Japanese Learners' Preference for CV/C Segmentation and Vulnerability to CV Overlap during L2 English Sentence Processing

Risa MATSUBARA

Abstract

刺激を音声提示されたとき、英語母語話者が CVC の構造を持つ英語の音節を C/VC と分けるのに対し日本語母語話者は CV/C と分ける傾向があり、これは日本語の音節構造が CV と C の間に切れ目を持つためであると考えられている。しかし、第二言語の黙読文処理時にも母語の音韻構造の転移が起こるのかは未検証である。そこで本研究は、音韻的一致が黙読文処理を阻害するという現象をふまえ、日本語を母語とする英語学習者は第二言語としての英語の黙読文処理時にも母語の日本語の音韻構造の影響を受けるため、CV の音韻的一致により強く文処理を阻害されるという仮説を立て、自己ペース文黙読実験（SPR 実験）によって検証した。実験では被験者は事前に単語を記憶してから読文に進んだ。結果として、事前に記憶した単語と文中に登場する語の最初の CV が一致している条件（例：*soul* を記憶し、文中には *soap* が登場する）では想起にあたる部分での読み時間が有意に長くなった。この結果は、日本語を母語とする英語学習者は英語の黙読文処理中にも日本語の音韻構造に影響され CV の一致に想起を阻害されていること、また、音韻情報を想起の際に利用していることを示唆する。

Key Words: L2 English, sentence processing, phonological interference

1. Introduction

Languages have different syllable structures. For instance, English has a VC-based structure while the Japanese has a CV-based structure. This means that Japanese speakers are likely to perceive English CVC syllable as CV/C by applying the rule of Japanese, their first language (L1) (Kubozono, 1995; Kubozono, 1996). However, it is still unclear if segmentation preference for the CV/C by Japanese speakers is also observed during sentence processing. In other words, it is an open question whether Japanese speakers regard *mat* and *map*, which share their first CV, as more phonologically similar words than *mat* and *rat*, which share their rhyme, during silent reading of L2 English. This current study will, therefore, investigate if the syllable structure of the learners'

L1 would be transferred into sentence processing in their second language (L2) by using self-paced reading (SPR) method, which enables the observation of the real-time sentence processing.

1.1 Difference in segmentation preference between English speakers and Japanese speakers

The syllable structure is different between English and Japanese. As Figure 1 shows, while the English syllable consists of an onset and a rhyme, Japanese syllable consists of morae, which are formed by CV, C, or V (Kubozono, 1989).

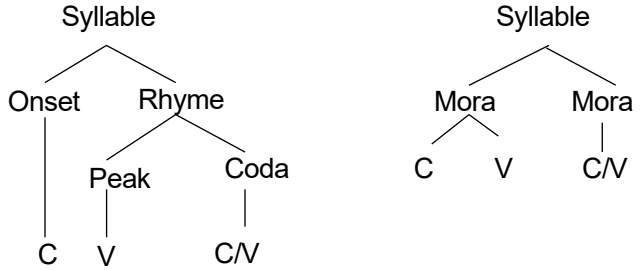

Figure 1. Difference of syllable structure between English (left) and Japanese (right) (cited from Kubozono, 1989, p254).

The difference in the syllable structure is reflected as a segmentation preference of the English CVC syllable. For instance, Treiman (1986) conducted a word-blend experiment using real CVCC words such as *packed* /pækt/ or *nuts* /nʌts/ on native English speakers. The stimuli were auditorily presented, and the participants were required to create a new word by combining two CVCC words. The results showed that C/VCC pattern (e.g., *putts* /pʌts/) was the most frequent in the responses, suggesting that English speakers prefer segmentation between onset and rhyme. Kubozono (1995, 1996) tested if the Japanese speakers' segmentation preference differed from the English speakers' by conducting an English word-blend experiment similar to Treiman's (1986) experiment targeting Japanese speakers. Real-word English CVC stimuli such as *man* /mæn/ or *pet* /pet/ were auditorily presented to the participants, and about 80% of their answers showed *mat* or *pen* pattern, combining CV at the first word (*ma* /mæ/) and C at the second word (*t* /t/). In other words, the Japanese speakers preferred the CV/C segmentation to the C/VC segmentation of the English CVC structure.

As shown above, it can be argued that the English speakers' segmentation preference for C/VC and the Japanese speakers' segmentation preference for CV/C have been evidenced. The segmentation preference would also be reflected by phonological interference during sentence processing, as will be explained in the next section.

1.2 Phonological interference with word or sentence processing

In the L1 English sentence processing literatures, it has been reported that phonological information is activated even during written word or sentence processing. For instance, the results of the silent reading experiment that tested comprehension by McCutchen & Perfetti (1982) showed that when the sentences contained onset overlap (e.g., *The detective discovered the danger and decided to dig for details*), the semantic comprehension was significantly slower compared to that of the sentences without onset overlap. On the other hand, Kush et al. (2015) suggested an interference from rhyme overlap with sentence processing. The results of their SPR experiment that used sentences such as *It was the boat that the guy who drank some hot coffee sailed on two sunny days* showed that the reading times (RTs) were significantly longer right after *It was the boat* when the participants memorized three words such as *coat–vote–note*, the rhyme of which overlaps with the word *boat* in region 1, before reading the sentence. In contrast, no significant difference in RTs was observed at or immediately after the transitive verb *sailed*. They conclude that the rhyme overlap interfered with the encoding, the process of memorizing the information of the phonologically overlapping word, and, in contrast, did not interfere with the retrieval, where the participants need to retrieve the memorized word *the boat* from their memory to follow the transitive verb *sailed*.

The phonological interference even with written-word processing can be explained by the idea of phonological memory (PM). According to Sperling (1967), the information represented by written words is transformed into phonological information and stored in auditory information storage, which is equivalent to PM (Figure 2). Baddeley's working memory (WM) model (Baddeley, 2010) also has a PM in the short-term memory (STM) and, according to Gathercole (1995) and Baddeley et al. (1988), language knowledge in the long-term memory (LTM) affects the PM and vice versa (Figure 3).

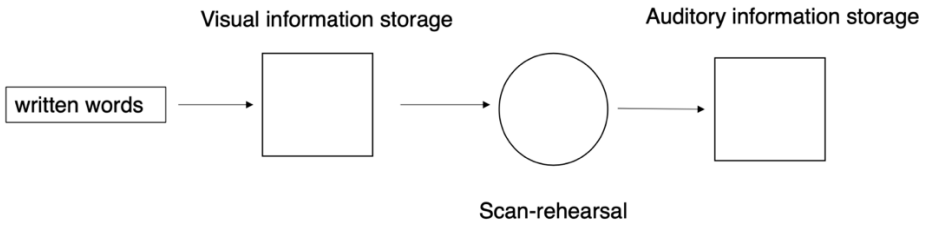

Figure 2. The transformation of the visual information into acoustic (phonological) information (based on Sperling, 1967).

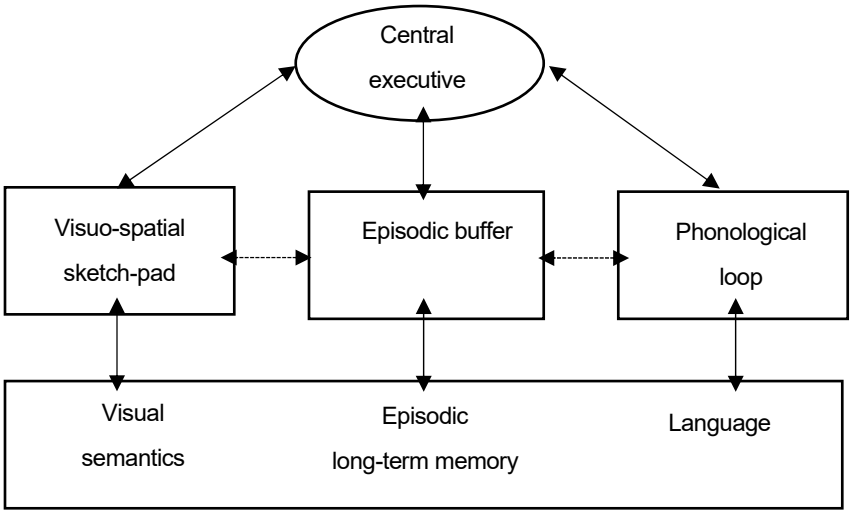

Figure 3. Baddeley's WM model (adopted from Baddeley, 2010, R138).

Given the influence of the language knowledge in the LTM on the PM, the knowledge of L1 phonology in the LTM may affect the process of memorizing the phonological information in the PM during the L2 sentence processing. Taking the possibility of an L1 phonological transfer into consideration, the WM model for L2 sentence processing would be refined as below (Figure 4).

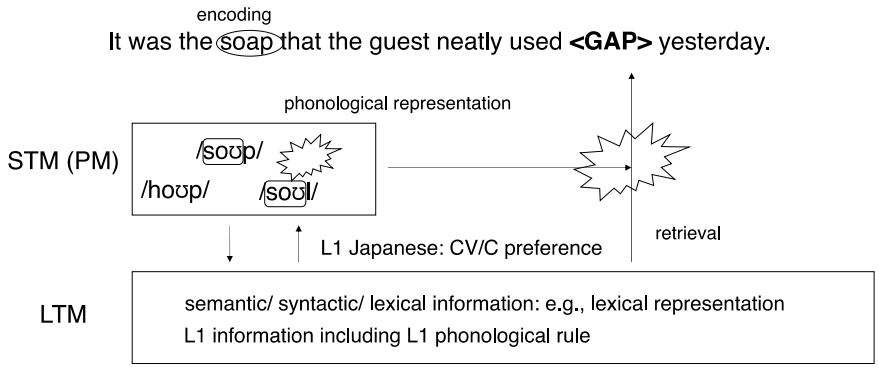

Figure 4. The refined WM model to consider the L1 Japanese phonological transfer to L2 English sentence processing.

In this case, when the filler is encoded, it is transformed into the phonological representation affected by the L1 Japanese phonology and stored in the PM. Its semantic representation is then stored in the LTM, which is in charge of syntactic, semantic, and lexical processing. As retrieval is mainly syntactic or semantic processing (Kush et al., 2015), the retrieval is mainly processed by

the LTM. However, it is also possible that the L1-influenced phonological representation interferes with the semantic or syntactic processing for the retrieval, causing an increase in processing cost at retrieval. It is therefore thought that the CV overlap will have a more dominant effect than the rhyme overlap for the Japanese learners at encoding and/or retrieval, as the CV/C segmentation is preferred due to the L1 Japanese phonological transfer.

However, word recall processing should be more STM-dependent, as there should be less or little semantic or syntactic processing, which is operated by the LTM. The phonological conflict in the STM would therefore be more likely to occur than at retrieval. The phonological interference can either be the CV overlap if the information of L1 Japanese strongly interferes with the phonological processing or the rhyme overlap if the information flow of the L1 phonological rule from the LTM is weakened due to the less dependency on the LTM.

Regarding the Japanese learners' vulnerability to the CV overlap, we set two research questions: 1) Is the CV/C segmentation preference of the Japanese learners transferred to L2 English sentence processing? In other words, are they more subject to CV overlap than to rhyme overlap? 2) Is the phonological information retained throughout L2 English sentence processing or used only at encoding?

To answer these research questions, we conducted an SPR experiment as described below.

2. Methods

2.1 Participants

21 Japanese learners of English were recruited at the University of Tokyo. The results of one participant were excluded because she was sick during the experiment and thus her answers did not correspond to her usual capacities. Therefore, 20 of them (15 males, mean age = 20.10, *SD* = 2.91) were analyzed. The mean score of Oxford Quick Placement Test (OQPT) was 43.00/60 (*SD* = 4.62), which was equivalent to CEFR B2 level. 13 native English speakers were recruited as a control group in the Kanto area, and they were either students or office workers. Two of them were excluded from the analysis because one answered that his first language was Tamil in the questionnaire, and the other showed a strong influence from Japanese as his second language. The total number of the English participants was therefore 11 (nine males, mean age = 24.36, *SD* = 3.75) and their English origin was New Zealand (one), Singapore (one), the U.K. (one), Ireland (one), or the U.S. (seven). Three out of the eleven were bilinguals of English and another language (English-Japanese, English-Chinese, and English-Filipino).

2.2 Stimuli

24 target sentences as below were presented per participant. They were of 1 factor

(Overlap_type) × 3 levels ((a) rhyme overlap, (b) onset overlap, (c) CV overlap).

Table 1. Example of a sentence used in the SPR experiment

conditions	load word	region 1	region 2	region 3	region 4	region 5
(a) rhyme overlap	h**ope**					
(b) onset overlap	**s**et	It was the **soap**/	that the guest/	neatly/	used/	yesterday.
(c) CV overlap	**sou**l					

Following the method of the SPR experiment by Kush et al. (2015), they were relative clause sentences to observe the phonological interference with encoding and retrieval. In region 1 the participants encounter the phonologically overlapping word (target word), and in region 4 they need to retrieve the information of the word in region 1. The load words and the target words were either CVC (13 sentences) or CVCC structure (11 sentences) (see the Appendix for all examples). Three out of the 24 were excluded from the analysis due to semantic overlap between the load word and the target word or phonological overlap inappropriate for this current study.

Each sentence had three conditions (a) rhyme overlap, (b) onset overlap, and (c) CV overlap. In (a) rhyme overlap, the load word and the target word in region 1 share the rhyme (/oʊp/ in *hope* and *soap*). In (b) onset overlap, the load word and the target word share the onset (/s/ in *set* and *soap*). In (c) CV overlap, the load word and the target word share the first CV (/soʊ/ in *soul* and *soap*). The sentences were randomized by Latin Square so that the participants would encounter every condition but would not encounter the same load word twice.

The familiarity of the load words was measured by 'level' from *JACET 8000 Eitango* (JACET 8000 English words list) (Aizawa et al. (ed)., 2017). According to the measurement, the higher the 'level' (JACET-level) of a word is, the less familiar it is for Japanese learners (e.g., *hope* = level one, *fake* = level seven). 94.55% of the load words of the analyzed items were level one to level three. The difference of the JACET-level did not bear significant difference in RTs in each region and LRTs when it was set as a covariant value in the formula ($p > 0.05$).

The 56 filler sentences included 30 three-conditioned sentences such as *This is the rice that the porter quickly boiled yesterday* (load word: *right*, *like*, or *might*). The conditions included phonological overlap between the load word and the target word. The first CV of the load word and the target word consists of the same sounds both in Japanese and English (*right* and *rice*) or only in Japanese (*like* and *rice*) due to the /l-r/ neutralization in Japanese and where the vowel of the first CV is the same both in Japanese and English (*might* and *rice*). The other 26 sentences were either simple sentences such as *The airplane has just flown* (load word: *color*) or complex sentences such as *I was surprised to know that the comedians were not paid for their work* (load

word: *wet*), with the load word without any phonological or semantic similarity.

2.3 Procedure

The participants first answered the questionnaire about their language background either by paper or via Google form. The SPR experiment was done in the sound-proof booth at the University of Tokyo and was run by E-prime 2.0 (Psychology Software Tools, Inc., Pittsburgh, PA). The participants were instructed to be seated in front of the monitor of the laptop PC and to follow the instructions on the monitor. It started with the five practice sentences so that they could get used to the task. The load word was first presented in the center of the monitor until the space-bar was pressed. The participants had been told that they could see the word until they properly memorized it. The sentence started with the black star mark '★.' When the participants pressed the space-bar, the star mark disappeared and a series of lines equivalent to the number of the regions appeared. Every time the participants pressed the space-bar, each line changed to a word or phrase from left to right. After finishing reading the sentence, the comprehension question appeared and the participants responded by pressing the 'f' key for *yes* and the 'j' key for *no*. After the question, the instructions 'Type the word' appeared and the participants needed to type the word that they had memorized before reading the sentence and pressed the enter key to confirm. There was no time limit for typing the word, and they were instructed to press the enter key without typing anything only if they could not remember the word at all. During the practice session, the experimenter stood by the participant so that they could ask the experimenter questions before the trial session started and left the booth when the practice session ended, confirming that the participants were ready for the experimental session. All participants were paid for their participation.

2.4 Analysis

First, the trials of wrongly answered comprehension questions and load-recall were excluded from the analysis because the results of the analysis of data that included the wrongly answered ones did not show a large difference from the data of only correct answers. 74.50% of the data remained. The answers to the load-recall that were thought to be spelling mistakes were counted as correct answers (e.g., *cource* for *course*). In order to omit the data with extremely short or long RTs/LRTs, only the data within the range of 150ms < RTs < 12000ms and LRTs < 10000ms was included. After this, 98.30% remained. The data were then separated into two categories: one for RTs analysis and the other for the LRTs analysis. Finally, the data that exceeded the SD = ± 2 was omitted, and 95.64% of RTs data and 95.60% of the LRTs data remained.

A linear mixed effect (LME) model with the lmer package in the R software was used for the

statistical analysis. The log-transformed RTs or LRTs (rt or lrt in the formula) were set as response variables, Group (GR in the formula), which refers to Japanese group or English group, and Overlap_type (OV in the formula) were set as fixed factors, and individual differences among the items (item in the formula) or the participants (subj in the formula) were set as random factors. The number 1 in the formula refers to a random intercept per participant and per item. The main effect of OV was selected as a random slope for individual differences in the participants, and the main effects of OV, GR and the GR × OV interaction were set as random slope for individual difference in the items. The formula is as below. The best fit model was selected by Backward Selection (Bates et al., 2015).

log(rt) ~ GR + OV + GR:OV + (1 + OV|subj) + (1 + GR + OV + GR:OV|item)
log(lrt) ~ GR + OV + GR:OV + (1 + OV|subj) + (1 + GR + OV + GR:OV|item)

2.5 Hypotheses and expected results

As studies by Kubozono (1989, 1995, 1996) have shown, the Japanese learners are expected to segment the English CVC(C) words by CV due to the transfer of L1 Japanese phonology. It is hypothesized that the preference for CV/C(C) segmentation that stems from the L1 syllable structure would be transferred to the L2 English sentence processing, and the CV overlap would cause a more considerable increase in processing cost than the rhyme overlap (CV preference hypothesis). It leads to the predictions that RTs would be the longest in the CV overlap in the Japanese group. In contrast, RTs would be the longest in the rhyme overlap in the English group. The difference would be reflected by a significant interaction between GR and OV. As seen in McCutchen & Perfetti (1982) and Yamazaki et al. (2016), there is also a possibility that the onset overlap would interfere with processing the most in both the Japanese learners and the English speakers (onset overlap hypothesis). This would expect the significant main effect of the OV, with RTs being the longest in the onset overlap both in the Japanese group and the English group. Third hypothesis is that, given that the Japanese learners who participated have high English proficiency, the Japanese learners adjust themselves to the English syllabification pattern. They would be affected the most by the rhyme overlap as the native English speakers would (rhyme overlap hypothesis). This leads to the predictions that RTs would be the longest in the rhyme overlap both in the Japanese group and the English group in region 1, reflected by the significant main effect of OV.

Regarding the persistence of phonological interference, we formed two hypotheses. The first one is that, following the results of Kush et al. (2015), the phonological interference would occur at encoding (encoding hypothesis). It is predicted that the increase in RTs would occur in region 1,

where the participants encounter the phonologically overlapping word with the load word they previously memorized and store the information of the word in their phonological memory (encoding). The second one is that, assuming that the phonological information has a persistent effect based on the idea of Baddeley's phonological memory (Baddeley, 1966), the phonological interference would occur at retrieval (retrieval hypothesis). It predicts the increase in RTs in region 4, where the participants need to retrieve the information of the word in region 1 to follow the transitive verb. Regarding the load-recall, the CV preference hypothesis predicts that there would be a significant GR × OV interaction effect, with the rhyme overlap < the CV overlap in the Japanese group while the rhyme overlap > the CV overlap in the English group. The onset overlap hypothesis predicts the main effect of the OV with the onset overlap > the rhyme overlap in both the Japanese group and the English group. The rhyme overlap hypothesis predicts the LRTs would be the longest in the rhyme overlap both in the Japanese group and the English group, reflected by the significant main effect of OV.

3. Results

3.1 RTs

In region 1, the critical region for encoding, no significant interaction effect between GR and OV was observed, and the main effect of GR was significant. Significant differences in RTs between the conditions were found neither in the Japanese group nor in the English group. However, a marginally significant GR × OV interaction effect was observed in region 2, the spillover region for encoding (see Table 2). It reflects (a) rhyme overlap < (b) onset overlap in the Japanese group and (a) rhyme overlap > (b) onset overlap in the English group as shown in Figure 5, though the simple main effect test did not show any significant differences in each group.

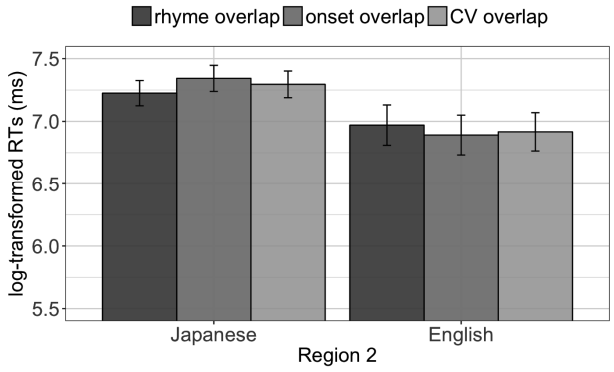

Figure 5. The difference in RTs between groups and conditions in region 2

Table 2. Statistical results of RTs in region 2[1]

	β	*SE*	*df*	*t*	*p*	
(Intercept)	7.239	0.096	51.238	75.586	<2e-16	***
GREnglish	-0.287	0.131	48.592	-2.194	0.033	*
OVonset overlap	0.094	0.082	36.125	1.153	0.257	
OVCV overlap	0.062	0.087	33.872	0.707	0.484	
GREnglish:OVonset overlap	-0.173	0.103	382.588	-1.675	0.095	.
GREnglish:OVCV overlap	-0.102	0.103	383.451	-0.997	0.319	

RTs in region 4 is shown in Figure 6. In region 4, the critical region for retrieval, a significant interaction between GR and OV was found (see Table 3), and the simple main effect test showed that a significant difference between (a) rhyme overlap and (c) CV overlap was found only in the Japanese group (see Table 4).

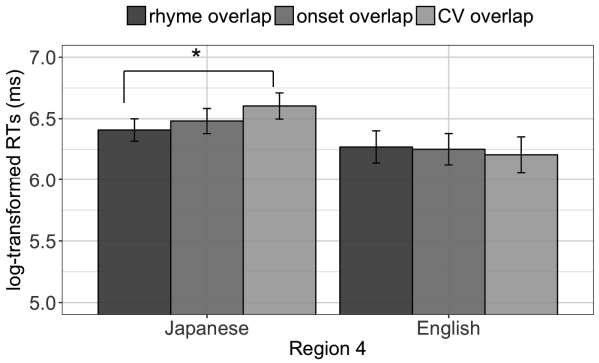

Figure 6. The difference in RTs between groups and conditions in region 4

Table 3. Statistical results of RTs in region 4

	β	*SE*	*df*	*t*	*p*	
(Intercept)	6.409	0.087	62.425	73.348	< 2e-16	***
GREnglish	-0.177	0.126	50.474	-1.409	0.165	
OVonset overlap	0.073	0.058	421.182	1.263	0.207	
OVCV overlap	0.176	0.057	420.224	3.101	0.002	**
GREnglish:OVonset overlap	-0.054	0.092	418.548	-0.590	0.555	
GREnglish:OVCV overlap	-0.186	0.091	418.127	-2.046	0.041	*

Table 4. Statistical results of RTs in region 4 in the Japanese group

	β	*SE*	*df*	*t*	*p*	
(Intercept)	6.410	0.080	50.486	79.926	< 2e-16	***
OVonset overlap	0.074	0.058	253.528	1.272	0.205	
OVCV overlap	0.175	0.057	252.732	3.050	0.003	**

3.2 The LRTs

The results of the statistical analysis of the LRTs did not show any significant interaction between GR and OV. They showed significant or marginally significant main effects of GR and OV as in Table 5. As shown in Figure 7, the LRTs were the longest in the rhyme overlap both in the Japanese group and the English group. The differences between (a) rhyme overlap and (b) onset overlap were significant and those between (a) rhyme overlap and (c) CV overlap were marginally significant. The simple main effect test showed that the LRTs were significantly longer in (a) rhyme overlap than in (b) onset overlap both in the Japanese group and the English group and the differences in the LRTs were marginally significant between (a) rhyme overlap and (c) CV overlap only in the Japanese group (see Table 6 and Table 7).

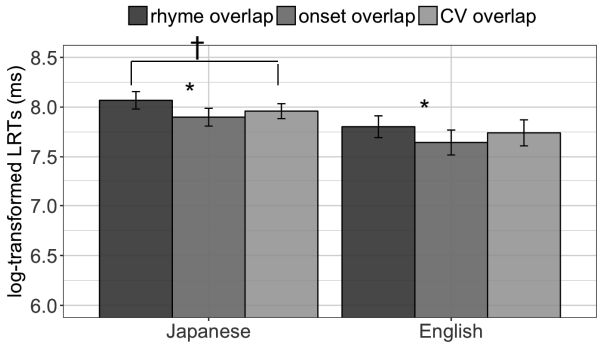

Figure 7. The difference in the LRTs between groups and conditions

Table 5. Statistical results of the LRTs

	β	*SE*	*df*	*t*	*p*	
(Intercept)	8.094	0.071	54.380	113.619	< 2e-16	***
GREnglish	-0.316	0.106	46.944	-2.991	0.004	**
OVonset overlap	-0.164	0.058	37.443	-2.820	0.008	**
OVCV overlap	-0.143	0.076	25.842	-1.874	0.072	.
GREnglish:OVonset overlap	0.013	0.077	381.074	0.165	0.869	
GREnglish:OVCV overlap	0.092	0.078	382.379	1.186	0.236	

Table 6. Statistic results of the LRTs in the Japanese group

	β	*SE*	*df*	*t*	*p*
(Intercept)	8.097	0.064	35.249	125.647	<2e-16 ***
OVonset overlap	-0.171	0.062	16.328	-2.775	0.013 *
OVCV overlap	-0.144	0.077	20.016	-1.877	0.075 .

Table 7. Statistic results of the LRTs in the English group

	β	*SE*	*df*	*t*	*p*
(Intercept)	7.767	0.101	16.198	77.230	<2e-16 ***
OVonset overlap	-0.144	0.065	157.429	-2.210	0.029 *
OVCV overlap	-0.021	0.066	158.904	-0.323	0.747

4. Discussion

The results showed no significant difference in RTs in region 1 and did not provide enough support for the CV preference hypothesis, the rhyme overlap hypothesis, the onset overlap hypothesis, and the encoding hypothesis. In region 2, the spillover region for the encoding, a marginally significant GR × OV interaction effect was found and the results reflect that RTs are longer in the onset overlap than in the rhyme overlap in the Japanese group while RTs are longer in the rhyme overlap than in the onset overlap in the English group. The results suggesting that the Japanese speakers are dependent on the onset overlap are unexpected. However, the slight differences in RTs can be attributed to the difference in length of region 2 rather than to the condition itself: region 2 consists of the relative pronoun *that* and either one word or two words, or short words or long words.

The lack of difference in region 1 can also be attributed to the failure of the experimental condition rather than to a matter of processing. First, unlike region 4, which consists of only one word, region 1 included more than just the target word. This may have blurred the effect of the phonological overlap to appear there because the time for the processing of the words before the target word such as *It was* or *This is* may have been counted as RTs for region 1. Second, for the native speakers of English, only one word for the load word may not be enough to have the 'power' to affect phonologically, which can be true for the English results of all regions.

The fact that the interaction effect between GR and OV was significant only in region 4 suggests that the Japanese learners are likely to be affected more by the CV overlap than the rhyme overlap at retrieval and use phonological information as a retrieval cue. The results support the CV preference hypothesis and the retrieval hypothesis, but not the encoding hypothesis. Though the results that the increase in the processing cost was observed only at retrieval seem to

be unnatural, the SPR experiment by Yamazaki et al. (2016) showed similar results. The results suggested the retrieval interference of the onset overlap when the word was written in kana, phonogram in the Japanese writing system. Although the SPR experiment by Yamazaki et al. (2016) was about onset overlap in Japanese, it can still be argued that Japanese speakers are dependent on phonological information during retrieval both in the processing of L1 Japanese and L2 English. The lack of phonological interference with encoding seems to be inconsistent with Kush et al. (2015), which observed the phonological interference with encoding. Nevertheless, as mentioned earlier, it can be attributed more to the methodological issues than the possibility that the (L1) phonological interference did not occur at encoding.

The results that the LRTs were significantly longer in the rhyme overlap than in the CV overlap both in the Japanese group and the English group seem to support the rhyme overlap hypothesis that the Japanese learners would also be affected by the rhyme overlap as the English speakers would. It is opposite to what was observed at retrieval in the Japanese group: the CV overlap increased RTs while the rhyme overlap did not. The results can be interpreted in two ways. The first is that, given that the Japanese learners showed the CV/C segmentation preference at retrieval, they use different strategies between the retrieval in the sentence and the word-recall out of context. That is, the Japanese learners may take a 'native-like' strategy when recalling the word out of context after reading the sentence, segmenting CVC as C/VC. The second is that the word-initial overlap is likely to facilitate the reproduction of the memorized word, regardless of the difference in the L1 syllable structure. Though the onset overlap facilitation in a shadowing task was denied and the rhyme overlap facilitation has been reported, attributing it to the perceptual saliency of the rhyme (Slowiaczek et al., 2000),[2] a different strategy may have been taken when typing the memorized word. It can be argued that the onset overlap may facilitate typing or writing the visually presented memorized word after silent reading sentence processing.

5. Conclusion and further issues

This current study looked at whether the L1 Japanese syllabification rule is transferred to L2 English sentence processing. It was first hypothesized that Japanese speakers segment English CVC(C) syllables into CV/C(C) and therefore, they would be affected more by CV overlap than rhyme overlap while English speakers would be affected more by rhyme overlap than CV overlap (CV preference hypothesis). Based on the evidence shown by the earlier studies such as McCutchen & Perfetti (1982), it was then hypothesized that both the Japanese learners and the native English speakers would be affected by the onset overlap (onset overlap hypothesis). Taking the relatively high English proficiency level of the Japanese learners into consideration, the rhyme overlap hypothesis, which hypothesized that the Japanese learners would be affected by the rhyme

as English speakers would be, was also tested. Regarding where the phonological interference would occur, two hypotheses that the phonological overlap would interfere with the encoding and that it would interfere with the retrieval were tested (encoding hypothesis and retrieval hypothesis).

The significant interaction effect between GR and OV in region 4, with RTs significantly longer in the CV overlap than in the rhyme overlap only in the Japanese group support the CV preference hypothesis and the retrieval hypothesis. The marginally significant and the significant main effect of OV reflecting that the LRTs were the longest in the rhyme overlap both in the Japanese group and the English group support the rhyme overlap hypothesis. In conclusion, the results suggested that the Japanese learners of English are dependent on their L1 Japanese syllabification during L2 English sentence processing and use the phonological information as a retrieval cue. It is concluded about the load-recall that the Japanese learners take a rhyme-based strategy or are facilitated by the initial overlap.

Some problems remain in the current study. First, this study treats auditory processing and visual processing as the same. Though this study discusses the cause of the processing cost based on the earlier studies about the processing of auditorily presented stimuli such as Slowiaczek et al. (2000), the processing strategy may not always be the same between the processing of auditory stimuli and visual stimuli.[3] Investigation into whether the vulnerability to the CV overlap of the Japanese learners of English changes when the stimuli presented auditorily is therefore needed. Second, the effect of the difference in the syllable structure on the processing cost was not considered. The sentences used in the SPR experiment included both CVC structure words and CVCC structure words. The difference between CVC and CVCC may have affected the segmentation preference of both the Japanese learners and native English speakers. A future study should consider this difference. Concretely, the stimuli should be limited to CVC or the processing behavior of the learners between CVC and CVCC should be compared with an enough number of stimuli.

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Notes

[1] *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. GREnglish refers to the difference in the value of the English group compared with the value of the Japanese group. OV onset overlap refers to how much the values in

the onset overlap are different from those in the rhyme overlap. OVCV overlap refers to how much the values in the CV overlap are different from those in the rhyme overlap

[2] Slowiaczek & Hamburger (1992) showed the facilitatory effect when the prime and the target word shared one or two initial phonemes (e.g., target word: *still*, primes: *steep* or *smoke*). However, Goldinger (1999) denied the facilitatory effect, pointing out that it was due to expectancy strategies. That is, participants possibly predicted the initial overlap and prepared for the production, which facilitated the shadowing.

[3] The experiment by Baddeley (1966) showed that phonologically similar words such as *man*, *mad*, and *map* were less likely to be correctly recalled than phonologically dissimilar words such as *pen*, *rig*, and *day* both when they were presented auditorily and they were presented visually.

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Appendix. All target sentences used in the SPR experiment

item	conditions	load word	region 1	region 2	region 3	region 4	region 5
1	a: rhyme overlap	coat					
1	b: onset overlap	bus	This is the boat	that the guy	actively	sailed	on a sunny day.
1	c: CV overlap	bowl					
2	a: rhyme overlap	band					
2	b: onset overlap	set	It was the sand	that the crab	silently	dug	last night.
2	c: CV overlap	sat					
3	a: rhyme overlap	pile					
3	b: onset overlap	foot	This is the file	that the officeworker	quickly	bought	during the lunch break.
3	c: CV overlap	five					
4	a: rhyme overlap	heat					
4	b: onset overlap	such	It was the seat	that the worker	immediately	booked	early in the morning.
4	c: CV overlap	seek					
5	a: rhyme overlap	fake					
5	b: onset overlap	cut	It was the cake	that the host	carefully	cooked	yesterday.
5	c: CV overlap	case					
6	a: rhyme overlap	coast					
6	b: onset overlap	tell	It was the toast	that the child	usually	ate	last year.
6	c: CV overlap	toad					
7	a: rhyme overlap	test					
7	b: onset overlap	not	This is the nest	that the birds	carefully	built	in the morning.
7	c: CV overlap	neck					

8	a: rhyme overlap	tense	This is the fence	that the guy	quickly	built	on the sunny day.
8	b: onset overlap	fat					
8	c: CV overlap	fed					
9	a: rhyme overlap	short	It was the court	that the guard	silently	entered	late at night
9	b: onset overlap	cut					
9	c: CV overlap	course					
10	a: rhyme overlap	hope	It was the soap	that the guest	neatly	used	yesterday.
10	b: onset overlap	set					
10	c: CV overlap	soul					
11	a: rhyme overlap	part	It was the cart	that the old woman	slowly	wheeled	last week.
11	b: onset overlap	cut					
11	c: CV overlap	cars					
12	a: rhyme overlap	beast	It was the feast	that the village head	annually	prepared for	during summer.
12	b: onset overlap	foot					
12	c: CV overlap	feet					
13	a: rhyme overlap	fond	It was the pond	that the cleaner	regularly	drained	during the holidays.
13	b: onset overlap	pick					
13	c: CV overlap	pop					
14	a: rhyme overlap	field	Mary likes the shield	that the tribe	commonly	used	hundreds of years ago.
14	b: onset overlap	shot					
14	c: CV overlap	sheep					
15	a: rhyme overlap	tease	It was the fees	that the parents	certainly	paid	yesterday.
15	b: onset overlap	fat					
15	c: CV overlap	feet					
16	a: rhyme overlap	hold	This is the gold	that the laboror	seriously	extracted	at night.
16	b: onset overlap	get					
16	c: CV overlap	goat					
17	a: rhyme overlap	sank	This is the bank	that the worker	often	visited	last year.
17	b: onset overlap	bit					
17	c: CV overlap	bag					
18	a: rhyme overlap	hate	It was the gate	that the manager	violently	closed	in the windy evening.
18	b: onset overlap	give					
18	c: CV overlap	gaze					
19	a: rhyme overlap	felt	This is the belt	that the fashion model	nicely	wore	last fall.
19	b: onset overlap	book					
19	c: CV overlap	bed					
20	a: rhyme overlap	pink	It was the sink	that the owner	thoroughly	washed	this weekend.
20	b: onset overlap	such					
20	c: CV overlap	sit					
21	a: rhyme overlap	bowl	This is the hole	that the teenagers	secretly	dug	at night.
21	b: onset overlap	hat					
21	c: CV overlap	hope					
22	a: rhyme overlap	socks	This is the box	that the child	carelessly	opened	before lunch.
22	b: onset overlap	bit					
22	c: CV overlap	boss					
23	a: rhyme overlap	board	It was the sword	that the boy	proudly	wore	yesterday.
23	b: onset overlap	set					
23	c: CV overlap	sort					
24	a: rhyme overlap	dish	It was the fish	that the penguin	easily	caught	yesterday afternoon.
24	b: onset overlap	foot					
24	c: CV overlap	fill					