behind the curtain). There was also a marginally significant effect of Clause Type (β = 0.15, z = 1.84, p = 0.065). Participants tended to produce more correct answers with the sentences with a comma than the sentences without a comma. Although the interaction between Verb Type and Clause Type did not reach the significance level (β = 0.12, z = 1.48, p = 0.138), it implies that the effect of Verb Type and the trend for the effect of Clause Type may not be independent to each other (the mean difference between the sentences without a comma and the sentences with a comma was 1.1% in the intransitive verb condition whereas it was 11.2% in the optionally transitive verb condition). The probability of correct answers differed depending on the type of the verb and the non-significant interaction is possibly due to the lack of statistical power as only half of the questions asked about the subordinate clause interpretation. In short, the results from the main clause questions showed that the native speakers consistently achieved the correct analysis irrespective of the verb type and the presence of a comma. The results from the subordinate clause questions showed that the effect of preserving the initial analysis due to structural ambiguity was larger in the optionally transitive verb condition than in the intransitive verb condition.

5.2.2.1 Reading times

Reading times over 2.5 standard deviations either side of the mean for each participant

and each region were replaced with the cut-off value (Sturt, Pickering, & Crocker, 1999). The reading times were analyzed using LME models, including Verb Type and Clause Type as fixed factors and the interaction between the two factors. The model also included the length of each region (referred to as Length), which is defined as the number of characters within each region. Participants and items were included as random factors. Figure 5.2 shows the mean reading times for each region per condition. The results of the analysis for the following four regions are reported; the verb in the subordinate clause (Region 2, e.g., *watched(,)* / *cried(,)*), the subject NP of the main clause (Region 3, e.g., *the actor*), the verb in the main clause (Region 4, e.g., *rested*), and the word following the verb (Region 5, e.g., *behind*). The analysis of region 5 was included because reading time effects at a previous region often spill over into the subsequent region in self-paced reading studies (Ferreira & Henderson, 1990). The region of the main interest is Region 4 as this is where a garden-path effect or ambiguity cost following the optionally transitive verb is expected to occur (i.e., longer reading times for the sentences without a comma than for the sentences with a comma). Below, all the effects that turned out significant in the model are reported, but an explanation for the effect of Length is omitted as it only accounts for the fact that longer words took longer to read and is not of the theoretical interest.

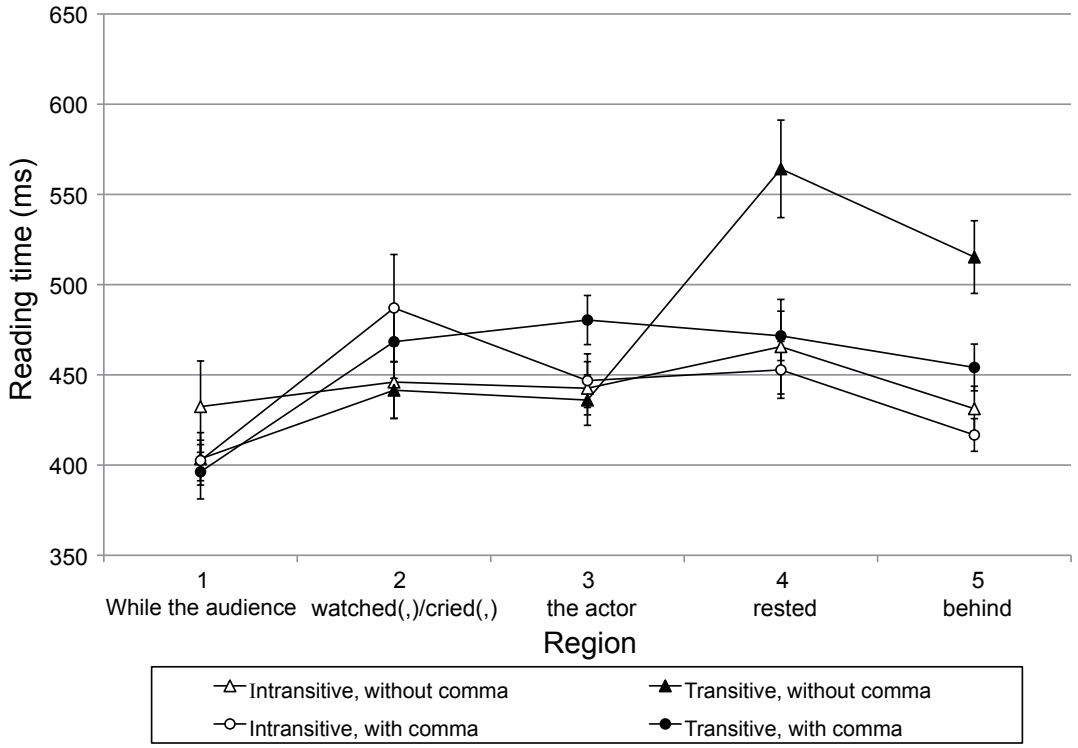

Figure 5.2: Mean reading times in each region (Native speakers of English).

Region 2

Only a main effect of Length was observed (β = 34.33, t = 2.92, p = 0.004). There was neither effect of Clause Type (β = 6.39, t = 0.62, p = 0.534) nor that of Verb Type (β = -13.3, t = 1.32, p = 0.197).

Region 3

A main effect of Clause Type (β = 12.15, t = 2.20, p = 0.031) was observed. Participants took longer to read the NP in the sentences with a comma than in those without a comma. This likely reflects that the comma indicates the clause boundary imposed extra processing cost. There was also a marginally significant interaction between Clause Type and Verb Type (β = 10.04, t = 1.82, p = 0.068). Further analyses showed that there was a

difference in reading times between the sentences without a comma and those with a comma when the verb was optionally transitive (β = 22.19, t = 2.85, p = 0.004) but there was no difference due to the presence of a comma when the verb was intransitive (β = 2.12, t = 0.28, p = 0.798). Therefore, this trend of an interaction implies that participants took longer to read the postverbal NP following optionally transitive verbs when the sentences contained a comma than when they did not. This slow-down likely reflects a strong bias of analyzing the NP as a direct object even though a comma disambiguated the sentence structure in the previous region.

Region 4

There were main effects of Clause Type (β = -26.36, t = 2.89, p = 0.004) and of Verb Type (β = 29.36, t = 3.22, p = .001). The region was read more slowly for the sentences without a comma than for those with a comma and it was also read slower in the optionally transitive verb condition than in the intransitive verb condition. Most importantly, there was an interaction between Clause Type and Verb Type (β = -19.94, t = 2.18, p = 0.028). Further analyses revealed that the effect of Clause Type was only observed in the optionally transitive verbs condition (β = -46.30, t = 3.50, p < .001) but not in the intransitive verb condition (β = -6.43, t = 0.52, p = 0.611). The results demonstrate that the ambiguity cost was present only when the subordinate clause had an optionally transitive verb but not when it had an intransitive verb. The results indicate that following an optionally transitive verb without a comma, participants analyzed the postverbal NP as a direct object of the verb, which led to increased reading time on encountering the verb in the main clause which indicates that the transitive analysis was

incorrect and forced participants into reanalyzing the sentence structure. This therefore demonstrated a typical garden-path effect for the sentences with an optionally transitive verb in the subordinate clause. Such an effect was not observed for the sentences with an intransitive verb.

Region 5

There were main effects of Clause Type (β = -18.93, t = 3.12, p = 0.002) and of Verb type (β = 30.38, t = 5.00, p < .001). There was also a marginally significant interaction between Clause Type and Verb Type (β = -11.67, t = 1.92, p = 0.053). Further analyses confirmed that the pattern of the interaction in this region was identical as in the previous region and it is most likely to reflect a spill-over of the garden-path effect observed in Region 4.

5.2.3 Discussion

Experiment 1 examined the influence of verb subcategorization information in processing structurally ambiguous and unambiguous sentences with native speakers of English. First, the analysis of reading times showed that the native speakers experienced processing difficulty due to structural ambiguity at the disambiguating information only when the subordinate clause verb was optionally transitive but not when it was intransitive. Consistent with the previous studies, this pattern indicates that the native speakers used verb subcategorization information to guide their structural analysis. Second, the results for the comprehension questions on the main clause interpretation showed that the native speakers consistently achieved the correct analysis irrespective of the verb type and the presence of a comma. On the other hand, the results for the comprehension questions on

the subordinate clause interpretation showed that their answers were affected by both of the factors. They tended to make more correct answers when the verb was presented with a comma than when it was not, suggesting that the incorrect transitive analysis was more likely to be adopted and persisted when the sentence was structurally ambiguous than when it was not. Also, they made more correct answers when the subordinate clause verb was optionally transitive than when it was intransitive. Although not statistically fully supported, there was a tendency that the effect of persistent structural misanalysis appeared to be larger when the verb was optionally transitive than when it was intransitive.

5.3 Experiment 2: Study on the processing of Japanese EFL learners

5.3.1 Method

Participants

Sixty Japanese EFL learners participated in Experiment 2. They were all undergraduate students at Waseda University. They had at least six years of English education in junior high and high school before enrolling in the university. The scores for the Versant English Test (www.versanttest.com for details) for all the participants except one were obtained as a measure of participants' English proficiency (see Downey, Farhady, Present-Thomas, Suzuki, & Van Moere, 2008). The Versant English Test measures the user's spoken English skills. Even though spoken skills might not directly tap into the participant's grammatical knowledge relevant to this study, the test was conducted as a course requirement and thus the score was most widely available. The mean score of the participants was 38.6 (SD = 7.7), which corresponds to the proficiency level 3. It is

mapped to the upper level of 'Basic User' (A2) of Common European Framework of Reference for Languages: Learning, Teaching Assessment (CEFR).

Materials, Design, and Procedure

The material and design were identical to those in Experiment 1 except that the experiment was programmed using E-prime 2.0 (Psychology software tools, Inc.) and participants were tested in a multi media room where each sat in front of a computer monitor. After the reading experiment, a sentence completion test was conducted.

5.3.2 Results

The results for the sentence completion test are reported, followed by the results for the comprehension questions and those for the reading times.

5.3.2.1 Sentence completion test

The sentence completion test was identical to the one that was conducted to the native speakers of English. Table 5.3 shows the raw numbers for each type of completions with Japanese EFL learners.

Table 5.3: Raw number and percentages of each type of completions (Japanese EFL learners).

	Completions		
	Intransitive	Transitive	Other
Intransitive verbs	609 (84.6%)	89 (12.4%)	22 (3.0%)
Transitive verbs	212 (29.4%)	485 (67.4%)	23 (3.2%)

The log-odds of transitive completions were analyzed using LME models including Verb Type as a single fixed factor and participants and items as random factors. The results showed a strong effect of Verb Type (β = -1.68, z = 20.29, p < .001). A combined analysis was further conducted on the results of sentence completion tests from the native speakers and the EFL learners. Verb Type was included as a within-participants and within-items variable and Group (native vs. EFL) as a between-participants and within-item variable, allowing the interaction between the two factors. The results showed a significant interaction between the two factors (β = -2.66, z = 6.79, p < .001). Further analysis revealed that the difference between the groups was highly significant for the intransitive verbs (β = 2.34, z = 5.54, p < .001) but only marginal for the optionally transitive verbs (β = -0.39, z = 1.82, p = 0.07). This demonstrates that with the intransitive verbs, the EFL learners were more likely to violate the subcategorization constraint compared to the native speakers who seldom used these verbs in a transitive structure. In contrast, with the optionally transitive verbs, there was no reliable difference in the preference for the transitive use between the native speakers and the EFL learners.

5.3.2.2 Comprehension accuracy

Table 5.4 shows the percentage of correct answers for the subordinate clause questions and those for the main clause questions. As in Experiment 1, the log-odds of correct answers were analyzed using LME models.

Table 5.4: Percentage of correct answers for the comprehension questions (Japanese EFL learners).

	Subordinate clause question	Main clause question
Intransitive without comma	31.7% (*SD* = 0.30)	79.4% (*SD* = 0.26)
Transitive without comma	31.7% (*SD* = 0.30)	80.6% (*SD* = 0.24)
Intransitive with comma	55.0% (*SD* = 0.30)	91.7% (*SD* = 0.15)
Transitive with comma	59.4% (*SD* = 0.29)	87.8% (*SD* = 0.22)

First, the answers to the subordinate clause questions were analyzed. The results revealed a main effect of Clause Type (β = 0.58, z = 7.18, p < .001). Participants produced more correct answers for the sentences with a comma than for those without a comma. However, there was neither effect of Verb Type (β = 0.05, z = 0.62, p = 0.54) nor interaction between Clause Type and Verb Type (β = 0.05, z = 0.63, p = 0.53). Importantly, the difference between sentences without a comma and those with a comma did not depend on whether the verb was optionally transitive (27.7%) or intransitive (23.3%).

Next, the answers to the main clause questions were anlyzed. Results again showed a main effect of Clause Type (β = 0.42, z = 3.62, p < .001) but neither effect of Verb Type (β = -0.09, z = 0.81, p = 0.42) nor interaction between the two factors (β = -

0.11, $z = 0.97$, $p = 0.33$). Participants produced more correct answers for the sentences with a comma than for those without a comma. The results showed that in both optionally transitive verb and intransitive verb conditions, the EFL learners answered less correctly to the main clause and the subordinate clause questions when the sentence was structurally ambiguous than when it was unambiguous. This suggests that structural ambiguity affected the interpretations of both initial analysis and correct analysis irrespective of the verb type.

5.3.2.3 Reading times

Figure 5.3 shows the mean reading times in each region for each condition. The same regions that were analyzed in Experiment 1 were analyzed including the same factors in the LME models as in Experiment 1.

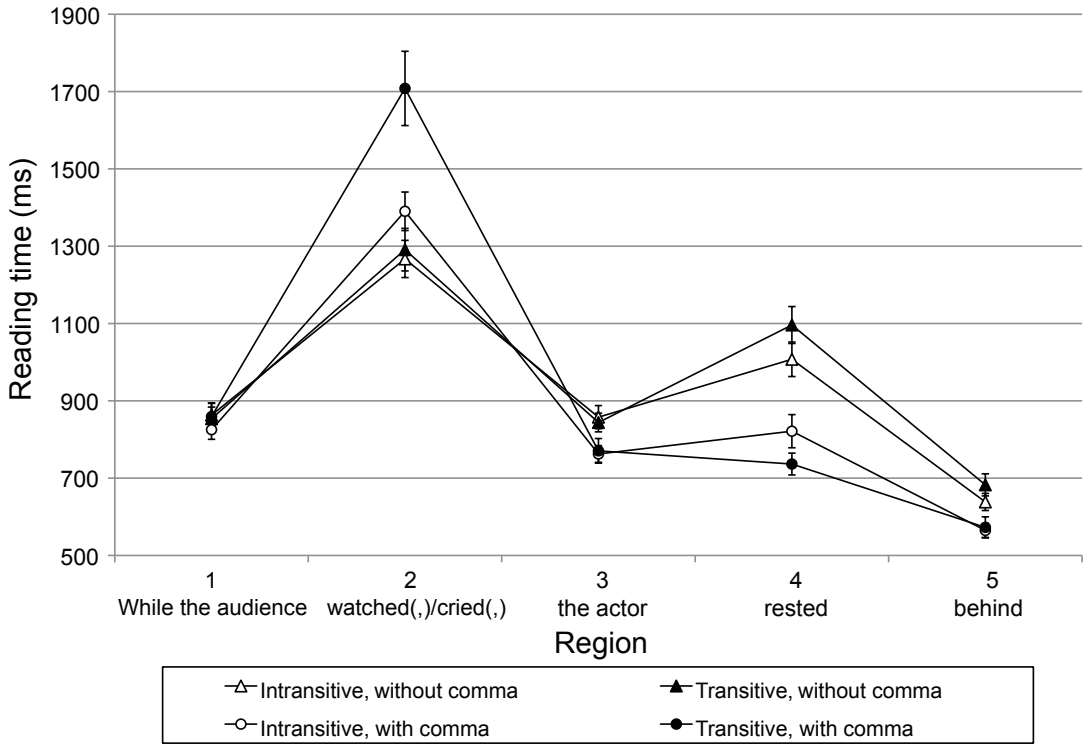

Figure 5.3: Mean reading times in each region for each condition (Japanese EFL Learners).

Region 2

There were main effects of Clause Type ($\beta = 90.76$, $t = 2.73$, $p = 0.01$) and of Length ($\beta = 169.75$, $t = 3.81$, $p < .001$). The coefficient of Clause Type showed that the sentences with a comma took longer to read than the sentences without a comma. There was also a significant interaction of Clause Type and Verb Type ($\beta = 68.66$, $t = 2.26$, $p = 0.03$). Further analyses revealed that the difference in reading times between the sentences without a comma and those with a comma was significant only in the optionally transitive verb condition ($\beta = 167.95$, $t = 2.98$, $p = 0.003$) but not in the intransitive verb condition ($\beta = 36.94$, $t = 1.00$, $p = 0.32$). This showed that participants experienced processing difficulty when a comma was present after an optionally transitive verb in the subordinate

clause. This pattern of results was not observed with the native speakers and it is possibly because the EFL learners are less familiar with the intransitive use of the optionally transitive verbs.

Region 3

There were main effects of Clause Type (β = -35.10, t = 2.84, p = 0.01) and of Length (β = 118.94, t = 3.81, p < .001). Participants took longer to read the NP following the verb in the subordinate clause without a comma than following it with a comma. It suggests that the longer reading time for the sentences with a comma in the previous region facilitated the processing of the NP in this region, possibly because the presence of a comma explicitly made it impossible to analyze the NP as a direct object.

Region 4

There were main effects of Clause Type (β = -133.28, t = 7.10, p < .001) and that of Length (β = 176.88, t = 5.96, p < .001). The verb in the main clause took longer to read for the sentences without a comma than for the sentences with a comma, reflecting the cost due to structural ambiguity. Importantly, there was an interaction between Clause Type and Verb Type (β = -41.31, t = 2.20, p = 0.03). Further analyses revealed that the difference between the sentences without a comma and those with a comma was significant both in the optionally transitive condition (β = -171.4, t = 6.80, p < .001) and in the intransitive verb condition (β = -95.33, t = 3.48, p < .001) but as revealed by the interaction the difference in the former condition was larger than that in the latter condition. This suggests that participants showed greater ambiguity cost at the verb in the

main clause when the subordinate clause contained an optionally transitive verb than when it contained an intransitive verb. However, the garden-path effect was observed with both types of verbs.

Region 5

There was a main effect of Clause Type (β = -42.96, t = 3.70, p < .001) but no interaction between Clause Type and Verb Type (β = -6.68, t = 0.58, p = 0.57). This region was read more slowly for the sentences without a comma than for those with a comma.

5.3.2.4 Additional analysis

In the additional analysis, the relationship between the reading time in Region 4 (where the garden-path effect was observed) and the scores for the subordinate clause questions was further investigated. The reading time in Region 4 was analyzed including the scores for the subordinate clause questions (Score) as an additional continuous variable (i.e., covariate) in the model, including the three-way interaction between Verb Type, Clause Type, and Score. The results showed a significant three-way interaction of the three factors (β = -41.41, t = 2.24, p = 0.02). Thus, participants were divided into two groups according to the scores for the subordinate questions: Higher Score Group (z-score > 0) and Lower Score Group (z-score < 0). The reading time in Region 4 was analyzed separately for the two groups. The results for the Higher Score Group showed a significant interaction between Clause Type and Verb Type (β = -96.80, t = 2.43, p = 0.02). In contrast, there was no interaction of these factors for the Lower Score Group (β = -9.83, t = 0.55, p = 0.58). This suggests that participants who got higher scores experienced greater garden-path effect in the optionally transitive verb condition than in

the intransitive verb condition. By contrast, the participants who got lower scores showed no difference in reading times between the optionally transitive and intransitive verb conditions. Figure 5.4 shows the mean reading times for two types of verb in Region 4 for the two groups. The results also suggest that the interaction between the two factors observed for the EFL learners overall was largely driven by those who correctly answered the subordinate clause questions.

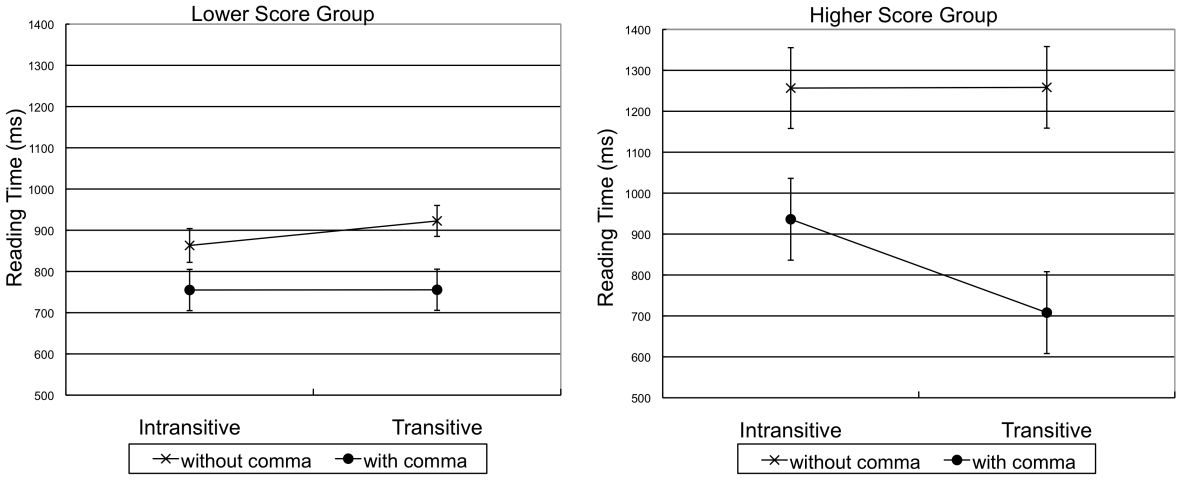

Figure 5.4: Reading time in Region 4 for Lower Score Group (left) and Higher Score Group (right).

Also, the relationship between the reading time in Region 4 and the outcome of the sentence completion test was explored. The means between the percentage of transitive completions for the optionally transitive verbs and that of intransitive completions for the intransitive verbs were used for analysis. As results, it was shown that there was no three-way interaction (Verb Type × Clause Type × Completion Score; β = -21.07, t = 1.03, p = 0.31). Furthermore, another analysis on the reading time in the same region was conducted with the scores for the subordinate clause questions for the

native English speakers but there was no three-way interaction (β = -14.48, t = 1.59, p = 0.12).

5.3.3 Discussion

Experiment 2 examined the influence of verb subcategorization information in processing temporarily ambiguous sentences with Japanese EFL learners. The analysis on the reading times showed that Japanese EFL learners experienced processing difficulty at the disambiguating information not only when the subordinate clause verb was optionally transitive but also when it was intransitive although the effect was stronger in the former condition than in the latter condition. Interestingly, the results also showed that Japanese EFL learners experienced difficulty at the subordinate clause verb when the verb was optionally transitive and appeared with a comma. This finding is unique to the EFL learners and suggests that Japanese EFL learners were surprised to see a comma with optionally transitive verbs. This is likely because they are not familiar with the intransitive use of the optionally transitive verbs, implying that Japanese EFL learners treated these verbs more like as obligatory transitive verbs. This in turn suggests that Japanese EFL learners possess some knowledge about subcategorization for these verbs and make use of it in parsing even though the knowledge does not reflect actual subcategorization information.

The results from the comprehension questions showed that the EFL learners made more correct answers when the verb was presented with a comma than when it was presented without a comma, but there was no difference due to the verb type. The results from the sentence completion test and the combined analysis of the results with those of native speakers showed that the EFL learners produced more incorrect transitive

completions with the intransitive verbs compared to the native speakers. The results together suggested that Japanese EFL learners do not have native-like knowledge about the verb subcategorization information of the intransitive verbs and thus they tended to incorrectly adopt a transitive analysis with the intransitive verbs.

An additional analysis on the reading times in the disambiguating region in relation to the scores for the subordinate clause questions showed different patterns of results between participants who got higher scores and those who got lower scores for the questions. While the participants with higher scores showed the same interactions between Verb Type and Clause Type, the participants with lower scores showed no difference due to the verb type. This demonstrates that the EFL learners who could not use the correct subcategorization information to process these structures showed the tendency to preserve the initial misanalysis regardless of the verb type.

5.4 General discussion

The purpose of this study was to investigate how the use of verb subcategorization information affects Japanese EFL learners' processing of temporarily ambiguous sentences in English and their ability to recover from the initial misanalysis. In the experiments, participants read temporarily ambiguous sentences containing either an intransitive or an optionally transitive verb. The results from the two experiments revealed the difference between native English speakers and Japanese EFL learners in the use of subcategorization information.

The results with the native speakers (Experiment 1) showed that they experienced processing difficulty at the main clause verb only when the subordinate clause contained an optionally transitive verb. This suggests that the native speakers analyzed the word

following the first verb as a direct object only with the optionally transitive verbs but they did not do so with the intransitive verbs. The results from the comprehension questions on the initial analysis also showed that the cost due to structural ambiguity appeared to be larger in the optionally transitive verb condition than in the intransitive verb condition, reflecting the fact that the native speakers tended to preserve the initial incorrect analysis with the optionally transitive verbs when the sentence was structurally ambiguous.

The results from the reading times with Japanese EFL learners (Experiment 2) also showed an interaction between the verb type and the presence of a comma at the disambiguating region but the pattern of the interaction was different from that of the native speakers. The EFL learners experienced processing difficulty at the main clause verb both when the subordinate clause contained an optionally transitive verb and when it contained an intransitive verb although the interaction showed that the cost in the former condition was larger than that in the latter condition. Also, the results from the comprehension questions showed no difference in accuracy rate due to the verb type. A further analysis revealed that the reading time at the disambiguating region was related to the scores for the subordinate clause questions. The participants who got higher scores showed greater processing difficulty in the optionally transitive verb condition than in the intransitive verb condition while the participants who got lower scores showed no such difference due to the verb type. This suggested that the pattern of reading time data for the Japanese EFL learners who used the correct subcategorization information to process these sentences were more similar to the native speakers in that the processing cost due to structural ambiguity was greater in the optionally transitive verb condition than in the intransitive verb condition. However, the participants with higher scores still differed

from the native speakers in one important aspect. They experienced processing difficulty at the main clause verb in the intransitive verb condition as well as in the optionally transitive verb condition. This suggests that unlike native speakers who showed no evidence for adopting the incorrect transitive analysis with the intransitive verbs, the EFL learners, both higher score and lower score groups, considered the transitive analysis with the intransitive verbs.

The combined analysis on the results from the sentence completion test showed that the EFL learners do not possess the complete (or native-like) knowledge about subcategorization information of the intransitive verbs although they showed similar structural preference to the native speakers for the optionally transitive verbs. This suggests that the processing difference between the native speakers and the EFL learners comes from the fact that the EFL learners do not possess the full intransitivity information for the intransitive verbs. The results from the comprehension questions and the sentence completion test together suggest that the difference between the native speakers and the EFL learners in processing temporarily ambiguous sentences was due to the fact that Japanese EFL learners do not possess complete knowledge of subcategorization information of the intransitive verbs.

Now let's consider some possibilities for why Japanese EFL learners do not have or fully use intransitivity information of the intransitive verbs. One possibility is transfer from their native language. In Japanese, intransitive verbs can be causativized with a suffix '-aseru' and used as a transitive structure. Thus it may be possible that the EFL learners interpreted the intransitive verb and the following NP as a causativized transitive structure (i.e., *the audience made the actor cry* for *the audience cried the actor*) as a

result of transfer from Japanese. However, this is rather unlikely because such a causativized interpretation is different from that of transitive misanalysis and should result in more correct answers to the subordinate clause questions, which is not supported by the results that showed no difference due to the verb type in response accuracy for the subordinate clause questions. Alternatively, what seems a more plausible reason is the amount of exposure to the intransitive verbs in the intransitive frame. Due to the overall shortfall of linguistic input, the EFL learners might be less certain about the fact that the intransitive verbs cannot occur with a direct object although the sentence completion test suggested that they were aware that these verbs are more likely to occur intransitively. This account fits well with the recent study by van Gompel, Arai, and Pearson (2012), who argue that information about the intransitive structure is stored at a lexically specific level and needs to be learned for individual verbs through linguistic exposures. On the other hand, information about the transitive structure is stored at the lexically general level and does not need to be specified for individual verbs because the transitive structure is the most common structure in English and almost all verbs can be used monotransitively. This predicts that only the intransitivity information is affected by insufficient linguistic exposure to the intransitive use of intransitive verbs. This may at least partly explain why the EFL learners did not have complete intransitivity information for the intransitive verbs.

Furthermore, it also appears consistent with many studies on first language acquisition which report that young children often have a difficulty in acquiring a grammatical rule that intransitive verbs cannot take a direct object and they often make so-called overgeneralization errors with intransitive verbs such as *Don't giggle me* (e.g.,

Braine & Brooks, 1995). These studies suggest that less proficient language users do not have as fully-developed grammatical knowledge as adult native speakers about the subcategorization information of intransitive verbs. These results together suggest that the EFL learners' incomplete subcategorization information of the intransitive verbs that lead to the garden-path effect with the intransitive verbs is likely due to the shortage of linguistic exposures to the intransitive use of the individual verbs.

Lastly, how should the results be interpreted in relation to the debate of whether L2 learners build complete syntactic representations in the same way as native speakers or they only build somewhat incomplete, shallow representations (Clahsen & Felser, 2006 for a summary)? Although the results are clearly in favor of the latter view, some recent studies provided support for the former view. For example, Omaki and Schulz (2011) demonstrated that L2 learners built complete syntactic representations for filler-gap dependencies and experienced processing difficulty when semantic fit between the verb and its argument was implausible (see also Felser, Cunnings, Batterham, & Clahsen, 2012). One possibility that may resolve the discrepancy between their studies and this study is that verb information tested in these studies (i.e., selectional restriction) does not rely on linguistic exposures as much as the knowledge about the intransitive structure. Although this remains still a speculation, it appears fairly plausible given that selectional restrictions draw upon verb semantics and it is known that L2 learners do not have a difficulty in using lexical–semantic information (Clahsen & Felser, 2006). From this it follows that verb subcategorization frequency or probability information, on the other hand, should be problematic for L2 learners as it is also based on the number of exposures to individual subcategorization frames. These are the issues that are largely

unexplored and it is hoped that future research will reveal precisely what type of information causes a problem for L2 learners to acquire and use in real-time comprehension.

To conclude the results, the current study investigated how Japanese EFL learners use the knowledge about verb subcategorization information in processing structurally ambiguous sentences in English by comparing Japanese EFL learners with native English speakers. Whereas the native speakers showed processing difficulty due to structural ambiguity only when the verb in the subordinate clause was optionally transitive, the EFL learners showed such difficulty both when the verb was intransitive and when it was optionally transitive. This difference was also evident in the results of the comprehension questions: With the EFL learners, response accuracy for the subordinate clause questions did not differ depending on the verb type although native speakers' accuracy did. The results further revealed that the EFL learners who distinguished the two types of the verbs for resolving structural ambiguity were more accurate in answering the subordinate clause questions. On the other hand, the EFL learners who could not use the correct subcategorization information to process these structures showed the tendency to preserve the initial misanalysis regardless of the verb type.

The results from the sentence completion test also revealed that there was no significant difference in structural preference of the optionally transitive verbs between the native speakers and the EFL learners, but there was a difference in the knowledge of subcategorization information of the intransitive verbs between the two groups. This suggests that the EFL learners do not have native-like knowledge about subcategorization information of the intransitive verbs.

These results together demonstrate that the difference in processing temporarily ambiguous sentences between native English speakers and Japanese EFL learners was due to EFL learners' incomplete intransitivity information, which led them to often adopt a transitive analysis with the intransitive verbs and to experience processing difficulty at disambiguating information.

CHAPTER 6

CONCLUSIONS

6.1 Summary of the results

The objective of this thesis was twofold. This thesis first examined what type of linguistic information Japanese speakers use to process sentence structures, focusing on the immediate or predictive influence on the initial analysis. In particular, it was examined whether speakers of Japanese language, which is typologically different from English, also use the same kinds of linguistic information as speakers of English language to construct a syntactic structure in processing Japanese. Second, this thesis examined the processing of English as a second language and compared Japanese EFL learners and native English speakers for the use of verb subcategorization information in online structural analysis. Below, brief summaries of the findings in each study and their implications are provided.

Chapter 2 reported the effect of prosodic information on online structural analysis in processing structurally ambiguous sentences in Japanese. The results demonstrated that listeners used prosody to predict an upcoming structure in listening to Japanese relative clause structure. Importantly, the effect of a prosodic cue was observed only when the visual scene provided an appropriate context. Furthermore, the results also showed a late influence of the prosodic cue following the disambiguating information. The pattern of results was the opposite of what was observed for prediction; participants experienced less difficulty at the disambiguating information when they already predicted the relative clause structure. The results from this study provided evidence for the influence of contrastive intonation on both predicting and integrating the relative clause structure in

Japanese. It was demonstrated that listeners can use prosody in combination with visual context to make a structural prediction and also such a prediction is related to the processing cost at the disambiguating information. This study also provided the first evidence for pre-head structural prediction driven by prosodic and visual information in a head-final language.

Chapter 3 reported the influence of syntactic priming in predicting Japanese relative clause structure. The results provided clear evidence that syntactic priming occurred as a prediction of the head noun of a relative clause structure after participants had read a relative clause sentence in the immediately preceding sentence. The results demonstrated the first clear evidence of syntactic priming as a prediction of a dispreferred structure. Another important finding of this study was that the effect of syntactic priming was observed only when the verb was repeated in prime and target sentences. This is consistent with the results of many previous studies in English and other head-initial languages, suggesting that the syntactic representation for the relative clause structure is lexically associated also in head-final languages such as Japanese. It also suggests the possibility that syntactic priming in sentence comprehension is lexically dependent in head-initial languages as well as in head-final languages.

Chapter 4 reported the influences of semantic bias and clause length on the persistence of the initial incorrect analysis. The results from the experiments provided evidence that comprehenders tend to preserve the initial analysis even with a sentence with which the correct interpretation following reanalysis makes an interpretation for the initial analysis pragmatically incompatible. The effects of semantic bias and clause length on the persistence of the initial analysis revealed that such a tendency is related to the

degree of processing difficulty that reflects how much comprehenders committed to the initial misanalysis. The results of eye-tracking reading data showed that participants indeed experienced large processing cost with the sentences when the semantic information supported the main clause analysis and the ambiguous region was longer. The results from the experiments in this chapter together provided evidence for pre-head processing in Japanese and also demonstrated that the persistence of the initial misanalysis occurs even when the sentence structure does not permit a pragmatic inference.

The studies in Chapter 2, 3, and 4 demonstrated the immediate influences of prosody, syntactic priming, and meaning of lexical items as well as clause length on online structural analysis in Japanese. Although more evidence for the immediate effect of these types of linguistic information is still needed in other head-final languages, the results from these studies suggest the possibility that the processing of ambiguous sentence structures in head-final languages is generally influenced without a delay by the same kinds of linguistic information as in head-initial languages.

Another important findings of the studies in Chapter 2 and 3 are that the effects of prosodic information and syntactic priming on structural analysis were observed prior to the disambiguating information. This is of particular importance because most of the results from previous studies on English could not tell whether the linguistic information in question directly influenced the initial syntactic analysis or it only affected a later stage of processing in revising the misanalysis. The results from the studies provided clear evidence for the direct influence of these factors on comprehenders' initial analysis even before the disambiguating information was encountered.

Also, the results of the studies mentioned above can make a substantial contribution to the evaluation of certain sentence processing models. In particular, one of the most influential model called the garden-path model (Frazier, 1987) assumes that the initial analysis of syntactic structure is constructed solely by a syntactic module, and that other types of information such as discourse context and semantics come to play a role in reanalyzing the structure at a later stage. In contrast, there are some other models such as constraint-based models (MacDonald et al., 1994), which assume that any source of information can potentially influence the process of determining the initial syntactic analysis. The results of the studies in Chapter 2, 3, and 4 provided evidence for influences of various sources of information on the initial structural analysis and therefore suggest that constraint-based models offer a better account for the processing of syntactic structures in Japanese that than the garden-path model does.

Following the results that Japanese speakers indeed use various kinds of linguistic information in online structural analysis in a similar way as English speakers do, Chapter 5 reported the study on the use of verb subcategorization information in L2 sentence processing. Specifically, the study in this chapter examined how Japanese EFL learners use their knowledge about verb subcategorization information of optionally transitive and intransitive verbs in processing structurally ambiguous sentences in English. The results showed that the EFL learners experienced processing difficulty due to structural ambiguity following optionally transitive as well as intransitive verbs, whereas native English speakers experienced such difficulty only following optionally transitive verbs. The result from a sentence completion test revealed also that the EFL learners were less accurate in using the verb subcategorization information of the intransitive verbs

compared to the native speakers, suggesting that the EFL learners do not have native-like complete knowledge about subcategorization information for the intransitive verbs. The results from this study demonstrated that the difference in processing temporarily ambiguous sentences between native speakers and Japanese EFL learners is, at least partly, due to the incomplete knowledge of intransitivity information for the EFL learners, which led them to adopt a transitive analysis with the intransitive verbs and to experience processing difficulty when the sentence was disambiguated.

6.2 Conclusions and implications

The studies in this thesis together showed the influences of various types of information such as prosody, syntactic priming, and meaning of lexical items as well as clause length during the online processing of structurally ambiguous sentences in Japanese. Importantly, the studies revealed the influences on the prediction of upcoming structures, demonstrating a direct influence on comprehenders' initial analysis in online structural building.

Regarding the typological difference between head-initial languages such as English and head-final languages such as Japanese, previous studies showed that there are certain differences between these languages in the way that comprehenders build syntactic representations online. For example, the word order in head-final languages tends to be relatively free, partly because comprehenders can use other information such as case markers to determine a syntactic structure. In other words, word order does not determine grammatical roles, as is the case for head-initial languages. Also, it is conceivable that since the verb does not appear until the sentence-final position, verb information play less prominent role in determining syntactic structure in head-final

languages. However, despite the typological difference between the languages, the studies on Japanese sentence processing in this thesis showed that Japanese speakers access the same kinds of information as English speakers do to construct a sentence structure during real time comprehension. This suggests that language users' online structural analysis is influenced by various kinds of information available in linguistic input regardless of what type of language they use. The results also indicate that some human sentence processing models such as constraint-based models in which the parsing process can be influenced by any type of information available can account for the processing of head-final languages as well as that of head-initial languages.

Following the results of the studies on Japanese sentence processing, it appeared highly likely that Japanese speakers are sensitive to the same kinds of linguistic information that have been shown to guide structural analysis in English. The study then asked the crucial question of whether Japanese speakers, in processing English as a second language, can use such information in the same way as native English speakers do. The results showed that Japanese EFL learners were unable to use lexically specific information to construct syntactic structure in the same way as native speakers did. The results from both online and offline studies together suggest that Japanese EFL learners do not possess native-like knowledge about verb subcategorization information for intransitive verbs, most likely due to their overall shortfall of language exposure.

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APPENDIX A

EXPERIMENTAL MATERIAL IN CHAPTER 2

The 28 experimental items used in the experiment in Chapter 2 are presented. The sentences were either with or without contrastive intonation on the relative clause (underlined).

1. OL が<u>ワインを飲んでいる</u>男性を誘った。

   Ooeru-ga <u>wain-o- nondeiru</u> dansei-o sasotta.

   businesswoman wine drinking man asked out

   'The office lady asked out the man who was drinking wine.'

2. 男の子が<u>三輪車に乗っていた</u>女の子を見つめた。

   Otokonogo-ga <u>sanrinsha-ni notteita</u> onnanoko-o mitsumeta.

   boy tricycle had been riding girl stared at

   'The boy stared at the girl who had been riding the tricycle.'

3. サラリーマンが<u>ビールをこぼした</u> OL に話しかけた。

   Sarariiman-ga <u>biiru-o koboshita</u> ooeru-ni hanashikaketa.

   businessman beer spilled businesswoman talked to

   'The businessman talked to the office lady who spilled the beer.'

4. 女優が<u>シャンパンを飲んでいる</u>ロックスターと意気投合した。

   Joyuu-ga <u>shanpan-o nondeiru</u> rokkusutaa-to ikitougou shita.

   actress champagne drinking rock star hit off with

   'The actress hit off with the rock star who was drinking champagne.'

5. ビジネスマンがタバコを買ってきた老人に近づいた。

Bijinesuman-ga tabako-o kattekita roujin-ni chikazuita.

businessman cigarette bought old man approached.

'The businessman approached to the old man who had bought the cigarette.'

6. 歌手がカクテルを注文したマネージャーに話しかけた。

Kashu-ga kakuteru-o chuumonshita maneejaa-ni hanashikaketa.

singer cocktail ordered manager talked to

'The singer talked to the manager who ordered a cocktail.'

7. モデルがサンドイッチを選んだアナウンサーを指差した。

Moderu-ga sandoicchi-o eranda anaunsaa-o yubisashita.

Model sandwich chose announcer pointed at

'The model pointed at the announcer who chose the sandwich.'

8. 男性がラグビーボールを蹴っている男の子に声をかけた。

Dansei-ga ragubiibooru-o ketteiru otokonoko-ni koe-o kaketa.

man rugby ball kicking boy said something to

'The man said something to the boy who was kicking the rugby ball.'

9. 女優がドレスを注文したアシスタントと一緒に出かけた。

Joyuu-ga doresu-o chuumonshita ashisutanto-to isshoni dekaketa.

actress dress ordered assistant with went out

'The actress went out with the assistant who ordered the dress.'

10. 新入社員がコーヒーを頼んだ上司と打ち合わせをした。

Shinnyuushain-ga koohii-o tanonda joushi-to uchiawase-o shita.

new employee coffee ordered boss had a meeting with

'The new employee had a meeting with the boss who ordered the coffee.'

11. 医師が薬を用意した看護婦に話しかけた。

Ishi-ga kusuri-o youishita kangoshi-ni hanashikaketa.

doctor medicine prepared nurse talked to

'The doctor talked to the nurse who prepared the medicine.'

12. 秘書がフランスパンを買ってきた女子高生を呼び止めた。

Hisho-ga furansupan-o kattekita joshikousei-o yobitometa.

secretary baguette had bought high school girl stopped

'The secretary stopped the high school girl who had bought the baguette.'

13. 店員がスープをこぼした客に話しかけた。

Tenin-ga suupu-o koboshita kyaku-ni hanashikaketa.

clerk soup spilled customer talked to

'The clerk talked to the customer who spilled the soup.'

14. 社長がネクタイをはずした会社員に詰め寄った。

Shachou-ga nekutai-o hazushita kaishain-ni tsumeyotta.

president necktie took off employee reproached

'The president reproached the employee who took off the necktie.'

15. 老人が新聞を読んでいるビジネスマンに話しかけた。

Roujin-ga shinbun-o yondeiru bijinesuman-ni hanashikaketa.

old man newspaper reading businessman talked to

'The old man talked to the businessman who was reading the newspaper.'

16. 弁護士がパソコンを使っている秘書に頼み事をした。

Bengoshi-ga pasokon-o tsukatteiru hisho-ni tanomigoto-o shita.

lawyer computer using secretary asked a favor

'The lawyer asked a favor to the secretary who was using the computer.'

17. シェフがお皿を運んだウェイターに話しかけた。

Shefu-ga osara-o hakonda ueitaa-ni hanashikaketa.

chef plate took waiter talked to

'The chef talked to the waiter who took the plate.'

18. 化学者がフラスコを使っているアシスタントを注意した。

Kagakusha-ga furasuko-o tsukatteiru ashisutanto-o chuuishita.

scientist flask using assistant warned

'The scientist warned his assistant who was using the flask.'

19. 店員がスーツケースを持っている客に話しかけた。

Tenin-ga suutsukeesu-o motteiru kyaku-ni hanashikaketa.

clerk suitcase had customer talked to

'The clerk talked to the customer who had a suitcase.'

20. ビジネスマンがゴルフをしてきた OL に話を聞いた。

Bijinesuman-ga gorufu-o shitekita ooeru-ni hanashi-o kiita.

Businessman had been out for golfing businesswoman heard the story from

'The businessman heard the story from the businesswoman who had been out for golfing.'

21. 女子高生が携帯を持っていたビジネスマンに話しかけた。

Joshikousei-ga keitai-o motteita bijinesuman-ni hanashikaketa.

High school girl cell phone holding businessman talked to

'The high school girl talked to the businessman who was holding the cell phone.'

22. おばあさんがゲートボールをしてきたおじいさんと出かけた。

Obaasan-ga geetobooru-o shitekita ojiisan-to dekaketa.

grandmother had been out for gate balling grandfather went out

'The grandmother went out with the grandfather who had been out for gate balling.'

23. 先生が教科書を読んでいる中学生をほめた。

Sensei-ga kyoukasho-o yondeiru chuugakusei-o hometa.

teacher textbook reading middle school student complimented

'The teacher complimented the middle school student who was reading the textbook.'

24. 女の子が積み木で遊んでいる男の子を世話した。

Onnanoko-ga tsumiki-de asondeiru otokonoko-o sewashita.

girl blocks playing boy took care of

'The girl took care of the boy who was playing with the blocks.'

25. 警察官が自転車に乗ってきた男性を追いかけた。

Keisatsukan-ga jitensha-ni nottekita dansei-o oikaketa.

policeman bicycle riding man chased

'The policeman chased the man who had been riding the bicycle.'

26. 男性が車を運転してきた女性を呼び止めた。

Dansei-ga kuruma-o untenshitekita josei-o yobitometa.

man car had been driving woman stopped

'The man stopped the woman who had been driving the car.'

27. 看護婦が注射を用意した医師に質問した。

Kangoshi-ga chuusha-o youishita ishi-ni shitsumonshita.

nurse injection prepared doctor asked a question

'The nurse asked a question to the doctor who prepared the injection.'

28. 女の子が鏡を持っているお姉さんに憧れた。

Onnanoko-ga kagami-o motteiru oneesan-ni akogareta.

girl mirror have sister dreamed of

'The girl dreamed of a sister who has the mirror.'

APPENDIX B

EXPERIMENTAL MATERIAL IN CHAPTER 3

The 28 sets of experimental items used in the experiments in Chapter 3 are presented. (a) and (b) are respectively prime and target. The sentences were either main clause (MC) or relative clause (RC).

1a. 大佐がブランデーを飲んでいる(時)兵士を叱った。

Taisa-ga burandee-o nondeiru (toki) heishi-o shikatta.

captain brandy drinking (when) soldier scolded

'When the captain was drinking brandy, he scolded the soldier.'(MC)

'The captain scolded the soldier who was drinking brandy.'(RC)

1b. OL がワインを飲んでいる(時)男性を誘った。

Ooeru-ga wain-o nondeiru (toki) dansei-o sasotta.

businesswoman wine drinking (when) man asked out

'When the businesswoman was drinking wine, she asked the man out.'(MC)

'The businesswoman asked out the man who was drinking wine.'(RC)

2a. 少年が自転車に乗っていた(時)少女を追いかけた。

Shounen-ga jitensha-ni notteita (toki) shoujo-o oikaketa.

boy bicycle riding (when) girl chased

'When the boy was riding the bicycle, he chased the girl.'(MC)

'The boy chased the girl who was riding the bicycle.'(RC)

2b. 男の子が三輪車に乗っていた(時)女の子を見つめた。

Otokonoko-ga sanrinsha-ni notteita (toki) onnanoko-o mitsumeta.

boy tricycle riding (when) girl stared at

'When the boy was riding the tricycle, he stared at the girl.'(MC)

'The boy stared at the girl who was riding the tricycle.'(RC)

3a. 赤ちゃんがミルクをこぼした(後)子犬を見つめた。

Akachan-ga miruku-o koboshita (ato) koinu-o mitsumeta.

baby milk spilled (after) puppy stared at

'After the baby spilled the milk, he stared at the puppy.'(MC)

'The baby stared at the puppy which spilled the milk.'(RC)

3b. サラリーマンがビールをこぼした(後)OL に話しかけた。

Sarariiman-ga biiru-o koboshita (ato) ooeru-ni hanashikaketa.

businessman beer spilled (after) businesswoman talked at

'After the businessman spilled the beer, he talked to the businesswoman.'(MC)

'The businessman talked to the businesswoman who spilled the beer.'(RC)

4a. 王様がお酒を飲んでいる(時)女王様に話しかけた。

Oosama-ga osake-o nondeiru (toki) joousama-ni hanashikaketa.

king alcohol drinking (when) queen talked to

'When the king was drinking alcohol, he talked to the queen.'(MC)

'The king talked to the queen who was drinking alcohol.'(RC)

4b. 女優がシャンパンを飲んでいる(時)ロックスターと意気投合した。

Joyuu-ga shanpan-o nondeiru (toki) rokkusutaa-to ikitougoushita.

actress champagne drinking (when) rock star hit off with

'When the actress was drinking champagne, she hit off with the rock star.'(MC)

'The actress hit off with the rock star who was drinking champagne.'(RC)

5a. 父親がプラモデルを買ってきた(後)息子と遊んだ。

Chichioya-ga puramoderu-o kattekita (ato) musuko-to asonda.

father plastic model bought (after) son played with

'After the father bought the plastic model, he played with his son.'(MC)

'The father played with his son who bought the plastic model.'(RC)

5b. ビジネスマンがタバコを買ってきた(後)老人に近づいた。

Bijinesuman-ga tabako-o kattekita (ato) roujin-ni chikazuita.

businessman cigarette bought (after) old man approached

'After the businessman bought the cigarette, he approached the old man.'(MC)

'The businessman approached the old man who bought the cigarette.'(RC)

6a. 教授がパスタを注文した(後)学生に話しかけた。

Kyouju-ga pasuta-o chuumonshita (ato) gakusei-ni hanashikaketa.

professor pasta ordered (after) student talked to

'After the professor ordered the pasta, he talked to the student.'(MC)

'The professor talked to the student who ordered the pasta.'(RC)

6b. ロックスターがカクテルを注文した(後)マネージャーに話しかけた。

Rokkustaa-ga kakuteru-o chuumonshita (ato) maneejaa-ni hanashikaketa.

rock star cocktail ordered (after) manager talked to

'After the rock star ordered the cocktail, he talked to the manager.'(MC)

'The rock star talked to the manager who ordered the cocktail.'(RC)

7a. 母親が絵本を選んだ(後)子供を寝かしつけた。

Hahaoya-ga ehon-o eranda (ato) kodomo-o nekashituketa.

mother picture book choose (after) kid lulled

'After the mother choose the picture book, she lulled the kid.'(MC)

'The mother lulled the kid who choose the picture book.'(RC)

7b. モデルがウェディングドレスを選んだ(時)アナウンサーを指差した。

Moderu-ga uedingudoresu-o eranda (toki) anaunsaa-o yubisashita.

model wedding dress chose (when) announcer pointed at

'When the model chose the wedding dress, she pointed at the announcer.'(MC)

'The model pointed at the announcer who chose the wedding dress.'(RC)

8a. サッカー選手が風船を蹴っている(時)少年と遊んだ。

Sakkaasenshu-ga fuusen-o ketteiru (toki) shounen-to asonda.

soccer player balloon kicking (when) boy played with

'When the soccer player was kicking the balloon, he played with the boy.'(MC)

'The soccer player played with the boy who was kicking the balloon.'(RC)

8b. 男性がラグビーボールを蹴っている(時)息子に声をかけた。

Dansei-ga ragubiibooru-o ketteiru (toki) musuko-ni koe-o kaketa.

man rugby ball kicking (when) son spoke to

'When the man was kicking the rugby ball, he spoke to his son.'(MC)

'The man spoke to his son who was kicking the rugby ball.'(RC)

9a. ピアニストが衣装を注文した(後)マネージャーに文句を言った。

Pianisuto-ga ishou-o chuumonshita (ato) maneejaa-ni monku-o itta.

pianist costume ordered (after) manager complained to

'After the pianist ordered the costume, she complained to the manager.'(MC)

'The pianist complained to the manager who ordered the costume.'(RC)

9b. 女優がドレスを注文した(後)スタイリストと一緒に出かけた。

Joyuu-ga doresu-o chuumonshita (ato) sutairisuto-to issho-ni dekaketa.

actress dress ordered (after) stylist went out with

'After the actress ordered the dress, she went out with the stylist.'(MC)

'The actress went out with the stylist who ordered the dress.'(RC)

10a. 男性がシャンパンを頼んだ(後)女性に話しかけた。

Dansei-ga shanpan-o tanonda (ato) josei-ni hanashikaketa.

man champagne ordered (after) woman talked to

'After the man ordered the champagne, he talked to the woman.'(MC)

'The man talked to the woman who ordered the champagne.'(RC)

10b. 新入社員がコーヒーを頼んだ(後)社長と打ち合わせをした。

Shinnyuushain-ga koohii-o tanonda (ato) shachou-to uchiawase-o shita.

new employee coffee ordered (after) president had a meeting with

'After the new employee ordered the coffee, he had a meeting with the president.'(MC)

'The new employee had a meeting with the president who ordered the coffee.'(RC)

11a. ディレクターが台本を用意した(後)カメラマンに指示した。

Direkutaa-ga daihon-o youishita (ato) kameraman-ni shijisita.

director script prepared (after) cameraman gave instructions to

'After the director prepared the script, he gave instructions to the cameraman.'(MC)

'The director gave instructions to the cameraman who prepared the script.'(RC)

11b. 医師が薬を用意した(後)看護婦に話しかけた。

Ishi-ga kusuri-o youishita (ato) kangofu-ni hanashikaketa.

doctor medicine prepared (after) nurse talked to

'After the doctor prepared the medicine, he talked to the nurse.'(MC)

'The doctor talked to the nurse who prepared the medicine.' (RC)

12a. 大学生が食べ物を買ってきた(後)仲間とキャンプした。

Daigakusei-ga tabemono-o kattekita (ato) nakama-to kyanpushita.

college student food bought (after) friends camped

'After the college student bought the food, he camped with his friends.'(MC)

'The college student camped with his friends who bought the food.' (RC)

12b. 秘書がワンピースを買ってきた(時)女子高生を呼び止めた。

Hisho-ga wanpiisu-o kattekita (ato) joshikousei-o yobitometa.

secretary dress bought (after) high school girl stopped

'After the secretary bought the dress, she stopped the high school girl.'(MC)

'The secretary stopped the high school girl who bought the dress.' (RC)

13a. 女の子が水をこぼした(時)少年を見つめた。

Onnanoko-ga mizu-o koboshita (toki) shounen-o mitsumeta.

girl water spilled (when) boy stared at

'When the girl spilled the water, she stared at the boy.'(MC)

'The girl stared at the boy who spilled the water.' (RC)

13b. 店員がスープをこぼした(時)客に話しかけた。

Tenin-ga suupu-o koboshita (toki) kyaku-ni hanashikakteta.

clerk soup spilled (when) customer talked to

'When the clerk spilled the soup, she talked to the customer.'(MC)

'The clerk talked to the customer who spilled the soup.' (RC)

14a. 女性がネックレスをはずした(後)友人に話しかけた。

Josei-ga nekkuresu-o hazushita (ato) yuujin-ni hanashikaketa.

woman necklace took off (after) friend talked to

'After the woman took off the necklace, she talked to her friend.'(MC)

'The woman talked to her friend who took off the necklace.' (RC)

14b. 社長がネクタイをはずした(後)会社員に詰め寄った。

Shachou-ga nekutai-o hazushita (ato) kaishain-ni tsumeyotta.

president necktie took off (after) employee reproached

'After the president took off the necktie, he reproached the employee.'(MC)

'The president reproached the employee who took off the necktie.' (RC)

15a. レポーターがニュースを読んでいる(時)アナウンサーに話しかけた。

Repootaa-ga nyuusu-o yondeiru (toki) anaunsaa-ni hanashikaketa.

reporter news reading (when) announcer talked to

'When the reporter was reading the news, he talked to the announcer.'(MC)

'The reporter talked to the announcer who was reading the news.' (RC)

15b. 老人が新聞を読んでいる(時)ビジネスマンに話しかけた。

Roujin-ga shinbun-o yondeiru (toki) bijinesuman-ni hanashikaketa.

oldman newspaper reading (when) businessman talked to

'When the old man was reading the newspaper, he talked to the businessman.'(MC)

'The old man talked to the businessman who was reading the newspaper.' (RC)

16a. シェフがオーブンを使っている(時)見習いに小言を言った。

Shefu-ga oobun-o tsukatteiru (toki) minarai-ni kogoto-o itta.

chef oven using (when) trainee a complaint gave.

'When the chef was using the oven, he gave a complaint to the trainee.'(MC)

'The chef gave a complaint to the trainee who was using the oven.' (RC)

16b. 弁護士がパソコンを使っている(時)秘書に頼み事をした。

Bengoshi-ga pasokon-o tsukatteiru (toki) hisho-ni tanomigoto-o shita.

lawyer computer using (when) secretary asked a favor.

'When the lawyer was using the computer, he asked the secretary a favor.'(MC)

'The lawyer asked the secretary who was using the computer a favor.' (RC)

17a. 店長が商品を運んだ(後)店員を叱りつけた。

Tenchou-ga shouhin-o hakonda (ato) tenin-o shikaritsuketa.

store manager products carried (after) clerk scolded.

'After the store manager carried the products, he scolded the clerk.'(MC)

'The store manager scolded the clerk who carried the products.' (RC)

17b. シェフがお皿を運んだ(後)ウェイターに話しかけた。

Shefu-ga osara-o hakonda (ato) uweitaa-ni hanashikaketa.

chef plate carried (after) waiter talked to

'After the chef carried the plate, he talked to the waiter.'(MC)

'The chef talked to the waiter who carried the plate.' (RC)

18a. 小学生が絵の具を使っている(時)同級生をからかった。

Shougakusei-ga enogu-o tsukatteiru (toki) doukyuusei-o karakatta.

elementary school kid paint using (when) classmate teased

'When the elementary school kid was using the paint, he teased his classmate.'(MC)

'The elementary school kid teased his classmate who was using the paint.' (RC)

18b. 化学者がフラスコを使っている(最中に)アシスタントを注意した。

Kagakusha-ga furasuko-o tsukatteiru (saichuu-ni) ashisutanto-o chuuishita.

chemist flask using (when) assistant warned

'When the chemist was using the flask, he warned his assistant. (MC)

'The chemist warned his assistant who was using the flask.' (RC)

19a. 部下が資料を落とした(時)上司の顔色をうかがった。

Buka-ga siryou-o otoshita (toki) joushi-no kao-o ukagatta.

subordinate document dropped (when) boss tried to read mood

'When the subordinate dropped the document, he tried to read his boss's mood.' (MC)

'The subordinate tried to read boss's mood who dropped the document.' (RC)

19b. 店員がスプーンを落とした(後)客に話しかけた。

Teiin-ga supuun-o otoshita (ato) kyaku-ni hanashikaketa.

clerk spoon dropped (after) customer talked to

'After the clerk dropped the spoon, she talked to the customer.' (MC)

'The clerk talked to the customer who dropped the spoon.' (RC)

20a. 監督が会見をしてきた(後)選手を激励した。

Kantoku-ga kaiken-o shitekita (ato) senshu-o gekireishita.

coach had interview (after) player encouraged

'After the coach had an interview, he encouraged the player.' (MC)

'The coach encouraged the player who had an interview.' (RC)

20b. ビジネスマンがゴルフをしてきた(後)OL に話を聞いた。

Bijinesuman-ga gorufu-o shitekita (ato) ooeru-ni hanashi-o kiita.

businessman golfing went (after) businesswoman heard story from

'After the businessman went golfing, he heard the story from the businesswoman.' (MC)

'The businessman heard the story from the businesswoman who went golfing.' (RC)

21a. ホテルマンが荷物を持っている(時)客を案内した。

hoteruman-ga nimotsu-o motteiru (toki) kyaku-o annaishita.

hotelkeeper baggage holding (when) guest guide

'When the hotelkeeper was holding the baggage, he guided the guest.' (MC)

'The hotelkeeper guided the guest who was holing the baggage.' (RC)

21b. 女子高生が携帯を持っていた(時)ビジネスマンに話しかけた。

Joshikousei-ga keitai-o motteita (toki) bijinesuman-ni hanashikaketa.

high school girl cell phone holding (when) businessman talked to

'When the high school girl was holding the cell phone, she talked to the businessman.' (MC)

'The high school girl talked to the businessman who was holing the cell phone.' (RC)

22a. 男性がジョギングをしてきた(後)隣人に挨拶した。

Dansei-ga jogingu-o shitekita (ato) rinjin-ni aisatsushita.

man jogging went for (after) neighbor said hello to

'After the man went for a jogging, he said hello to his neighbor.' (MC)

'The man said hello to the neighbor who went for a jogging.' (RC)

22b. おばあさんがゲートボールをしてきた(後)おじいさんと出かけた。

Obaasan-ga geetobooru-o shitekita (ato) ojiisan-to dekaketa.

grandmother gate ball (after) grandfather went out

'After the grandmother did gate balling, she went out with the grandfather.' (MC)

'The grandmother went out with the grandfather who did gate balling.' (RC)

23a. バスガイドが地図を読んでいる(時)運転手に質問した。

Basugaido-ga chizu-o yondeiru (toki) untenshu-ni shitsumonshita.

bus guide map reading (when) driver asked a question to

'When the bus guide was reading the map, she asked a question to the driver.' (MC)

'The bus guide asked a question to the driver who was reading the map.' (RC)

23b. 先生が教科書を読んでいる(時)中学生をほめた。

Sensei-ga kyoukasho-o yondeiru (toki) chuugakusei-o hometa.

teacher textbook reading (when) student complimented

'When the teacher was reading the textbook, she complimented the student.' (MC)

'The teacher complimented the student who was reading the textbook.' (RC)

24a. 男の子が鉄棒で遊んでいる(時)同級生に話しかけた。

Otokonoko-ga tetsubou-de asondeiru (toki) doukyuusei-ni hanashikaketa.

boy bar playing (when) classmate talked to

'When the boy was playing on the bar, he talked to his classmate.' (MC)

'The boy talked to his classmate who was playing on the bar.' (RC)

24b. 女の子がおもちゃで遊んでいる(時)赤ちゃんを世話した。

Onnanoko-ga omocha-de asondeiru (toki) akachan-o sewashita.

girl toy playing (when) baby looked after

'When the girl was playing with the toy, she looked after the baby.' (MC)

'The girl looked after the baby who was playing with the toy.' (RC)

25a. 王子様が馬車に乗っていた(時)お姫様に求婚した。

Oujisama-ga basha-ni notteita (toki) ohimesama-ni kyuukonshita.

prince carriage riding (when) princess proposed to

'When the prince was riding in the carriage, he proposed to the princess.' (MC)

'The prince proposed to the princess who was riding in the carriage' (RC)

25b. 警察官が自転車に乗ってきた(後)男性を追いかけた。

Keisatsukan-ga jitensha-ni nottekita (ato) dansei-o oikaketa.

policeman bicycle riding (after) man chased

'After the policeman rode the bicycle, he chased the man.' (MC)

'The policeman chased the man who rode the bicycle.' (RC)

26a. 母親が車を運転してきた(後)父親に話しかけた。

Hahaoya-ga kuruma-o untenshitekita (ato) chichioya-ni hanashikaketa.

mother car drove (after) father talked to

'After the mother drove the car, she talked to the father.' (MC)

'The mother talked to the father who drove the car.' (RC)

26b. 男性が車を運転してきた(後)女性を呼び止めた。

Dansei-ga kuruma-o untenshitekita (ato) josei-o yobitometa.

man car drove (after) woman stopped

'After the man drove the car, he stopped the woman.' (MC)

'The man stopped the woman who drove the car.' (RC)

27a. 会社員が資料を用意した(後)同僚と出かけた。

Kaishain-ga shiryou-o youishita (ato) douryou-to dekaketa.

employee documents prepared (after) with colleague went out

'After the employee prepared the documents, he went out with his colleague.' (MC)

'The employee went out with his colleague who prepared the documents.' (RC)

27b. 看護婦が注射を用意した(後)医師に質問した。

Kangofu-ga chuusha-o youishita (ato) ishi-ni shitsumonshita.

nurse injection prepared (after) to doctor asked a question

'After the nurse prepared the injection, she asked a question to the doctor.' (MC)

'The nurse asked a question to the doctor who prepared the injection.' (RC)

28a. 女性が花束を持っている(時)友人と写真を撮った。

Josei-ga hanataba-o motteiru (toki) yuujin-to shashin-o totta.

woman flowers holding (when) with friend took a picture

'When the woman was holding the flowers, she took a picture with the friend.' (MC)

'The woman took a picture with the friend who was holding the flowers.' (RC)

28b. 女の子がドレスを持っている(ので)お姫様に憧れた。

Onnanoko-ga doresu-o motteiru (node) ohimesama-ni akogareta.

girl dress has (since) princess dreamed of

'Since the girl has the dress, she dreamed of a princess.' (MC)

'The girl dreamed of a princess who has the dress.' (RC)

APPENDIX C

EXPERIMENTAL MATERIAL IN CHAPTER 5

The 24 sets of experimental items used in the experiments in Chapter 5 are presented. Experiment 1 used sentences in Subject-biased, Neutral and Object-biased conditions with a short relative clause (without adjuncts between RC object and RC verb). Experiment 2 used sentences in Subject-biased, Neutral and Object-biased conditions with a long relative clause (with adjuncts between RC object and RC verb). Experiment 3 used sentences in Subject-biased and Object-biased conditions with short and long relative clauses.

1. サラリーマンがネクタイ／グラス／口紅を（引き出しに大切そうに）持っている OL にそっと話しかけた。

   'The businessman softly talked to the office lady who has a necktie / glass / lipstick (protectively in a drawer).'

2. 男性がバイク／メニュー／キャンディーを（すみっこでじっと）見つめている女の子を大声で呼び止めた。

   'The man loudly stopped the girl who was staring at the motorcycle/menu/candy (fixedly in the corner)'

3. 高校生がサッカー／読書／ゲートボールを（公園で楽しそうに）している老人にさりげなく近づいた。

   'The high school student casually approached to the old man who was doing soccer/reading/gate ball (playfully in the park).'

4. 子供がおもちゃ／ジュース／ビールを（大切そうにぎゅっと）持っているビジネスマンに小さな声で話しかけた。

   'The child quietly talked to the businessman who was holding the toy/juice/beer (strongly in his hand).'

5. 赤ちゃんがミルク／飲み物／シャンパンを（テーブルで派手に）こぼした女優をじっと見つめた。

‘The baby fixedly stared at the actress who spilled the milk/drink/champagne (wildly on the table).’

6. ロックスターがギター／手袋／ランドセルを（胸の中に大切そうに）持っている小学生にそっと声をかけた。

‘The rock star softly said something to the elementary school kid who had the guitar/gloves/school bag (protectively in his arms).’

7. 医師が薬／メモ／体操着を（鞄の中にこっそり）持っている高校生をあわてて追いかけた。

‘The doctor hastily chased the high school student who had the medicine/memo/gym clothes (secretly in his bag).’

8. 小学生がマンガ／ノート／万年筆を（コンビニで急いで）買ってきた先生にこっそりと話しかけた。

‘The elementary school kid secretly talked to the teacher who bought comic book/note book/fountain pen (hurryingly at the convenience store).’

9. 社長がタキシード／ソファー／イヤリングを（デパートで楽しげに）選んだ女性を食事に誘った。

‘The president invited the lady who chose the tuxedo/sofa/earrings (happily at the department store) to dinner.’

10. ビジネスマンがゴルフ／食事／追いかけっこを（屋上で疲れた様子で）している小学生を楽しげに見つめた。

‘The businessman amusingly stared at the elementary school kid who was golfing/eating/tagging (tiredly on the rooftop).’

11. 女子高生が携帯／コップ／おしゃぶりを（すみっこで興味しんしんに）触っている赤ちゃんを楽しそうに世話した。

‘The high school girl joyfully took care of the baby who was touching the cell phone/cup/pacifier (interestedly in a corner).’

12. 浪人生が参考書／ボールペン／注射器を（鞄の中にこっそりと）持っている看護婦に嬉しそうに話を聞いた。

‘The gap year student happily heard a story from the nurse who had textbook/pen/injector (secretly in the bag).’

13. 俳優が台本／新聞／教科書を（公民館で大きな声で）読んでいた受験生と思いがけず意気投合した。

‘The actor happenstantialy clicked with the student who was reading the scrip/newspaper/textbook (loudly in the community center).’

14. 女の子がメリーゴーランド／自転車／バイクに（ショッピングモールで楽しそうに）乗っている男性に力いっぱい手をふった。

‘The girl intensely waved at the man who was riding the merry-go-round/bicycle/motorcycle (happily at the shopping center).’

15. 小学生が絵の具／麦茶／ビールを（テーブルで思いっきり）こぼしたサラリーマンに大声で文句を言った。

‘The elementary school kid loudly complained to the businessman who spilled the paint/tea/beer (wildly on the table).’

16. 男の子がプラモデル／マグカップ／カクテルを（大切そうにそっと）持っている女優に礼儀正しくサインを求めた。

‘The boy politely asked for an autograph to the actress who had the plastic model/mug/cocktail (carefully and softly).’

17. 幼稚園児が積み木／カバン／名刺を（棚の中にないしょで）持っている会社員をトコトコと追いかけた。

‘The kindergarten child trotted after the employee who had the block/bag/name card (secretly in the shelf).’

18. 病人が車いす／エレベーター／オープンカーに（近くで機嫌良く）乗っているプロデューサーを急いで追いかけた。

‘The sick person hastily chased the producer who was in the wheelchair/elevator/convertible (happily in the neighborhood).
’

19. 女優がドレス／風邪薬／腹巻きを（近所で面倒くさそうに）購入したおじいさんに詳しく話をきいた。

‘The actress closely heard a story from the grandfather who had bought the dress/cold medication/belly-warmer (reluctantly in the neighborhood).’

20. おばあさんが扇子／マフラー／マスカラを（鞄の中に密かに）持っている女子高生に優しく質問した。

‘The grandmother sweetly asked a question to the high school girl who had the folding fan/scarf/mascara (secretly in the bag).’

21. 化学者が実験／昼寝／鬼ごっこを（実験室で楽しそうに）している中学生に厳しくアドバイスした。

‘The chemist strictly advised the junior high school student who was doing experiment/nap/tagging (happily in the laboratory).’

22. 小学生がクレヨン／ハンカチ／ひげ剃りを（ポケットの中にこっそり）持っているビジネスマンをじっと見つめた。

‘The elementary school kid fixedly stared at the businessman who had the crayon/handkerchief/shaver (secretly in the pocket).’

23. 病人が点滴／散歩／筋トレを（公園で退屈そうに）している大学生にこっそりと近づいた。

‘The sick person secretly approached to the university student who was doing instilment/walk/exercise (boringly in the park).’

24. 教授が論文／文章／絵日記を（喫茶店で忙しそうに）書いている小学生を大げさに褒めたたえた。

‘The professor effusively complimented the elementary school kid who was writing the thesis/text/picture diary (busily at the cafe).’

APPENDIX D

EXPERIMENTAL MATERIAL IN CHAPTER 6

The 24 sets of experimental items used in the experiments in Chapter 6 are presented. The sentences had either an intransitive verb (a) or an optionally transitive verb (b). The sentences were also presented either with or without a comma.

1a. When the manager shouted (,) the competitor became really angry.
1b. When the manager helped (,) the competitor became really angry.
2a. After the man screamed (,) the policeman drove the car to the station.
2b. After the man shot (,) the policeman drove the car to the station.
3a. As the celebrity laughed (,) the team failed to arrive at the stadium.
3b. As the celebrity visited (,) the team failed to arrive at the stadium.
4a. When the reporter disagreed (,) the manager left the room for a cigarette.
4b. When the reporter interviewed (,) the manager left the room for a cigarette.
5a. When the president smiled (,) Susan stayed at home to watch TV.
5b. When the president answered (,) Susan stayed at home to watch TV.
6a. When the analyst complained (,) the lawyer sent money from the bank.
6b. When the analyst investigated (,) the lawyer sent money from the bank.
7a. When the girl cried (,) the old lady went out to see the neighbor.
7b. When the girl sketched (,) the old lady went out to see the neighbor.
8a. When the runner winked (,) the audience went to shop for a cup of coffee.
8b. When the runner chased (,) the audience went to shop for a cup of coffee.
9a. While the guard listened (,) the assistant called for the police.
9b. While the guard protected (,) the assistant called for the police.
10a. While the nurse yawned (,) the doctor told the patient to stand up.
10b. While the nurse supported (,) the doctor told the patient to stand up.
11a. While the cat jumped (,) the woman lay on the sofa for a nap.
11b. While the cat scratched (,) the woman lay on the sofa for a nap.
12a. When the interviewer coughed (,) the musician played the background music behind the curtain.

12b. When the interviewer questioned (,) the musician played the background music behind the curtain.

13a. While the manager shouted (,) the athlete fell asleep on the bench.

13b. While the manager coached (,) the athlete fell asleep on the bench.

14a. When the activist screamed (,) the politician joined in to support him.

14b. When the activist accused (,) the politician joined in to support him.

15a. While the professor smiled (,) the students exercised at the gym.

15b. While the professor lectured (,) the students exercised at the gym.

16a. While the audience cried (,) the actor rested behind the curtain.

16b. While the audience watched (,) the actor rested behind the curtain.

17a. When the trainer laughed (,) the referee stopped the game immediately.

17b. When the trainer assisted (,) the referee stopped the game immediately.

18a. While the soldier complained (,) the captain flew back to his country.

18b. While the soldier defended (,) the captain flew back to his country.

19a. When the policeman disagreed (,) the brother helped the suspect to escape.

19b. When the policeman contacted (,) the brother helped the suspect to escape.

20a. When the mechanic winked (,) the housewife made him a cup of tea.

20b. When the mechanic checked (,) the housewife made him a cup of tea.

21a. While the student chatted (,) the writer finished his latest book.

21b. While the student studied (,) the writer finished his latest book.

22a. As the therapist listened (,) the assistant asked the patient to sit down.

22b. As the therapist advised (,) the assistant asked the patient to sit down.

23a. As the wrestler jumped (,) the audience became very excited.

23b. As the wrestler attacked (,) the audience became very excited.

24a. As the grandmother coughed (,) the girl made a cup of tea in the kitchen.

24b. As the grandmother dressed (,) the girl made a cup of tea in the kitchen.