Japanese EFL Learners' Asymmetrical Sensitivity to English Number Dis/agreement[1]

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Abstract

本研究は、母語である日本語にはみられない第二言語の英語における特性に対して、日本人英語学習者がオンライン処理において敏感であるかどうか調査した。対象の言語現象は、主語動詞の数一致である。自己ペース読文課題の結果は、学習者は複数の主語が単数の *be* 動詞（*was*）に後続される時よりも、単数の主語が複数の *be* 動詞（*were*）に後続される時において数(不)一致に敏感であることを示した。また、TOEFL の文法テストで測った英語習熟度と自己ペース読文課題で測った読み時間の相関関係(微弱)から、第二言語処理におけるある文法特性に対する敏感度には習熟度が影響することが示唆された。なぜ数(不)一致の第二言語処理において非対称性が観察されたのかという問題に対して二つの観点から議論する。一つは主語と *be* 動詞の数素性指定であり、もう一つは（単数は無標であり、複数は有標であるという）数の有標性である。

Key Words: subject-verb number agreement, singular/plural asymmetry, Japanese EFL learners, on-line parsing, self-paced reading

1. Introduction

The goal of this study is to investigate whether second language (L2) learners are sensitive to a L2 property that is not found in their first language (L1). Our focus is on Japanese EFL (English as a foreign language) learners' sensitivity to English number agreement as in (1a-b).

(1) a. One dog is/*are barking.
b. Two dogs are/*is barking.

In English, the subject and the following verb have to agree in terms of number (e.g., singular in (1a) and plural in (1b)).[2] As we can see in (2a-b) below corresponding to the English counterparts in (1a-b), subject-verb number agreement is not observed (at least, on the surface forms) in Japanese (Kuno 1973; Kuroda 1988; among others).

(2)[3] a. 一匹の犬が吠えている。
Ippiki-no inu-ga *hoeteiru*.
one.CL-Gen dog-Nom barking.is
b. 二匹の犬が吠えている。
Nihiki-no inu-ga *hoeteiru*.
two.CL-Gen dog-Nom barking.is

Then, how do Japanese EFL learners deal with such grammatical information in L2 English, especially in their real-time processing?

2. Earlier Studies on L2 Sensitivity

There are a number of studies examining whether L2 learners whose L1's lack number agreement are sensitive to such information in L2 English by comparing their responses to such a pair of grammatical and ungrammatical sentences as in (3a-b) (a star indicates ungrammaticality).

(3) a. The bridges to the island were about ten miles away.
b. *The bridge to the island were about ten miles away.
(Jiang 2004: 615)

It has been demonstrated that native speakers of English show on-line sensitivity to number-agreement violations as in (3b) but most of the L2 learners do not, although both native speakers and L2 learners are able to make off-line un/grammaticality judgments with respect to number dis/agreement (e.g., Jiang 2004; Ojima, Nakata, & Kakigi 2005; Chen, Shu, Liu, Zhao, & Li 2007; Sato & Felser 2010).

Wen, Miyao, Takeda, Chu, & Schwartz (2010) argue that the linear or structural distance between an agreement-triggering element (e.g., the subject) and an element that is to agree with it (e.g., the following verb) affected the experimental results. It was pointed out that the L2 speakers showed sensitivity to number dis/agreement only when those two elements were adjacent to each other (for exceptions, cf. Sato & Felser 2010). To focus on the linear distance effect, Wen *et al*. (2010) examined L2 sensitivity to number dis/agreement within such a single NP (Noun Phrase) as in (4a-d).

(4) a. Jill sold this$_{[sg]}$ beautiful house$_{[sg]}$ to her niece every evening.
b. *Jill sold this$_{[sg]}$ beautiful houses$_{[pl]}$ to her niece every evening.
c. Jill sold these$_{[pl]}$ beautiful houses$_{[pl]}$ to her niece every evening.
d. *Jill sold these$_{[pl]}$ beautiful house$_{[sg]}$ to her niece every evening.
(Wen *et al*. 2010: 450, $_{[sg/pl]}$ added)

A word-by-word self-paced reading experiment showed that both the native English speakers and the Chinese-speaking and Japanese-speaking advanced learners were sensitive to number disagreement, whereas the intermediate learners were not. Interestingly, in both the group of

native speakers and the group of advanced learners, an asymmetry in the degrees of sensitivity was found depending on the number marking of the demonstrative and the following noun. In particular, those two groups exhibited a stronger sensitivity when the singular demonstrative was followed by the plural noun as in (4b) compared to the reversed relation as in (4d).

3. The Present Study

The purpose of the present study is to examine whether Japanese EFL learners show an asymmetrical pattern of sensitivity in subject-verb number agreement that is never found in their L1 Japanese. Notice that number agreement within a single NP, which was examined by Wen *et al*. (2010), is partially observed in Japanese[4], while number agreement in the subject-verb relation as in (1a-b) is never observed in Japanese (see (2a-b) above). Given that in Japanese there is no equivalent (at least, overtly) property to subject-verb number agreement in English, then how do Japanese EFL learners process it? To investigate this research question, an on-line experiment was conducted.

3.1 Method

Participants

Thirty-two undergraduates at the University of Tokyo and thirty-nine under/graduates at Gunma University were paid to participate in the experiment. They were 43 males and 28 females, and their mean age was 19.92 years old (SD = 1.00). Their English proficiency level was estimated by a single TOEFL (Test Of English as a Foreign Language) grammar test (extracted from Sharpe 2001), and their mean score was 13.87 out of 20 points (one point for one question) (SD = 2.99) (69.35% in percentage terms). (Three participants were in fact excluded from further analyses (see *Data treatment* below).)

Materials

Twenty-four sets of target sentences as in (5a-d) were used in the experiment (R in (5) stands for a Region of interest for self-paced reading) (see Appendix A for the target stimuli).

(5) R1 / R2 / R3 / R4 / <u>R5</u> / R6 / R7

a. The principal / saw / the students' teacher$_{[sg]}$ / who / was$_{[sg]}$ / relaxing / on the bench. (SG-SG)

b. *The principal / saw / the students' teacher$_{[sg]}$ / who / were$_{[pl]}$ / relaxing / on the bench. (*SG-PL)

c. The principal / saw / the student's teachers$_{[pl]}$ / who / were$_{[pl]}$ / relaxing / on the bench. (PL-PL)

d. *The principal / saw / the student's teachers$_{[pl]}$ / who / was$_{[sg]}$ / relaxing / on the bench. (*PL-SG)

As seen in (5a-d) above, the un/grammaticality was manipulated by number dis/agreement between the head noun and the following *be*-verb of relative clauses.[5] The experiment adopted 2x2 condition design (Singular or Plural (*Number* of the head noun) x Match or Mismatch (*Matching* in number between the head noun and the following *be*-verb)). The resulting four conditions will be referred to as Singular-Singular Match (SG-SG) as in (5a), Singular-Plural Mismatch (*SG-PL) (an asterisk means number mismatch) as in (5b), Plural-Plural Match (PL-PL) as in (5c), and Plural-Singular Mismatch (*PL-SG) as in (5d), in order to clarify the number marking of the head noun and the following *be*-verb in each condition.

Procedure

A phrase-by-phrase, non-cumulative, moving-window, self-paced reading task[6] (controlled by Linger) was conducted individually in a soundproof chamber (the slashes in (5a-d) indicate segmentation). First, the participant received the oral and written experimental instructions. He/She was told about the inclusion of some ungrammatical sentences in the experiment (the ratio of ungrammatical sentences was 25% (18 out of 72 sentences (24 targets plus 48 fillers to be described below)), which was not informed to him/her). After the eight practice trials for the participant's familiarization with the PC procedure for self-paced reading, the main trials were administered (the stimulus presentation was randomized by Linger for each participant). The 24 target sentences were counterbalanced into four lists so that one participant could be exposed to only one of the four conditions for each sentence. For the target sentences not to be consecutively presented, 48 fillers were inserted. Twenty-four filler sentences included temporary PP (Prepositional Phrase) attachment ambiguity, 12 fillers contained anaphora resolution (six were grammatical, whereas the other six were ungrammatical), and 12 fillers were distracters of various types of constructions. The 12 distracters were used for participant screening. Each sentence for self-paced reading was followed by a corresponding comprehension question, e.g., for (5b), as in (6).

(6)[7] The principal saw the teacher.
1) correct 2) incorrect
3) ungrammatical

The participants were instructed to choose *in/correct* if the sentence for self-paced reading was in/consistent with the content of the question sentence for comprehension or *ungrammatical* if the sentence for self-paced reading was ungrammatical. As for the choice of *ungrammatical*, even though the sentence for self-paced reading is consistent with the content of the question sentence, the instruction required the participants to choose *ungrammatical* when the sentence for self-paced reading was ungrammatical. Note that the choice of *grammatical* was not given. In (6), the expected answer was *ungrammatical* because of the ungrammaticality of (5b). There were no

time limits for the participant's self-paced reading and answering the questions, nor feedback for his/her responses to the questions. Immediately after the self-paced reading task, a background questionnaire and then a TOEFL grammar test were carried out. Each participant took approximately 45 minutes to finish the experiment.

Data treatment

The participants were screened by their accuracy for the 12 comprehension questions accompanying the corresponding distracter sentences.[8] If the participant's accuracy was below 65%, he/she was not included in further analyses. Three participants were excluded from further analyses. The remaining 68 participants were 41 males and 27 females, and their mean age was 19.86 years old (SD = 0.94). Their mean score on the TOEFL grammar test was 13.89 out of 20 points (SD = 3.03) (69.45% in percentage terms).

The raw reading time (RT) data were trimmed as follows. First, absolute cutoffs were applied for each region to exclude erroneous data points (for R3, for example, absolute cutoffs were shorter than 200 ms or longer than 6500 ms). Then, the data points shorter or longer than each participant's mean RT plus or minus 3SD were replaced with these cutoff values. (Less than 5% of the data were affected by this trimming.) After the data trimming, a series of analyses by linear mixed-effects models (Baayen, Davidson, & Bates 2008) were performed for the RT's in each region. The dependent variable was RT, the two independent or manipulated variables were Number and Matching, and the random variables were participants and items. The optimal model was chosen by backward selection (see Appendices B and C). The rationale was that the participant's longer RT in the underlined, critical R5 in mismatch conditions as in *SG-PL (5b) and *PL-SG (5d) compared to their match control conditions as in SG-SG (5a) and PL-PL (5c), respectively, would indicate his/her sensitivity to number dis/agreement.

3.2 Results

The participants' mean accuracy for the 12 comprehension questions was 85.67% (SD = 9.28). This indicates that the participants concentrated well on the task.

The mean RT's by condition can be summarized as in Figure 1 below (the solid lines stand for match SG-SG as in (5a) and PL-PL as in (5c) with black triangle and white square plots, respectively, and the broken lines for mismatch *SG-PL as in (5b) and *PL-SG as in (5d) with black triangle and white square plots).[9]

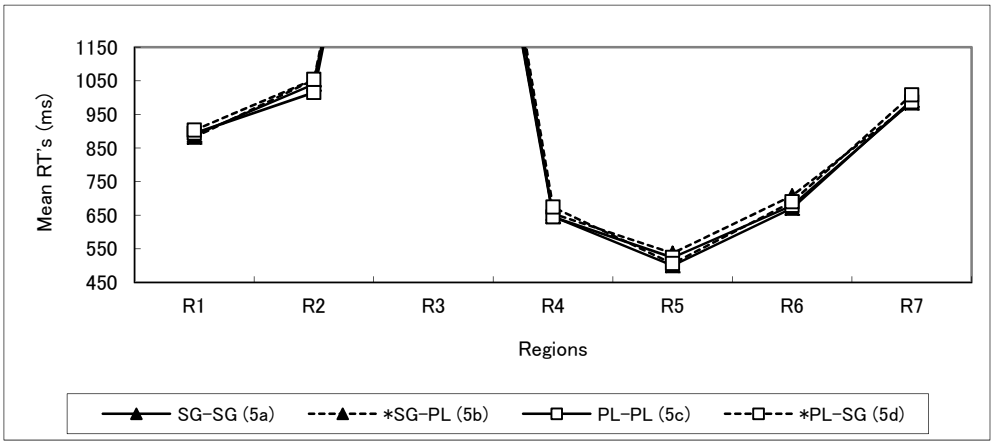

Figure 1: Mean RT's by Condition

Since the mean RT's in R3 were longer than those in other regions due to lexical length, they are separately presented in Figure 2 (the black bars stand for match SG-SG and mismatch *SG-PL, and the white bars for match PL-PL and mismatch *PL-SG).

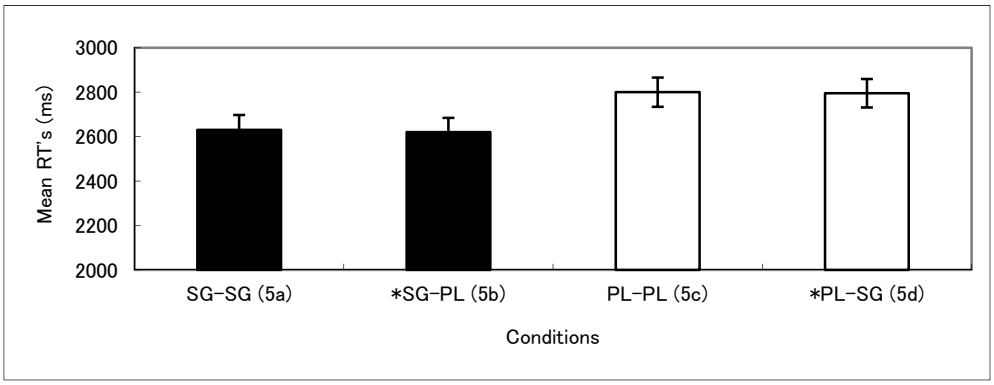

Figure 2: Mean RT's in R3

In R1 and R2, there were no reliable RT differences among the four conditions because the optimal one of the linear mixed-effects models for each region did not show any significant interaction between Matching and Number or main effects of them (all p's > .05). As for R3, neither reliable interaction nor main effect of Matching was observed, but there was a main effect of Number ($\beta = 84.369$; $SE = 26.668$; $t = 3.164$; $p < .01$), as seen in Figure 2. Since no reliable RT difference among the conditions was found in the next R4 (all p's > .05), it is not unreasonable that we treat the RT data from R4 independently of the RT difference in R3. It was R5 that was critical for analysis because the sentence in question turned out to be grammatical or ungrammatical there. The results of RT's in the critical R5 are summarized in Figure 3 below (the black bars for SG-SG and *SG-PL and the white bars for PL-PL and *PL-SG).

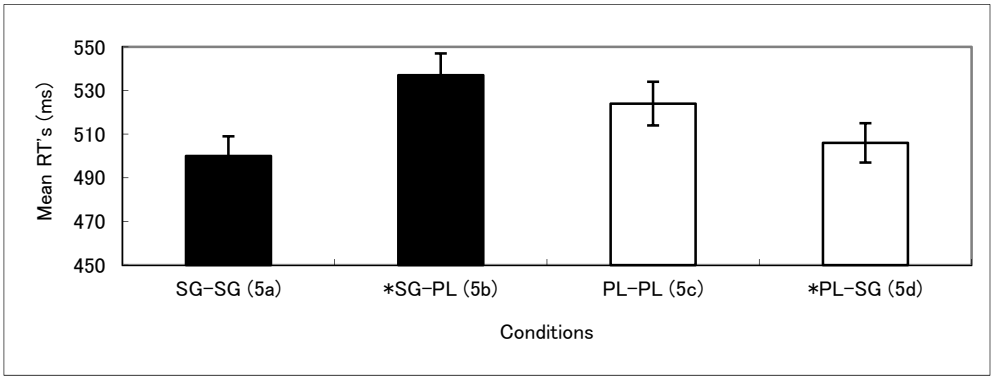

Figure 3: Mean RT's in the Critical R5

In the critical R5, the optimal model showed no main effects of Matching or Number (*p*'s > .05), but the interaction between them was significant (β = -12.389; *SE* = 4.420; *t* = -2.80; *p* < .01). In the following R6 and R7, there were no significant RT differences among the conditions (all *p*'s > .05).

Given that the interaction between Matching and Number was significant in the critical R5, the subsequent pairwise comparisons were performed for the mean RT's in match and mismatch conditions. The RT difference was significant between SG-SG and *SG-PL (500 ms (SE = 9) vs. 537 ms (SE = 10) (β = 17.808; *SE* = 6.191; *t* = 2.88; *p* < .01)) but not reliable between PL-PL and *PL-SG (524 ms (SE = 10) vs. 506 ms (SE = 9) (*p* > .05)).

To examine proficiency effects on L2 sensitivity, the correlation between the RT difference (in the mean RT in the mismatch sentences minus that in their match controls for each participant) and each participant's score on the grammar test was examined for the critical R5. A weak correlation was found in SG-SG and *SG-PL (*r* = .217, *p* = .074), whereas there was no reliable correlation at all in PL-PL and *PL-SG (*r* = .012, *p* > .05).

4. Discussion

The mean RT difference in the critical R5 was significant between SG-SG (e.g., *teacher ... was* as in (5a)) and *SG-PL (e.g., **teacher ... were* as in (5b)) but not reliable between PL-PL (e.g., *teachers ... were* as in (5c)) and *PL-SG (**teachers ... was* as in (5d)). This suggests that the Japanese EFL learners were sensitive to English subject-verb number dis/agreement (in this case, for relative clauses) when the singular head noun was followed by the plural *be*-verb but not when the plural head noun was followed by the singular *be*-verb. In other words, we observed an asymmetry in their on-line L2 sensitivity in English depending on the combination between the number marking of an agreement-triggering subject and that of a *be*-verb that is to agree with it.

Furthermore, a marginally significant positive correlation was found between each participant's RT difference in the critical R5 in SG-SG and *SG-PL, not in PL-PL and *PL-SG, and his/her score on the grammar test. This leaves a possibility that Japanese EFL learners' on-line sensitivity to subject-verb number agreement in L2 English, which is never found in their L1 Japanese, is in fact modulated by their proficiency levels in English. In other words, L2 sensitivity could become stronger as the learner's proficiency in the target language becomes higher. However, note that in the present study, the participants' proficiency was estimated by a single TOEFL grammar test, and that the results of the grammar test suggested that the individual differences in proficiency were not large. Recall that Wen *et al*. (2010) found that, while the advanced learners showed an on-line (asymmetrical) sensitivity to number dis/agreement within a single NP, the intermediate learners did not. Thus, for further investigation of proficiency effects on on-line L2 sensitivity to subject-verb number dis/agreement, a population with diverse levels of proficiency should be examined.

4.1 Why Asymmetrical Sensitivity?

Compare Wen *et al*.'s (2010) experimental results as in (7) with the present study's results as in (8).

(7) Wen *et al*.'s (2010) Results of Number Agreement within a Single NP
a. *this$_{[sg]}$ … houses$_{[pl]}$ (as in (4b))
b. *these$_{[pl]}$ … house$_{[sg]}$ (as in (4d))
L2/L1 Sensitivity Strength: a > b

(8) The Present Study's Results of Subject-verb Number Agreement
a. *teacher$_{[sg]}$ … were$_{[pl]}$ (as in (5b))
b. *teachers$_{[pl]}$ … was$_{[sg]}$ (as in (5d))
L2 Sensitivity Strength: a > b

The results of the two studies suggest that L2 sensitivity becomes stronger when a singular agreement-triggering element is followed by a plural element that is to agree with it, as in (7a) and (8a) compared to the reversed relation as in (7b) and (8b). The comparison may imply that the asymmetrical sensitivity is a phenomenon to be observed in number agreement in general in English (i.e., both in the demonstrative-noun relation as in (7a-b) and in the subject-verb relation as in (8a-b)[10]). Since the present study dealt with only *be*-verbs for subject-verb number agreement, a question remains as to whether an asymmetrical sensitivity is observed for number agreement between the subject and the ordinary main verb (i.e., third person singular *-s*). Wakabayashi, Fukuda, Bannai, & Asaoka (2007) examined in an ERP (Event-Related Potentials) study Japanese speakers' sensitivity to the un/grammaticality of the following sentences[11]:

(9) a. The teachers$_{[pl]}$ *answers$_{[sg]}$/answer$_{[pl]}$ our questions.
b. My mother$_{[sg]}$ *answer$_{[pl]}$/answers$_{[sg]}$ your question.

(Wakabayashi *et al*. 2007: 26, $_{[sg/pl]}$ added)

Wakabayashi *et al*'s (2007) ERP study demonstrated that the native English speakers showed sensitivity (i.e., P600) to the un/grammaticality of (9a-b), whereas the Japanese speakers did not. However, whether the native speakers exhibited an asymmetrical sensitivity in (9a-b) is not discussed. Ojima, Nakata, & Kakigi (2005) (using ERPs) and Sato & Felser (2010) (using self-paced reading) also examined Japanese speakers' sensitivity to subject-verb number agreement using sentences such as (10) and (11).

(10) The turtles$_{[pl]}$ *moves$_{[sg]}$/move$_{[pl]}$ slowly.

(Ojima *et al*. 2005: 1224, $_{[sg/pl]}$ added)

(11) He$_{[sg]}$ frequently *yawn$_{[pl]}$/yawns$_{[sg]}$.

(Sato & Felser 2010: 109, $_{[sg/pl]}$ added)

Although the two studies showed the Japanese-speaking learners' on-line sensitivity, whether such sensitivity differs depending on the combination of the number features is unclear because both studies adopted only two conditions for number agreement ([pl] – *[sg]/[pl] in (10) and [sg] – *[pl]/[sg] in (11)).

Putting aside number agreement between the subject and the ordinary main verb (see Section 5 below), it appears that sensitivity becomes stronger if an agreement-triggering element is singular and an element that is to agree with it is plural as shown in (7) and (8). Why do we observe such an asymmetrical pattern of L2 (and L1) sensitivity? There are two possible sources for the asymmetry in sensitivity: the number marking of (i) an agreement-triggering element (e.g., the demonstrative in (7a-b) and the subject in (8a-b)) and (ii) an element that is to agree with it (i.e., the noun in (7a-b) and the *be*-verb in (8a-b)). In the following, we consider the characteristics of Japanese EFL learners' L1 Japanese and discuss featural specifications and markedness of number in relation with those two sources.

As exemplified in (1a-b) and (2a-b) above, subject-verb number agreement is observed in English but not in Japanese. Thus, it is hard to consider our experimental results as a transfer effect of the Japanese EFL learners' L1 knowledge in L2 processing.[12] Then, what caused such an asymmetrical sensitivity to subject-verb number agreement observed in the present study as in (8a-b)? First, the featural specifications of number (i.e., singular or plural) marked on the subject and the *be*-verb seem to yield an asymmetrical sensitivity as in (8a-b). It is conceivable that depending on the combination of the featural specifications, sensitivity to subject-verb number agreement would become stronger or weaker. Second, markedness of number may account for the

asymmetrical sensitivity. "It is generally accepted that the singular is the unmarked number as compared to the plural" (Corbett 2000: 17). In terms of markedness, the asymmetrical sensitivity can be described as follows: sensitivity becomes stronger when the unmarked singular element is followed by the marked plural element as in (8a) compared to the reversed relation as in (8b).

From the markedness perspective, the studies of a phenomenon called agreement attraction may be worth discussing. As for production, Eberhard (1997, Experiments 1 and 2) showed that the error rate was higher in such a preamble as *The key$_{[sg]}$ to the cabinets$_{[pl]}$* (the error rate was 65 out of 121 (i.e., 53.71%)) compared to such a preamble as *The keys$_{[pl]}$ to the cabinet$_{[sg]}$* (the error rate was 11 out of 811 (i.e., 13.58%)). That is, it was demonstrated that the native English speakers were likely to produce correctly plural *be*-verb (*were*) for *The keys$_{[pl]}$ to the cabinet$_{[sg]}$*, where the unmarked singular modifier (i.e., *the cabinet*) intervened between the subject and the verb, but to produce incorrectly plural *be*-verb (*were*) for *The key$_{[sg]}$ to the cabinets$_{[pl]}$*, where the marked plural modifier (i.e., *the cabinets*) interfered. For comprehension of agreement attraction, Pearlmutter, Garnsey, & Bock (1999, Experiment 3) examined native English speakers' sensitivity to the following set of sentences (only the relevant parts are presented):

(12) a. The key$_{[sg]}$ to the cabinet$_{[sg]}$ was rusty
b. The key$_{[sg]}$ to the cabinets$_{[pl]}$ was rusty
c. The keys$_{[pl]}$ to the cabinets$_{[pl]}$ were rusty
d. The keys$_{[pl]}$ to the cabinet$_{[sg]}$ were rusty

(Pearlmutter *et al*. 1999: 455, $_{[sg/pl]}$ added))

In word-by-word self-paced reading, difference in processing difficulty was observed at the *be*-verb position between (12a-b) but not between (12c-d). That is, (12b) ([sg] – [pl]) was more difficult to read than (12a) ([sg] – [sg]), whereas (12d) ([pl] – [sg]) was not different in processing difficulty from (12c) ([pl] – [pl]).[13] Thus, both in production and comprehension for agreement attraction, markedness of number seems to be involved in processing of number agreement.[14]

A possible generalization to be verified in future research is that the processing difficulty in subject-verb number agreement would be higher when the unmarked singular is followed by the marked plural than when the marked plural is followed by the unmarked singular. The reason why there is such a difference in processing difficulty may be related to some subset relation attributed to markedness of number.[15] Plurality includes the notion of singularity, but not vice verse. Thus, it is possible that the superset-subset (PL-SG) relation might be tolerated for processing (i.e., can be insensitive to or ignored) but the subset-superset (SG-PL) relation might not. Notice that markedness of number or the singular and plural distinction is available to Japanese speakers (cf. Note 4); however, the singular and plural distinction is not overt in subject-verb number agreement in the Japanese language (see (2a-b) above). Hence, the experimental results presented

in the current study may suggest that the Japanese EFL learners acquired the singular and plural distinction for subject-verb number agreement absent in their L1 Japanese and thus showed an asymmetrical sensitivity to the violations of subject-(*be*-)verb number agreement in L2 English by using their L1 knowledge of markedness of number.

5. Conclusion

This study found an asymmetry in the Japanese EFL learners' on-line sensitivity to subject-(*be*-)verb number agreement in L2 English. Based on Wen *et al.*'s (2010) findings, it seems that L2 learners' on-line sensitivity to English number agreement is modulated by the number marking of an agreement-triggering element (e.g., the subject for the following verb) and an element that is to agree with it (e.g., the noun for the preceding demonstrative).

Which of those two elements or what combination of them in terms of number causes an asymmetrical sensitivity is an intriguing question for future research. To narrow down the possible factors for the above-reported asymmetrical sensitivity, the following should be considered. In this study, we examined subject-verb number agreement involved in relative clauses. In the relative-clause environment, there is a processing load related to the formation of a relative clause, and the relative-clause boundary makes the subject (i.e., head noun) and verb structurally distant, although not so distant linearly. Thus, a possibility remains that such peculiarities of a relative clause itself might have affected the participants' real-time performance. In further studies, it would be worthwhile to investigate whether such an on-line, asymmetrical sensitivity to subject-verb number agreement as observed in this study is found even in a variety of other environments such as the main clauses and questions. Moreover, the head noun treated as subject in this study was within a complex NP like *the students' teacher*, and consequently the processing of the Genitive Case marker might also have affected the participants' performance. In future studies, a simplex NP rather than a complex NP should be used as subject for subject-verb number agreement. Possible examples of subject-verb number agreement to be examined are like (13) and (14) with *be*-verbs and like (15) and (16) with ordinary main verbs.[16]

(13) a. The teacher$_{[sg]}$ was$_{[sg]}$ relaxing on the bench. (SG-SG)
b. *The teacher$_{[sg]}$ were$_{[pl]}$ relaxing on the bench. (*SG-PL)
c. The teachers$_{[pl]}$ were$_{[pl]}$ relaxing on the bench. (PL-PL)
d. *The teachers$_{[pl]}$ was$_{[sg]}$ relaxing on the bench. (*PL-SG)

(14) a. Was$_{[sg]}$ the teacher$_{[sg]}$ relaxing on the bench? (SG-SG)
b. *Were$_{[pl]}$ the teacher$_{[sg]}$ relaxing on the bench? (*SG-PL)

(15) a. The teacher$_{[sg]}$ relaxes$_{[sg]}$ on the bench. (SG-SG)
b. *The teacher$_{[sg]}$ relax$_{[pl]}$ on the bench. (*SG-PL)

(16) a. Does$_{[sg]}$ the teacher$_{[sg]}$ relax on the bench? (SG-SG)
b. *Do$_{[pl]}$ the teacher$_{[sg]}$ relax on the bench? (*SG-PL)

To examine whether an asymmetrical sensitivity is limited to the relative-clause environment or to the complex NP subject, the following examples would be also worth investigating (a simplex NP for the head noun in (17) with *be*-verbs and in (18) with ordinary main verbs and a complex NP for the subject in (19) and (20) with *be*-verbs and in (21) and (22) with ordinary main verbs).

(17) a. The principal saw the teacher$_{[sg]}$ who was$_{[sg]}$ relaxing on the bench. (SG-SG)
b. *The principal saw the teacher$_{[sg]}$ who were$_{[pl]}$ relaxing on the bench. (*SG-PL)

(18) a. The principal saw the teacher$_{[sg]}$ who relaxes$_{[sg]}$ relaxing on the bench. (SG-SG)
b. *The principal saw the teacher$_{[sg]}$ who relax$_{[pl]}$ relaxing on the bench. (*SG-PL)

(19) a. The students' teacher$_{[sg]}$ was$_{[sg]}$ relaxing on the bench. (SG-SG)
b. *The students' teacher$_{[sg]}$ were$_{[pl]}$ relaxing on the bench. (*SG-PL)

(20) a. Was$_{[sg]}$ the students' teacher$_{[sg]}$ relaxing on the bench? (SG-SG)
b. *Were$_{[pl]}$ the students' teacher$_{[sg]}$ relaxing on the bench? (*SG-PL)

(21) a. The students' teacher$_{[sg]}$ relaxes$_{[sg]}$ on the bench. (SG-SG)
b. *The students' teacher$_{[sg]}$ relax$_{[pl]}$ on the bench. (*SG-PL)

(22) a. Does$_{[sg]}$ the students' teacher$_{[sg]}$ relax on the bench? (SG-SG)
b. *Do$_{[pl]}$ the students' teacher$_{[sg]}$ relax on the bench? (*SG-PL)

A possible prediction is as follows: Sensitivity would become stronger in unmarked-marked *SG-PL than in marked-unmarked *PL-SG (note that in questions as in (14b), (16b), (20b), and (22b), the order of unmarked SG and marked PL is linearly reverse (i.e., *PL-SG rather than *SG-PL, as shown by $_{[sg/pl]}$) for parsing, and thus that some difference in sensitivity might be found in the minimal pair of declarative and interrogative sentences such as (13b) and (14b)). For ordinary main verbs, SG can be morphologically more marked compared to PL because the verbal suffix *-s* is used only for the third person *singular* subject, not for the plural subject. If so, we would observe some difference between *be*-verbs and ordinary main verbs in on-line sensitivity to the violations of subject-verb number agreement.

Another interesting question is whether number-agreement in/sensitivity hinges on the L2 learners' proficiency levels in the target language (in this case, English). Recall Wen *et al.*'s (2010) findings that the advanced learners were sensitive to number dis/agreement, while the intermediate learners were not, and that only the advanced learners showed an asymmetry in the degrees of sensitivity as the native speakers did. The present study also suggested a possibility that L2 sensitivity could become stronger as the learner's proficiency becomes higher. To investigate proficiency effects on L2 sensitivity, more heterogeneous groups of learners should be examined.

One final question is whether an on-line asymmetrical sensitivity to subject-verb number agreement in English is specific to L2 learners or generally holds even for native speakers. Wen *et al*. (2010) demonstrated that both the advanced L2 learners and the native speakers showed an on-line asymmetrical sensitivity to number dis/agreement within a single NP (i.e., stronger sensitivity for *SG-PL (e.g., **this … houses*) than for *PL-SG (e.g., **these … house*)). Thus, in further research a native control group should be recruited.

Notes

[1] Portions of this study were presented at J-SLA2012 at Hosei University on June 2, 2012, at TL&MAPLL2012 at Yamagata University on July 22, 2012, and at JCSS2012 at Sendai International Center on December 13, 2012. I thank the audience for their invaluable comments. I also have to express my great gratitude toward the two reviewers, both of whose comments on the earlier version of this paper are kind and useful for improvement.

[2] As for ordinary main verbs, number agreement exists only in the third person singular subject in the present tense (e.g., *John likes/*like dogs*.).

[3] The abbreviations and notation used in this paper are as follows:
CL: a CLassifier; β: coefficient; EFL: English as a Foreign Language; Gen: a Genitive case marker; L1: first language; L2: second language; Loc: a Locative case marker; ms: millisecond; Nom: a Nominative case marker; NP: Noun Pharse; *p*: probability (or statistically significant level); pl: plural; PP: Prepositional Phrase; RT: Reading Time; SD: Standard Deviation; SE: Standard Error; sg: singular; *t*: *t*-value; TOEFL: Test Of English as a Foreign Language; *: the ungrammaticality of the sentence/expression in question.

[4] In Japanese, number agreement exists between the demonstrative and the following noun as in *kono inu* 'this dog' for one dog and *korera-no inu(-tati)* 'these dog(s)' for more than one dog (cf. Kuno's (1973) discussion that *-tati* in Japanese and *-s* in English are functionally different). Thus, it is conceivable that the L2 sensitivity to number agreement found in Wen *et al*. (2010) might have been affected by the learners' L1 characteristics.

[5] In this paper, we treat the head noun of relative clauses as subject in the sense of subject-verb number agreement.

[6] See Just, Carpenter, & Wolley (1982) for a self-paced reading technique. Basically, the participant can see only a single phrase for one time on the display. After his/her pushing the button, the next phrase appears while the first one disappears.

[7] The intension for why the comprehension question was not interrogative but rather affirmative was to measure the time of the participant's self-paced reading as naturally as possible, for example, without his/her paying too much attention to answering such a question as "Is the sentence that you have read ungrammatical?" by using his/her metalinguistic knowledge. As for one of the three possible choices as in

(6), however, note that the metalinguistic term, *ungrammatical*, was used.

[8] This means that in the following, the reading time data of the target items were analyzed irrespective of the participants' responses to the accompanied questions. The reason why only the 12 questions were used for participant screening was that those questions were easy to answer without any confusion, compared to the other 60 questions accompanying the target and other filler sentences (comprehension accuracy of the 60 questions was relatively low (around 60%) probably because of three possible choices (in particular, *ungrammatical*) leading to the participants' confusion).

[9] In the following Figures, (5a-d) indicate examples of the four conditions (i.e., SG-SG, *SG-PL, PL-PL, and *PL-SG).

[10] Recall that as in (i), the present study treated the head noun and *be*-verb of relative clauses as subject and verb in the sense of subject-verb number agreement and manipulated the number marking of agreement-triggering NP2 and *be* that is to agree with it.

(i) R1 / R2 / R3 / R4 / <u>R5</u> / R6 / R7
Matrix Subject / Matrix V(erb) / NP1's $NP2_{[sg/pl]}$ / who / $\underline{be}_{[sg/pl]}$ / V-ing / PP

In the following, *subject-verb* number agreement refers mainly to subject-*be*-verb number agreement.

[11] Although Wakabayashi *et al*. (2007) used (9b) for person agreement rather than number agreement, both of (9a-b) can be discussed in terms of number agreement as specified in them (note that *answer*, not *answers*, can be used for the singular subject like *I* and *you*).

[12] See Wakabayashi *et al*. (2007). Based on an ERP study, they discuss that Japanese speakers are sensitive to the violations of subject-verb person agreement in L2 English because such kind of agreement exists in Japanese (e.g., **Watasi/Anata/Kare-ga (watasi-ni) sore-o kureta*. "*I/You/He gave it (to me)"), while they are insensitive to the violations of subject-verb number agreement in L2 English because such type of agreement is absent in Japanese (e.g., (2a-b) above).

[13] In (12c-d), the processing difficulty was found at *rusty*, but the pattern was opposite to (12a-b). That is, (12c) was more difficult than (12d), which is discussed in terms of some discourse effects (see Pearlmutter, Garnsey, & Bock 1999: 448-449).

[14] The experimental stimuli used in the present study may be considered an interesting case of agreement attraction (see (5a-d)). Notice that the number marking of the two nouns (e.g., *student* and *teacher*) that constitute the head of relative clauses does not match in number and thus may yield similar effects to agreement attraction.

[15] See Eberhard's (1997: 162-163) account referring to the different featural specifications of singular and plural: The marked plural possesses an additional feature that is absent in the unmarked singular and thus

the processing of the marked plural yields an extra processing load.

[16] To exclude subject-verb person agreement as in personal pronouns like *I* and *you* (cf. Wakabayashi *et al*. 2007), the subjects in the examples are limited to the third-person nouns. This is also because for ordinary main verbs, only the third person singular subject requires an agreement morpheme *-s* on a verb in the present tense context (cf. Note 2). Out of the four conditions as in (13), only two conditions like (13a-b) are presented from (14). Note that for ordinary main verbs as in (15) and (16), the verb without the third person singular morpheme *-s* (e.g., *relax*, not *relaxes*) can be used for the singular subject like *I* and *you* (cf. Note 11). Although in the examples, the subject and verb are adjacent, it is interesting to observe sensitivity to subject-verb number agreement when an adverb intervenes between them to make them non-adjacent (cf. Bannai 2011).

Appendix A: The Target Experimental Stimuli

S and Q stand for Sentence (for self-paced reading) and Question (following that sentence), respectively. The slashes in S mean segmentation for self-paced reading. The items in the squared brackets in Q indicate three possible answers for forced choice. The item following the brackets is the correct answer (the correct answers were counterbalanced between conditions (a) and (c)). Only for the first example, are four conditions presented (conditions (a) and (c) are grammatical, whereas conditions (b) and (d) are ungrammatical). For the remaining twenty-three examples, only one of the four conditions is provided without the corresponding question.

S1a.	The principal / saw / the students' teacher / who / was / relaxing / on the bench. (SG-SG)		
Q1a.	The teacher relaxed on the bench	[correct, incorrect, ungrammatical]	correct
S1b	The principal / saw / the students' teacher / who / were / relaxing / on the bench. (*SG-PL)		
Q1b.	The principal saw the teacher.	[correct, incorrect, ungrammatical]	ungrammatical
S1c.	The principal / saw / the student's teachers / who / were / relaxing / on the bench. (PL-PL)		
Q1c.	The student relaxed on the bench.	[correct, incorrect, ungrammatical]	incorrect
S1d.	The principal / saw / the student's teachers / who / was / relaxing / on the bench. (*PL-SG)		
Q1d.	The principal saw the student.	[correct, incorrect, ungrammatical]	ungrammatical
S2.	The child / laughed at / the ministers' servant / who / was / relaxing / with the music.		
S3.	The policeman / talked with / the lawyers' client / who / was / sitting /on the chair.		
S4.	Someone / spoke with / the tourists' guide / who / was / sitting / in the seat.		
S5.	The manager / argued with / the workers' colleague / who / was / chatting / in the meeting.		
S6.	The customer / spoke to / the clerks' boss / who / was / chatting / with the staff.		
S7.	The boy / noticed / the presidents' interpreter / who / was / standing / on the street.		
S8.	The photographer / smiled at / the musicians' child / who / was / standing / by the statue.		
S9.	The farmer / chatted with / the emperors' slave / who / was / walking / in the garden.		
S10.	The mothers / worried about / the pupils' caretaker / who / was / walking / with the dog.		
S11.	The lady / talked to / the scholars' friend / who / was / smiling / at the children.		
S12.	The student / visited / the professors' researcher / who / was / wandering / around the room.		
S13.	The police / wrote to / the detectives' assistant / who / was / working / in the office.		
S14.	The audience / watched / the dancers' partner / who / was / singing / in the hall.		

S15. People / were surprised at / the swimmers' fan / who / was / screaming / in the event.
S16. The teenagers / loved / the singers' guitarist / who / was / jumping / on the stage.
S17. The woman / met / the governors' driver / who / was / jogging / in the park.
S18. The children / approached / the mayors' secretary / who / was / yelling / in the game.
S19. The reporter / interviewed / the runners' coach / who / was / crying / at the stadium.
S20. The lawyer / told about / the politicians' supporter / who / was / dancing / in the party.
S21. The journalist / found / the artists' model / who / was / living / in the countryside.
S22. The man / disliked / the fighters' rival / who / was / running / on the road.
S23. The girl / looked at / the scientists' baby / who / was / shouting / in the laboratory.
S24. Many people / heard about / the doctors' nurse / who / was / staying / at the hotel.

Appendix B: R Script for Backward Selection of Linear Mixed-Effects Models

For linear mixed-effects modeling, the dependent variable was reading time (rt), the independent or manipulated variables were matching and number, and the random variables were participants and items. The following is the R script used for backward selection of the optimal model.

```
rt <- read.csv("numagr.csv")
rt$nmatching <- ifelse(rt$matching == "match", 1, 2)
rt$nnumber <- ifelse(rt$number == "singular", 1, 2)
rt$cmatching <- scale(rt$nmatching)
rt$cnumber <- scale(rt$nnumber)
library(lme4)
rt.lme10 <- lmer(rt ~ cmatching*cnumber + (1+cmatching*cnumber|participant) + (1+cmatching*cnumber|item), data=rt)
rt.lme9 <- lmer(rt ~ cmatching*cnumber + (1+cmatching*cnumber|participant) + (1+cmatching+cnumber|item), data=rt)
rt.lme8 <- lmer(rt ~ cmatching*cnumber + (1+cmatching+cnumber|participant) + (1+cmatching+cnumber|item), data=rt)
rt.lme7 <- lmer(rt ~ cmatching*cnumber + (1+cmatching+cnumber|participant) + (1+cmatching|item), data=rt)
rt.lme6 <- lmer(rt ~ cmatching*cnumber + (1+cmatching|participant) + (1+cmatching|item), data=rt)
rt.lme5 <- lmer(rt ~ cmatching*cnumber + (1+cmatching|participant) + (1|item), data=rt)
rt.lme0 <- lmer(rt ~ cmatching*cnumber + (1|participant) + (1|item), data=rt)
anova(rt.lme10, rt.lme9, rt.lme8, rt.lme7, rt.lme6, rt.lme5, rt.lme0)
```

Appendix C: The Optimal Model for Each Region

The following models were the optimal models for seven regions (R5 was the critical region).

R1: rt ~ cmatching*cnumber + (1|participant) + (1|item)
R2: rt ~ cmatching*cnumber + (1|participant) + (1|item)
R3: rt ~ cmatching*cnumber + (1|participant) + (1|item)
R4: rt ~ cmatching*cnumber + (1+cmatching|participant) + (1+cmatching|item)
R5: rt ~ cmatching*cnumber + (1|participant) + (1|item)
R6: rt ~ cmatching*cnumber + (1|participant) + (1|item)
R7: rt ~ cmatching*cnumber + (1|participant) + (1|item)

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