Processing of Gapless Dependency without Thematic Cues: A Study on Negative Adverbs in Japanese

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1. Introduction

Processing of long-distance dependencies is one of the central topics of psycholinguistic researches in the past decades. Most of these studies have focused mainly on wh-phrases and how the parser forms a link between the displaced filler and the corresponding gap in its original position in head-initial languages like English (Stowe, 1986, *inter alia*); or the wh-phrase and the required clause-final question particle in head-final languages like Japanese (Miyamoto & Takahashi, 2003; Aoshima, Phillips, & Weinberg, 2003, 2004; Aoshima, Phillips, & Yoshida, 2005).

Unlike English wh-phrases, negative adverbs in Japanese do not involve displaced fillers and gaps; but they are polarity items that form syntactic dependency with negative predicates (McGloin, 1976; Kato, 1985). Moreover, negative adverbs do not bear any thematic relation with predicates, unlike argument wh-phrases. This paper is an attempt to elucidate the nature of such gapless dependency formation and how it is being processed online. Findings provide evidence that increased processing cost due to temporarily unresolved dependency observed in wh-phrases extends to negative adverbs in Japanese. We took advantage of the thematic cue-less feature of negative adverbs to
support the claim that dependency formation is not mainly motivated by thematic role satisfaction.

The paper is organized as follows. In Section 2, we review some relevant studies on dependencies in both English and Japanese. After providing some basic data involving negative adverbs in Japanese in Section 3, we then present pieces of empirical evidence from offline and online experiments in Sections 4, 5, and 6. General discussion and a brief conclusion follow in Section 7.

2. Processing of filler-gap dependencies

Rapid construction of filler-gap dependencies in wh-phrases in English has been widely confirmed by numerous studies. Stowe (1986), for instance, observed a reading time slowdown when an overt element appears in the position where the parser expects a potential gap, upon identifying the filler (i.e. a displaced wh-phrase). This slowdown is called the Filled Gap Effect (FGE).

In Japanese, on the other hand, instead of the link formation between the filler and the gap, the type matching between the wh-phrase and the clause-final particle ‘ka’ is crucial to dependency formation. Miyamoto & Takahashi (2003) showed that the absence of the required question particle in the earliest grammatically possible position leads to a Typing Mismatch Effect (TME), a reading time slowdown that resembles FGE in English.

Findings from a series of experiments using fronted wh-phrases by Aoshima and colleagues (Aoshima et al., 2003, 2004) replicated Miyamoto & Takahashi’s results and further demonstrated that dependency formation is motivated by the need to satisfy thematic role requirements as soon as possible. However, as Aoshima et al. (2004) pointed out in their study, their results ‘do not lead to a conclusion that formation of wh-dependencies is specifically driven
by the need to satisfy thematic requirements’ (Aoshima et al., 2004; p. 42). They indicated that this is due to the fact that the thematic interpretation of the wh-phrase and, at the same time, the scope interpretation of the wh-phrase can be made at the same position, i.e. embedded verb.

(1) Dono-seito-ni
tannin-wa
dkocyoo-ga	hon-o
\_which.student-DAT\_class.teacher-TOP\_principal-NOM\_book-ACC
yonda-ka
tosyositu-de
sisyo-ni
iimasita.
\_read-Q\_library-at\_librarian-DAT\_said

As shown in (1), the thematic interpretation of the wh-phrase ‘dono-seito-ni’ can be made at the embedded verb ‘yonda’; and the scope interpretation of the said wh-phrase can also be made at the embedded verb position due to the question particle ‘ka’.

To tease apart these two possibilities, Aoshima et al. (2005) conducted two experiments comparing wh-phrases and referential NPs that are both sentence-initial, as shown in (2) and (3) respectively.

(3) a. NP-dat NP-top [NP-nom Adv NP-dat NP-acc V-comp] V
   b. NP-top NP-dat [NP-nom Adv NP-dat NP-acc V-comp] V

Relevant to our purposes, the most important finding in these experiments is that while no FGE in the second dative NP was observed in the fronted non-wh-NP condition (3a), FGE was observed in the fronted wh-NP condition. This suggests
that fronted wh-phrases are interpreted in the embedded clause, while fronted non-wh-NPs are interpreted in the matrix clause. This contrast led to the conclusion that the interpretation of the wh-phrase in the embedded clause is not motivated by the need to satisfy thematic role requirements; but instead, by the need to license a wh-phrase with a question particle as soon as possible.

Taken together, recent studies on wh-phrases in Japanese show that dependency formation is mainly driven by the immediate licensing of the wh-phrase with a question particle. However, it is important to examine different types of syntactic dependencies to be able to determine the universality of the parsing mechanisms involved in syntactic processing. The present study explores the nature of dependency formation using negative adverbs, which are quite similar to wh-phrases in that they require licensing elements, but they involve neither gaps nor thematic relation with predicates. This feature of negative adverbs can further provide evidence that dependency formation is not solely driven by the need to satisfy thematic requirements.

3. **Negative adverbs in Japanese**

We now turn to a brief discussion of negative adverbs that are the focus of the current study. Negative adverbs in Japanese do not involve fillers and gaps; but they are polarity items that form syntactic dependency with negative predicates. As (4) shows, (4b) is ungrammatical because it does not contain a negative morpheme that licenses the negative adverb ‘mettani’.

(4) a. Basugaido-wa **mettani** yotee-o kakunin-**sinai**.

> bus.guide-**TOP** rarely schedule-**ACC** not.to.**confirm**

‘The bus guide rarely confirms the schedule.’
Although negative adverbs and wh-phrases in Japanese resemble each other in that a licensor is required to form a grammatical sentence, they differ in a sense that negative adverbs do not bear any thematic relation with predicates. Hence, it is neither the existence of displaced fillers nor thematic role bearers, but exclusively the syntactic features of negative adverbs that trigger dependency formation. This study takes advantage of the features of negative adverbs to further explore the nature of dependency formation and to examine whether dependency formation is mainly driven by the immediate licensing of the negative adverbs with negation.

Relevant studies have been conducted on negative polarity items (NPIs) in Japanese as well as in Korean (Yoshida, 2002; Lee, 2005). Yoshida (2002) made use of the Japanese NPI ‘sika’ and showed that NPI triggers expectation of upcoming negation and thus, processing of a negative sentence is easier with the presence of an NPI that triggers such expectation. One difference between negative adverbs and ‘sika’ is that ‘sika’ is a bound morpheme that typically attaches to a noun, while adverbs are basically independent lexical items. This property eliminates the possible use of thematic cues in dependency formation in the case of negative adverbs.

The purpose of this study is to examine whether syntactic features of negative adverbs trigger dependency formation, even though they do not involve gaps or thematic cues. We have two separate predictions. First, if the parser tries to form dependency as soon as possible, we predict that temporarily unresolved dependency that arises from incongruity between the negative adverb and the
immediate predicate would result to a reading time slowdown upon encountering the incongruity, as has been shown by previous studies on wh-phrases (Miyamoto & Takahashi, 2003; Aoshima et al., 2004, 2005). Second, if NPIs trigger expectation of upcoming negation, as has been shown by Yoshida (2002), despite of a reading time slowdown due to the incongruity, we expect that processing of the succeeding parts could be facilitated due to prediction of upcoming predicates. Two sentence fragment completion experiments and one self-paced reading experiment were conducted to confirm these predictions.

4. **Experiment 1**

As a preliminary experiment, an offline sentence fragment completion experiment was conducted to verify dependency formation induced by negative adverbs in Japanese.

4.1 **Participants**

Twenty-nine native speakers of Japanese participated in Experiment 1. They were all undergraduate students at the Prefectural University of Hiroshima, Japan and received partial course credit for their participation, which lasted about 15 minutes.

4.2 **Materials and design**

Experiment materials consisted of sixteen sets of sentence fragments with two conditions each. Two lists were created by distributing the sixteen stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with thirty-two unrelated fillers in a random order. The fragments in both conditions consisted of two subject NPs (the first one bearing the topic marker
‘wa’ and the next bearing the nominative marker ‘ga’, indicating that the sentence was bi-clausal), an adverb (neutral or negative), and an accusative NP. The negative adverbs used were mettani (rarely), amari (not much), mottaku (absolutely), sukosimo (not at all); and the neutral adverbs used were itumu (always), tabitabi (often), tokidoki (sometimes), nandomo (frequently). A sample set of items is illustrated in (5).

(5) a. NEUTRAL ADVERB
untensyu-wa basugaido-ga    itumo yotee-o _________
driver-TOP  bus.guide-NOM  always  schedule-ACC
b. NEGATIVE ADVERB
untensyu-wa basugaido-ga    mettani yotee-o _________
driver-TOP  bus.guide-NOM  rarely  schedule-ACC

If negative adverbs trigger expectation of negative predicates, we expect more completions with negative predicates in the negative adverb condition compared to the neutral adverb condition, wherein both affirmative and negative predicates are possible.

4.3 Results and discussion
The experiment yielded a total of 464 grammatical sentence fragment completions, which were classified according to the polarity types of the immediate predicates provided to complete the sentences.

Results are shown in Table 1. There was a clear difference in the polarity types of the predicates depending on the adverb type. Fragments containing negative adverbs yielded more completions with negation in the immediate
predicates (98.3%) compared to those with neutral adverbs (10.3%) \( \chi^2(1) = 361.4, p<.01 \).

It was thus confirmed that negative adverbs elicit negative predicates in the earliest grammatically possible position; and although, in principle, neutral adverbs could be followed by either affirmative or negative predicate, native speakers prefer affirmative predicates.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Experiment 1, counts and percentages of the polarity types of the immediate predicates provided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AFF predicates</td>
</tr>
<tr>
<td></td>
<td>( n )</td>
</tr>
<tr>
<td>NEUT adverbs</td>
<td>208</td>
</tr>
<tr>
<td>NEG adverbs</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note. \( n \) is the number of grammatical completions.*

5. Experiment 2

After verifying dependency formation induced by adverbs in Experiment 1, another offline experiment was conducted to examine the native speakers’ awareness of unresolved dependency due to incongruity between negative adverbs and the immediate predicates.

5.1 Participants

Fifty-one native speakers of Japanese, who had not taken part in the previous experiment, participated in Experiment 2. They were all undergraduate students at Hiroshima University, Japan, and received partial course credit for their participation, which lasted about 25 minutes.

5.2 Materials and design

Experiment materials consisted of twenty-four sets of sentence fragments
with four conditions each. Four lists were created by distributing the twenty-four stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with forty-eight unrelated fillers in a random order. Aside from an additional embedded predicate (verb), the fragments up until the accusative NP in all conditions were similar to the previous experiment. We manipulated the types of adverbs (neutral vs. negative adverb) and predicates (affirmative vs. negative). The adverbs used were the ones used in Experiment 1. A sample set of items is illustrated in (6).

(6)  
a. NEUTRAL ADVERB-AFFIRMATIVE PREDICATE  
untensyu-wa basugaido-ga itumo yotee-o  kakunin-suru  
driver-TOP  bus.guide-NOM always schedule-ACC  confirm-affirmative

b. NEUTRAL ADVERB-NEGATIVE PREDICATE  
untensyu-wa basugaido-ga itumo yotee-o  kakunin-sinai  
driver-TOP  bus.guide-NOM always  schedule-ACC  confirm-negative

c. NEGATIVE ADVERB-AFFIRMATIVE PREDICATE  
untensyu-wa basugaido-ga mettani yotee-o  kakunin-suru  
driver-TOP  bus.guide-NOM rarely  schedule-ACC  confirm-affirmative

d. NEGATIVE ADVERB-NEGATIVE PREDICATE  
untensyu-wa basugaido-ga mettani yotee-o  kakunin-sinai  
driver-TOP  bus.guide-NOM rarely  schedule-ACC  confirm-negative

If native speakers are sensitive to the unresolved dependency due to incongruity between the adverbs and the immediate predicates, we expect different completion patterns between conditions with incongruity (6b and 6c) and those without (6a and 6d). Specifically, we expect native speakers to add two or more
predicates in (6c) because the absence of negation in the immediate predicate makes the embedded clause ungrammatical. In (6b), on the other hand, although native speakers might prefer affirmative predicates in the immediate predicate position based on the results in Experiment 1, negative predicates do not make the embedded clause ungrammatical. Therefore, although it may seem like there is a kind of incongruity in (6b), we don’t expect native speakers to treat it like (6c). Grammatical completions can be made in (6b) with completion patterns similar to the other conditions without incongruity, e.g. adding a complementizer and a main verb.

5.3 Results and discussion

The experiment yielded a total of 1185 grammatical sentence fragment completions, which were classified according to the number of predicates provided. This enables us to examine the difference in the completion patterns among conditions.

Results are shown in Table 2. Fragments with unresolved dependency (6c above) showed a strong bias to add another predicate\(^1\) (73.8%) as in (7), whereas those of the other conditions proved otherwise (\(\chi^2(3)=492.4, p<.01\)) and were mostly completed by providing just one predicate.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Experiment 2, counts and percentages of the number of predicates provided in each condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ONE Predicate</td>
</tr>
<tr>
<td></td>
<td>(n)</td>
</tr>
<tr>
<td>NEUT-AFF</td>
<td>257</td>
</tr>
<tr>
<td>NEUT-NEG</td>
<td>275</td>
</tr>
<tr>
<td>NEG-AFF</td>
<td>72</td>
</tr>
<tr>
<td>NEG-NEG</td>
<td>295</td>
</tr>
</tbody>
</table>

*Note. \(n\) is the number of grammatical completions.*
The underscored part is a completion sample with two predicates (6c):

untensyu-wa basugaido-ga mettani yotee-o kakunin-suru

driver-TOP bus.guide-NOM rarely schedule-ACC confirm-aff

koto-o sina-node (predicate 1) iraira-siteita (predicate 2).

‘The driver got irritated because the bus guide rarely confirms the schedule.’

Results show that participants were sensitive to the absence of elements licensing negative adverbs, which resulted in the inability of the existing predicate (kakunin-suru) to form a thematic link with the preceding nominative NP (basugaido-ga). Therefore, supplying another predicate is necessary to be able to immediately provide negation that could resolve dependency with negative adverbs. Findings imply that native speakers expect upcoming negation that can immediately license negative adverbs. This conforms to findings of previous studies on NPIs. However, recall that it is widely established in the literature on filler-gap dependency that failure to form dependency as soon as possible causes processing cost increase. This leads to an interesting question as to whether unresolved dependency induced by negative adverbs would behave like wh-phrases and result to processing cost increase in the region where incongruity arises; and whether processing of subsequent regions would be facilitated due to prediction of upcoming predicates as shown by Yoshida (2002). The next experiment aims to answer this question.

6. Experiment 3

The main objective of this study was to investigate how gapless
dependency without thematic cues is being processed. Results from the sentence fragment completion task in Experiment 1 demonstrated that negative adverbs trigger dependency formation with the immediate predicate. Results in Experiment 2 led to a prediction that unresolved dependency could possibly lead to cost increase when the parser encounters such unresolved dependency in processing. Also, expectation of upcoming predicates could result to facilitation of the processing of the succeeding parts. The purpose of this last experiment was to confirm this prediction and to observe how the parser is affected by temporarily unresolved dependency in real-time processing.

6.1 Participants

Forty native speakers of Japanese, who had not taken part in the previous experiments, participated in Experiment 3 for financial compensation. They were undergraduate and graduate students at Hiroshima University, Japan. The experiment lasted about 30 minutes.

6.2 Materials and design

Experiment materials consisted of twenty-four sets of sentences with four conditions each. Four lists were created by distributing the twenty-four stimuli in a Latin Square design. Each participant saw exactly one of the lists intermixed with forty-eight unrelated fillers in a random order. The four experimental conditions followed a $2 \times 2$ factorial design that manipulated the factors adverb type (neutral vs. negative) and predicate type (affirmative vs. negative). To be able to clearly detect the effect of temporarily unresolved dependency and, at the same time, the facilitation effect expected in the succeeding regions, we used relative clause structures in all the stimulus sentences. Relative clause structures
are known to cause a garden path (GP) effect, and we assume that a magnified GP effect compared to sentences without incongruity reflects cost increase, while faster recovery from it shows facilitation. A sample set of items is illustrated in (8).

(8) a. Neutral adverb-Affirmative predicate (NEUT-AFF)

sangakugaido-wa itumo tenkiyohoo-o sinyoo-suru

mountain.guide-TOP always weather.forecast-ACC believe

kankoobasu-no tendyooin-ni gezan-o susumenakatta.

tour.bus-GEN attendant-DAT descend.a.mountain-ACC did.not.advise.

‘The mountain guide did not advise the tour bus attendant who always believes the weather forecast to descend the mountain.’

b. Neutral adverb-Negative predicate (NEUT-NEG)

sangakugaido-wa itumo tenkiyohoo-o sinyoo-sinai

mountain.guide-TOP always weather.forecast-ACC not.to.believe

kankoobasu-no tendyooin-ni gezan-o susumeta.

tour.bus-GEN attendant-DAT descend.a.mountain-ACC advised.

‘The mountain guide advised the tour bus attendant who does not always believe the weather forecast to descend the mountain.’

c. Negative adverb-Affirmative predication (NEG-AFF)

sangakugaido-wa mettani tenkiyohoo-o sinyoo-suru

mountain.guide-TOP rarely weather.forecast-ACC believe

kankoobasu-no tendyooin-ni gezan-o susumenakatta.

tour.bus-GEN attendant-DAT descend.a.mountain-ACC did.not.advise.

‘The mountain guide rarely advised the tour bus attendant who believes the weather forecast to descend the mountain.’
6.3 Procedure

The experiment was conducted on a Dell computer running the Linger software developed at MIT (Rohde, 2001-2003). Participants were timed in a phrase-by-phrase self-paced non-cumulative moving-window reading task (Just, Carpenter, & Woolley, 1982). Sentences were presented one at a time on a single line. Stimulus segments initially appeared as a row of dashes, and participants pressed the space bar on the keyboard to reveal each subsequent region of the sentences and to cause all other regions to revert to dashes. The segmentation in the sentences in (8) was the actual segmentation used in the experiment.

A yes/no comprehension question was presented after each sentence with feedback on incorrectly answered items in order to ensure that the participants attended to the content of the sentences. The experimental trials were preceded by instructions and three practice trials.

6.4 Data analysis

Analyses were conducted on comprehension question response accuracy and reading times. One participant was eliminated due to poor overall comprehension performance (below 70%). Three additional participants were
eliminated due to abnormally long reading times. Reading times longer than 5000ms were discarded and were trimmed so that the data points beyond 2.5 standard deviations from the relevant condition \( \times \) region cell mean were discarded, affecting 4.7% of the test data. The means and analyses below are based on the remaining trials.

6.5 Results

Comprehension Question Accuracy

Among the thirty-six participants who were included in the analysis, average comprehension accuracy was 86.9%. Mean accuracy scores differ significantly across the four conditions \([F_1(1,35)=7.47, p<.01; F_2(1,23)=7.33, p<.01]\). Comprehension performance in the NEG-AFF condition (79%) was the poorest among the four conditions (NEUT-NEG, 91.0%; NEUT-AFF, 84.6%; NEG-NEG, 92.8%). This suggests that the parser was rather affected by the incongruity between the negative adverb and the immediate predicate; and that this incongruity is uncommon and disruptive.

Reading Times

The analyses with reading times yielded the following results for the four conditions. Reading times for regions 4 to 8 are shown in Table 3.

<table>
<thead>
<tr>
<th>CONDITIONS</th>
<th>4 (embedded V)</th>
<th>5 (NP-GEN)</th>
<th>6 (NP-DAT)</th>
<th>7 (NP-ACC)</th>
<th>8 (main V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>S.E.</td>
<td>RT</td>
<td>S.E.</td>
<td>RT</td>
</tr>
<tr>
<td>NEUT-AFF</td>
<td>734.4</td>
<td>30.9</td>
<td>939.1</td>
<td>42.0</td>
<td>1053.0</td>
</tr>
<tr>
<td>NEUT-NEG</td>
<td>796.4</td>
<td>33.0</td>
<td>863.4</td>
<td>37.7</td>
<td>1057.9</td>
</tr>
<tr>
<td>NEG-AFF</td>
<td>721.8</td>
<td>31.8</td>
<td>1099.5</td>
<td>57.6</td>
<td>1213.6</td>
</tr>
<tr>
<td>NEG-NEG</td>
<td>783.0</td>
<td>33.2</td>
<td>873.9</td>
<td>39.7</td>
<td>1016.9</td>
</tr>
</tbody>
</table>
Two critical regions were analyzed. One is region 4 with the embedded verb, where the adverb-predicate incongruity is encountered. Another one is the region where facilitation is expected, region 5.

In region 4, there was no significant main effect of adverb type \([F_{p}<1]\). The main effect of predicate type was significant in the item analysis but only marginally significant in the participant analysis \([F_1(1, 35)=3.77, p<.10; F_2(1, 23)=5.90, p<.05]\). This is due to longer reading times in the negative predicate conditions (NEUT-NEG and NEG-NEG), wherein the embedded verbs consisted of the negative morpheme ‘-nai’.

In region 5 (genitive NP), there was a significant main effect of adverb type only in the participant analysis \([F_1(1,35)=5.89, p<.05; F_2(1,23)=2.14, ns]\), and the main effect of predicate type was significant \([F_1(1,35)=26.73, p<.01; F_2(1,23)=8.44, p<.01]\). This is due to longer reading times observed in the NEG-AFF condition. There was also a significant interaction of adverb and predicate types only in the participant analysis \([F_1(1,35)=3.90, p<.05; F_2(1,23)=2.16, ns]\). Pairwise comparisons revealed that within negative adverb conditions, the affirmative predicate condition was read significantly more slowly than the negative predicate condition \([F_1(1,35)=15.52, p<.01; F_2(1,23)=3.84, p<.10]\). In contrast, the same comparison for the neutral adverb conditions showed no corresponding slowdown \([F_1(1,35)=1.94, ns; F_2(1,23)=3.62, p<.10]\). On the other hand, within affirmative predicate conditions, the negative adverb condition was read significantly more slowly than the neutral adverb condition in the participant analysis but not in the item analysis \([F_1(1,35)=6.96, p<.05; F_2(1,23)=2.83, ns]\). The same comparison for the negative predicate condition showed no corresponding slowdown \([F_{p}<1]\) (see Figures 1 and 2).
Results for the remaining regions were as follows.

In regions 1 (subject NP) and 2 (adverb), the four conditions did not differ significantly (all $F$s<1).

In region 3 (accusative NP), the main effect of adverb type was significant in the participant analysis and marginally significant in the item analysis [$F_1(1,35)=6.62$, $p<.05$; $F_2(1,23)=3.97$, $p<.10$]. The neutral adverb conditions were read more slowly than the negative adverb conditions in this region.

In region 6 (dative NP), there was a marginally significant main effect of
adverb type only in the participant analysis \([F_1(1,35)=3.24, p<.10; F_2(1,23)=1.40, ns]\). The main effect of predicate type was significant in the participant analysis and marginally significant in the item analysis \([F_1(1,35)=5.20, p<.05; F_2(1,23)=3.21, p<.10]\). The interaction of adverb and predicate types was significant in the participant analysis and marginally significant in the item analysis \([F_1(1, 35)=5.80, p<.05; F_2(1,23)=3.50, p<.10]\). Pairwise comparisons revealed that within negative adverb conditions, the affirmative predicate condition was read significantly more slowly than the negative predicate condition \([F_1(1,35)=9.38, p<.01; F_2(1, 23)=5.63, p<.05]\). In contrast, the same comparison for the neutral adverb conditions showed no corresponding slowdown \([Fs<1]\).

In region 7 (accusative NP), there was no significant main effect of adverb type \([Fs<1]\). The main effect of predicate type was significant in the participant analysis but not in the item analysis \([F_1(1, 35)=5.35, p<.05; F_2(1, 23)=2.83, ns]\). This is due to longer reading times in the NEUT-AFF and NEG-AFF conditions.

In region 8 (matrix verb), there was no significant main effect of adverb type \([Fs<1]\). There was a significant main effect of predicate type \([F_1(1,35)=49.35, p<.01; F_2(1,23)=22.36, p<.01]\), due to longer reading times in the NEUT-AFF and NEG-AFF conditions, wherein the matrix verbs consisted of the negative past morpheme ‘-nakatta’.

6.6 Discussion

The purpose of this experiment was to investigate whether temporarily unresolved dependency would result to a reading time slowdown upon encountering the incongruity; and whether prediction of upcoming predicates would facilitate the processing of the next regions. The main finding in this
experiment was that native speakers of Japanese were surprised to encounter an affirmative morpheme on the immediate predicate following a negative adverb, although the slowdown was not directly seen in the embedded verb region. Moreover, instead of a facilitation effect, reading slowdown was continuously observed in the succeeding parts. Below is further discussion on the results of the reading times of the two critical regions, regions 4 and 5.

We shall first discuss effects observed in region 4. The reading time slowdown in the NEG-AFF condition, where incongruity arises, was expected in this region. However, it turned out that the verbs with negative morphemes were read more slowly than the ones with affirmative morphemes in region 4. One possible explanation is the difference in the number of moras, with the affirmative morphemes having only two moras, e.g. ‘suru’, and the negative morphemes having three, e.g. ‘sinai’; thus, verbs with negative morphemes were read more slowly. Alternatively, a more plausible reason for longer reading times in region 4 with negative predicates is the fact that negative statements are more difficult to process than affirmative ones without any given context (Horn, 1989), regardless of the presence of triggering elements in the preceding regions.²

Next, we shall turn to region 5, which contained the same word (genitive NP) across the four conditions. We predicted that reading time would be shorter after the incongruity in the NEG-AFF condition due to prediction of upcoming predicates. On the contrary, a reading time slowdown was observed in region 5, the region after the incongruity in the NEG-AFF condition. No corresponding slowdown was observed in the neutral adverb conditions because these could be followed by either affirmative or negative predicate, as suggested by the results in Experiment 2. A possible explanation for this is that cost increase anticipated in region 4 might have appeared in region 5 and this can be interpreted as a
spillover effect from region 4. Moreover, results in region 6 of the same condition did not also show any sign of facilitation but instead showed a similar pattern of reading time slowdown as observed in region 5.

In a previous study on wh-phrases, reading time slowdown was also slightly delayed in certain conditions, appearing in the region after the embedded verb where TME was anticipated (Aoshima et al., 2004). Furthermore, TME continued beyond the embedded verb region in Miyamoto and Takahashi’s results in one of their experiments (Miyamoto & Takahashi, 2003). In other words, the delayed slowdown in this experiment can be interpreted as an effect similar to the TME observed in wh-phrases. This can be attributable to the parser’s incapability to recover after the incongruity due to the need to reinterpret a simple sentence into a complex one with an embedded clause.

Shown below is a sample sentence in the NEG-AFF condition used in Experiment 3 ((8c) repeated here as (9)).

(9) sangakugaido-wa mettani tenkiyohoo-o sinyoo-suru
  mountain.guide-TOP rarely weather.forecast-ACC believe
  kankoobasu-no tendyooin-ni gezan-o susumenakatta.
  tour.bus-GEN attendant-DAT descend.a.mountain-ACC did.not.advise.
  a. sangakugaido-wa mettani tenkiyohoo-o …
  b. sangakugaido-wa mettani tenkiyohoo-o sinyoo-sinai.
  c. sangakugaido-wa mettani [tenkiyohoo-o sinyoo-suru …
  d. *sangakugaido-wa mettani tenkiyohoo-o sinyoo-suru …

As the parser reads word strings like that of (9a), the initial preference would be a simple sentence like (9b). However, the appearance of the embedded verb (9c)
signals that the initial interpretation is incorrect because as (9d) shows, the absence of the licensing negative morpheme ‘-nai’ in the embedded verb makes this interpretation ungrammatical. Therefore, the parser needs to put a clause boundary after the negative adverb (9c) and reinterpret it into a complex sentence to be able to correctly process the sentence with an embedded clause.

Cost increase observed in this experiment reflects the parser’s immediate search for negation after the negative adverb. This suggests that TME found in wh-phrases extends to negative adverbs in Japanese. Incapability of the parser to recover from incongruity eventually hindered the facilitation of the processing of the next regions, which was expected to be triggered by the negative adverb.

7. General Discussion

The main objective of this study was to examine whether syntactic features of negative adverbs trigger dependency formation, even though they do not involve gaps or thematic cues. Results from the sentence fragment completion task in Experiment 1 demonstrated that negative adverbs trigger dependency formation with the immediate predicates. Results in Experiment 2 led to a prediction that unresolved dependency could possibly lead to cost increase when the parser encounters such unresolved dependency in processing; and that processing of the succeeding parts could be facilitated due to expectation of upcoming predicates. Experiment 3 was conducted to confirm this prediction and to observe how the parser is affected by temporarily unresolved dependency in real-time processing. Results showed that native speakers of Japanese were surprised not to encounter negation on the immediate predicate following a negative adverb, although the slowdown was not directly observed in the embedded verb region but in the succeeding region. Furthermore, failure to
recover from this led to consecutive reading time slowdown in the next regions.

Findings suggest that incongruity between the negative adverb and the embedded verb results to a slowdown similar to the observed TME in previous studies on wh-phrases. This consequently hindered the anticipated facilitation of the processing of the succeeding regions, supposedly triggered by negative adverbs.

Alternatively, it is also important to consider the structure of the stimulus sentences used in Experiment 3. Slowdown was observed in regions 5 and 6: regions that consist of the genitive NP and the head noun of the relative clause. Recall that we used relative clause structures to detect the effect of temporarily unresolved dependency and, at the same time, the facilitation effect expected in the next regions. As mentioned earlier, we took advantage of the GP effect brought about by the relative clause structures, assuming that a larger GP effect compared to sentences without incongruity reflects cost increase, while faster recovery from it shows facilitation. A larger GP effect was observed in the NEG-AFF condition as reflected by a slower reading time in region 5 compared to all the other conditions. Unfortunately, what we considered as an effective measure of the facilitation proved to be impedimental in that the parser was not only disrupted by the absence of negation in the immediate predicate but also by the unexpected presence of an embedded clause.

Taken together, results of the present study indicate that cost increase due to temporarily unresolved dependency observed in previous studies on wh-phrases extends to negative adverbs in Japanese. It also provides further evidence that the parser prefers dependency formation in the earliest grammatically possible position. It is clear that mainly the syntactic features of negative adverbs trigger dependency formation because they do not bear any thematic cues, unlike
wh-phrases. Recall that Aoshima et al. (2005) showed that the interpretation of the wh-phrase in the embedded clause is not motivated by the need to satisfy thematic role requirements; but instead, by the need to license a wh-phrase with a question particle on a verb at the earliest position possible. By investigating the nature of dependency formation of a different type of dependency, i.e. negative adverbs, we were able to verify this claim and contribute to the growing number of researches that suggest a universal parsing mechanism across languages and syntactic constructions.

Notes

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1 It may seem surprising that there were completions with only one predicate in the condition with incongruity between negative adverbs and the immediate predicate (6c: 26.2%). Some of the sentence fragments in Experiment 2 consisted of verbs in the past tense ‘sita’, which might have caused some participants to attach morphemes like ‘-garanai’ (e.g. ‘sitagaranai’) and ‘-ri-sinai’ (e.g. ‘sitari-sinai’) to the given verbs to complete the fragments. The completions with only one predicate were made up of such completions and were considered grammatical.

2 This can be corroborated by the reading time results of the main verb in region 8. A reading time slowdown was observed in region 8 in conditions (NEUT-AFF
and NEG-AFF) wherein the main verb consisted of the negative past morpheme ‘-nakatta’. It is supposed that region 8 is where incongruity between the negative adverb and its predicate is resolved, particularly in the NEG-AFF condition; and hence, facilitation was expected in this condition since prediction of a negative predicate is triggered by the negative adverb. However, no reading time difference was observed. Therefore, the processing difficulty of negative sentences is a seemingly reasonable explanation for this, although the difference in the number of moras and integration or wrap-up effects cannot be totally ignored.

References


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